Determination of Biogas Potential of Livestock Manure: A Case Study from Mersin Province

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Abstract

Rapidly growing population, ever-evolving industrialization, increasing energy and fertilizer prices with the decreasing natural resources caused the interest in biogas technology. At this point, waste produced from livestock farming is a good source for biogas production either on farm scale or as cooperatives involving several farms of a whole region. In this study, it was aimed to determine the potential of biogas from accessible animal manure such as bovine, ovine and poultry in Mersin province and its equivalence to other types of fuels by the information obtained from the literature. When the animal existence is examined based on districts of Mersin province, it is seen that there are 20,200,937 farm animals in total. In the direction of this numerical data, the total amount of calculated annual manure is 1,752,474 ton/year, while the amount of usable/collectible animal manure is 1,009,452 ton/year. It has been determined that biogas of about 60 million m$^3$ per year can be theoretically obtained from the sum of the animal manures and this value can produce electric energy of 280 GWh per year. It has been determined that a total of 128,609,656 TL (21,217,378 $) in electricity consumption can be achieved in the district by using animal manure in biogas production. It is also estimated that the biogas produced could meet the need for 1 year cooking energy for approximately 106,606 households. It has been determined that the utilization of animal manures will make an important contribution to Mersin in terms of socio-economic development.

Keywords: Animal manure, Biogas, Electricity, Livestock farming, Mersin

1. INTRODUCTION

Due to the limited availability of fossil fuel reserves, the importance of energy procurement in sustainable development is increasing steadily. On a global scale, it is predicted that energy consumption will increase by 28 percent until 2040 and a large part of this increase will be due to the developing countries. Green energy and new technologies are emerging as priority issues while energy politics is being dealt with nowadays. For this reason, renewable energy is expected to stand out as the world's fastest growing energy source [1].

In the search for all this energy source, biomass energy is the new alternative which has been prominent and demanded among the energy sources in recent years. Encouragement of biomass-related investments, which experts describe as an inexhaustible source of energy, is one of the priorities of the energy sector worldwide. In addition, the conversion of biomass resources to energy is very important because of its positive environmental impacts. When the optimum balance between raw materials and production technologies is established, biomass energy can be produced in an environmentally sensitive manner [2]. Biomass energy will be sustainable if the reduction in carbon emissions and increased economic efficiency are correctly assessed [3].

Nowadays, Turkey's waste biomass potential is about 8.6 million tons of oil equivalent (Mtoe) and the amount of biogas that can be produced is estimated to be 1.5-2 Mtoe by the end of 2017, 634.2 MW of installed power of 122 pieces “waste renewable energy plant” (biogas, biomass, waste heat and pyrolytic oil) is operated in Turkey. This corresponds to approximately 0.7% of Turkey's total installed power base. Biomass-derived electricity production was 1.610 GWh at the end of June, 2018 [4].

Biogas production processes are at the forefront of the most up-to-date technology in which biomass energy is actively produced. It is a flammable gas obtained as a result of the processing of biomass and is derived from organic raw materials, unlike other gases. In addition, energy plants such as corn, barley or sugar beet [5], municipal or industrial wastes [6], animal manure [7], timber wastes [8], forest [9] and agricultural residues [10] etc. can be used as raw material in biogas production. Biogas; to be stored as a flexible energy carrier, the availability of a wide variety of biological resources

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that can be used for production and the advantages of having a wide range of applications, it has an important position in heating, transportation and electricity generation etc. [6].

The use of animal and agricultural wastes, which play an important role in terms of raw material quality for alternative energy production, is gaining importance in terms of environmental and energy optimization within sustainable development models. In particular, animal solid wastes are regarded as the ideal source for the production of biogas (65% CH₄, 35% CO₂) after being subjected to biological treatment [11]. Some of the animal manures are used in agriculture as organic fertilizer, but these wastes, especially stored in open fields on the farms, cause mosquitoes and other pests to replicate. In this way, such nonpoint source (NPS) pollution is transported to other environments and creates non-hygienic conditions. In addition, the odor problem that emerges is an undeniable issue. Uncontrolled disposal and storage of such wastes also lead to contamination of groundwater and surface waters. The evaluation of these wastes is very important in terms of the country’s economy and environmental health. In particular, the use of animal manure for energy production presents significant opportunities in areas where intensive stockbreeding is being implemented [12].

In Turkey, as well as all over the world, animal products are the most important resource in society adequate and balanced nutrition. Animal husbandry is crucial not only in the provision of food but also in the protection of rural areas, the protection of biodiversity and the raising of living standards in rural areas.

Mersin province is located between 36-37° north latitude and 33-35° east longitude in southern of Turkey and located on the Mediterranean coast and called as “Pearl of the Mediterranean”. The total area of Mersin is 16,010 km², making it the 9th largest province in the country. In this study, firstly the production potential of livestock manure in Mersin province and districts has been defined. Then, depending on the data obtained, biogas production potential of livestock manure and equivalent quantities of other fuels of this potential are calculated in the province. In addition, bio-fertilizer potential which can be produced after biogas production is calculated.

2. MATERIAL AND METHODS

In this study, for the determination of the biomass potential of Mersin Province, waste manure amounts of bovine, ovine and poultry were evaluated. To obtain the necessary numerical values, Turkey Statistical Institute (TUIK) data of 2017 was used [13]. According to this data, the biogas quantities that can be obtained from accessible animal wastes and the conversion capacities of different types of effective fuels that can be obtained from 1 m³ biogas have been calculated. The assumptions that can be used in the calculation of the biogas potential that can be obtained from animal wastes and the biogas values that can be produced are given in Table 1 [14-16]. In addition, the effective heat of 1 m³ biogas and the equivalent of different fuel types are presented in Table 2 [17-20].

| Animal Species | Amount of manure produced per animal (ton/year wet manure) | The amount of biogas that can be obtained from one ton of manure (m³/year biogas) |
|----------------|----------------------------------------------------------|-------------------------------------------------------------------------------------|
| Bovine         | 3.6                                                      | 33                                                                                  |
| Ovine          | 0.7                                                      | 58                                                                                  |
| Poultry        | 0.022                                                   | 78                                                                                  |

Table 1. Theoretical manure and biogas amounts produced per year depending on animal class

| Energy Type   | Equivalent | Energy Type   | Equivalent |
|---------------|------------|---------------|------------|
| Electric      | 4.70 kWh   | Butane        | 0.43 kg    |
| Gas           | 0.62 L     | Propane       | 0.25 m³    |
| Diesel        | 0.66 L     | Coal          | 1.46 kg    |
| Gasoline      | 0.75 L     | Wood          | 3.47 kg    |

Table 2. Equivalent to different fuel types of effective heat of biogas (1 m³)

3. RESULTS AND DISCUSSION

3.1 Theoretical Animal Manure Potential of Mersin Province

There are 20,200,937 livestock including 115,120 bovine, 1,321,761 ovine, and 18,764,056 poultry in Mersin Province. Distribution of total livestock numbers in districts of Mersin Province is given in Figure 1 and initial data including the population of each animal species per districts are given in Table 3 and determined using TUIK data for the year 2017. Generally, potential values are taken into account when estimating animal manure generation data for different animal species, but in practice only a specific fraction of this manure can be collected. The amount of manure can be accessed according to the study conducted for the biogas potential in Turkey has been described as technical biogas potential. In this case, 50% of the current manure of bovine is considered collectible, while for poultry this value is chosen as 99%. In some studies, collectible bovine manure was accepted at 50% for western region while those at the east was accepted at 15%. In this study, acceptances for collectible manure rates were determined as 41% for bovine-ovine and 99% for poultry by taking an average of pasture (3 months) and other months (9 months) [21]. Estimation of the collectible manure amount per year was calculated by multiplying the amount of manure produced per animal species by the collectible manure rate after multiplying with the relevant animal population. Theoretical and collectible manure quantities that can be obtained annually by considering the population of each animal species in Mersin province are given in Table 4. Total theoretical and collectible livestock manure based on districts of Mersin are given in Figure 2.
Figure 1. Distribution of total livestock numbers in districts of Mersin Province

Table 3. Distribution of livestock numbers according to districts of Mersin

| Districts  | Bovine | Ovine | Poultry | Total |
|------------|--------|-------|---------|-------|
| Akdeniz    | 13,279 | 79,856| 1,671,400| 1,764,535 |
| Anamur     | 3032   | 39,086| 55,213 | 97,331 |
| Aydıncık   | 424    | 37,741| 3250   | 41,415 |
| Bozyazı    | 1133   | 31,369| 4905   | 37,407 |
| Çamlıyayla | 1631   | 43,564| 903,290| 948,485 |
| Erdemli    | 8550   | 218,768| 281,350| 508,668 |
| Gülner     | 6283   | 91,635| 51,925 | 149,843 |
| Mezitli    | 2167   | 36,097| 985,497| 1,023,701 |
| Mut        | 20,403 | 178,848| 172,792| 372,043 |
| Silifke    | 12,737 | 200,376| 187,910| 401,023 |
| Tarsus     | 37,956 | 275,710| 12,450,630| 13,052,296 |
| Toroslar   | 5849   | 60,701| 1,757,250| 1,823,800 |
| Yenişehir  | 1676   | 28,070| 238,644| 268,390 |
| **Total**  | **115,120** | **1,321,761** | **18,764,056** | **20,200,937** |

Table 4. Theoretical and collectible manure quantities that can be produced per year in Mersin

| Districts | Theoretical manure (ton/year) | Collectible manure (ton/year) |
|-----------|-------------------------------|-------------------------------|
|           | Bovine | Ovine | Poultry | Total | Bovine | Ovine | Poultry | Total |
| Akdeniz   | 47,804 | 55,899| 36,771 | 140,474| 19,600 | 22,919| 36,403 | 78,922 |
| Anamur    | 10,915 | 27,360| 1215   | 39,490| 4475   | 11,218| 1203   | 16,895 |
3.2 Theoretical Biogas Production Potential from Animal Manure in Mersin Province

When biogas potential that can be obtained according to animal species is examined, it is estimated that more biogas can be produced from poultry in proportion to the amount of animal fertilizer that can be collected in Mersin Province. Due to the fact that the bovine and ovine livestock are carried out in the grassland and the control of waste manure in the pasture areas cannot be provided, the biogas production potential from the livestock activity is technically low despite the fact that it is high in theory. Theoretical biogas production potential calculated by taking into consideration collectible animal manure in Mersin province is given in Table 5. In accordance with the calculations performed, the biogas potential from animal manure across Mersin has been
determined as 59,486,428 m$^3$/year. Theoretical biogas production potential according to manure type in Mersin province is given in Figure 3.

When the seasonal effect is considered, the amount of collectible manure is increased by making livestock in enclosed areas in winter months. This is an indication that biogas production potential may change depending on the waste variability that can be achieved during summer and winter months.

![Figure 3. Theoretical biogas production potential according to manure type in Mersin province](image)

### 3.3 Conversion of Biogas Heat Power to Other Fuels in Mersin

The equivalent heat power of the producible biogas in Mersin Province to other fuels is given in Table 6. It has been determined that the thermal energy corresponding to the theoretical amount of biogas that can be produced annually in Mersin in the direction of the calculations made can be provided with 279,586,210 kWh electrical, 206,417,900 kg wood, 44,614,820 L gasoline or 39,261,041 L diesel fuel. Consumption of 1 kWh of electricity [22], 1 kg wood [23], 1 L gasoline and 1 L diesel [24] are billed as 0.46 TL, 0.5 TL, 6.95 TL and 6.35 TL, respectively for the year 2018 in Turkey.

Consumption of 1 L of other fuels that are equal to producible biogas potential from animal manure annually in Mersin, it is estimated that a profit of 128,609,656 TL; 103,208,950 TL; 310,072,999 TL and 249,307,610 TL could be achieved from electric energy, wood, gasoline and diesel, respectively. The value of the financial savings that can be obtained from the use of other fuels through the production of biogas in Mersin is given in Table 7.

When the table is examined, it is seen that the province-wide income that can be obtained from electricity is 20,689,380 $, 16,513,432 $ from wood, 49,611,680 $ from gasoline and 39,889,218 $ from diesel oil. The amount of income that can be obtained based on districts of Mersin Province is given in Figure 4.

![Figure 4. The amount of income that can be obtained based on districts of Mersin Province](image)

### 3.4. Biogas for Cooking in Mersin Province

Biogas is a type of alternative energy that can be used for cooking and heating needs in areas such as homes and offices. A family of five or six people needs an average of 1 m$^3$ of methane (CH$_4$) per day to cook three meals [25]. According to this information, if 1 m$^3$ of biogas contains about 65% methane on average, it is possible that one family can provide daily cooking needs with 1.53 m$^3$ biogas. The annual theoretical biogas potential of Mersin Province is 59,486,428.5 m$^3$ as shown in Table 5. When this value is divided by the biogas value (558 m$^3$), which is the annual cooking requirement of a family, it is predicted that the cooking needs of 106,606 families living in Mersin province can be met. Thanks to the biogas energy, it is also possible to meet the heating or electricity needs of the residents in the region.
Table 5. Theoretical biogas production potential from animal manure in Mersin province

| Districts      | Bovine       | Ovine        | Poultry      | Total        |
|---------------|--------------|--------------|--------------|--------------|
| Akdeniz       | 646,793.5    | 1,329,283    | 2,839,441.2  | 4,815,518    |
| Anamur        | 147,682.7    | 650,625.6    | 93,798.053   | 892,106.3    |
| Aydincik      | 20,652.19    | 628,236.7    | 5521.23      | 654,410.1    |
| Bozyaza        | 55,186.16    | 522,168.4    | 8332.8102    | 585,687.3    |
| Camhiyayla    | 79,442.75    | 725,166.3    | 1,534,545.2  | 2,339,154    |
| Erdemli       | 416,453.4    | 3,641,612    | 477,968.63   | 4,536,034    |
| Gultan        | 306,032.4    | 1,525,356    | 88,212.267   | 1,919,601    |
| Mezitli       | 105,550.2    | 599,871.9    | 1,674,201.7  | 2,379,624    |
| Mut           | 993,789.3    | 2,977,104    | 293,545.96   | 4,264,439    |
| Silifke       | 620,393.8    | 3,335,459    | 319,229.02   | 4,275,082    |
| Tarsus        | 1,848,761    | 4,589,469    | 21,151,628   | 27,589,858   |
| Toroslar      | 284,893.1    | 1,010,429    | 2,985,286.6  | 4,280,609    |
| Yenishehir    | 81,634.61    | 467,253.2    | 405,417.97   | 954,305.8    |
| **Total**     | **5,607,265.1** | **22,002,034.1** | **31,877,128.6** | **59,486,428.5** |

3.5. Bio-fertilizer Production and Sales in Mersin Province

The proportion of dry matter content contained in animal wastes is important in the production of bio-fertilizer. The dry matter ratios vary according to the animal species. It is stated that the dry matter ratios are 15-20% in bovine manure, 40% in ovine manure and 30% in poultry manure [14,26].

In calculations for bio-fertilizer production after producing biogas; the dry matter content of bovine manure, ovine manure and poultry manure were accepted as 20%, 40% and 30%, respectively. In Mersin province, annual collectible bovine, ovine and poultry manure were given as 169,917 ton/year; 379,346 ton/year and 408,683 ton/year, respectively in Table 4. If the dry matter content of the manures attached to animal species in Mersin Province according to Eq (1);

$$CDM = M \times \%DM$$

CDM: Dry matter content of manure (tonDM/year),
M: Amount of annual manure (ton/year),
\%DM: Dry matter content

Bovine manure: 169,917 x 0.20 = 33,983 tonDM/year
Ovine manure: 379,346 x 0.40 = 151,738 tonDM/year
Poultry manure: 408,683 x 0.30 = 122,604 tonDM/year

It is stated that packable-pelleted bio-fertilizer should contain an average of 12% moisture [27]. The annual amount of bio-fertilizer that can be obtained after achieving this moisture content in manures was calculated according to Eq (2);

$$BF = CDM + (CDM \times 0.12)$$

BF: Amount of bio-fertilizer (ton BF/year),
CDM: Dry matter content of manure (tonDM/year)

Bovine bio-fertilizer: 33,983+ (33,983 x 0.12) = 38,060 ton BF/year or 3172 tonBF/month

Ovine bio-fertilizer: 151,738 + (151,738 x 0.12) = 169,946 ton BF/year or 14,162 tonBF/month

Poultry bio-fertilizer: 122,604+ (122,604 x 0.12) = 137,317 ton BF/year or 11,443 tonBF/month

In calculations for the income from the sale of bio-fertilizer; the price of 1 kg bovine, ovine and poultry bio-fertilizer were accepted as 1.57 TL, 1.49 TL and 1.80 TL, respectively. In this case, with the sale of bio-fertilizer that are formed after biogas production in Mersin province 59,754,200 TL; 253,219,540 TL and 247,170,600 TL can be earned by bovine, ovine and poultry bio-fertilizers, respectively.
Table 6. The equivalent heat power of the producible biogas in Mersin to other fuels

| Districts  | Animal Species | Biogas production (m³/year) | Electricity (kWh/year) | Wood (kg/year) | Gasoline (L/year) | Diesel (L/year) |
|------------|----------------|-----------------------------|------------------------|----------------|------------------|-----------------|
| Akdeniz    | Bovine         | 646,794                     | 3,039,930              | 2,244,374      | 485,095          | 426,884         |
|            | Ovine          | 1,329,283                   | 6,247,630              | 4,612,612      | 996,962          | 877,327         |
|            | Poultry        | 2,839,441                   | 13,345,374             | 9,852,861      | 2,129,581        | 1,874,031       |
| Anamur     | Bovine         | 147,683                     | 694,108                | 512,459        | 110,762          | 97,471          |
|            | Ovine          | 650,626                     | 3,057,940              | 2,257,671      | 487,969          | 429,413         |
|            | Poultry        | 93,798                      | 440,851                | 325,479        | 70,349           | 61,907          |
| Aydınce    | Bovine         | 20,652                      | 97,065                 | 71,663         | 15,489           | 13,630          |
|            | Ovine          | 628,237                     | 2,952,712              | 2,179,981      | 471,178          | 414,636         |
|            | Poultry        | 5521                        | 25,950                 | 19,159         | 414              | 3644            |
| Bozyazı    | Bovine         | 55,186                      | 259,375                | 191,496        | 41,390           | 36,423          |
|            | Ovine          | 522,168                     | 2,454,191              | 1,811,924      | 391,626          | 344,631         |
|            | Poultry        | 8333                        | 39,164                 | 28,915         | 625              | 5500            |
| Çamlıyayla | Bovine         | 79,443                      | 373,381                | 275,666        | 59,582           | 52,432          |
|            | Ovine          | 725,166                     | 3,408,282              | 2,516,327      | 543,875          | 478,610         |
|            | Poultry        | 1,534,545                   | 7,212,362              | 5,324,872      | 1,150,909        | 1,012,800       |
| Erdemli    | Bovine         | 416,453                     | 1,957,331              | 1,445,093      | 312,340          | 274,859         |
|            | Ovine          | 3,641,612                   | 17,115,577             | 12,636,394     | 2,731,209        | 2,403,464       |
|            | Poultry        | 477,969                     | 2,246,453              | 1,658,551      | 358,476          | 315,459         |
| Gülner      | Bovine         | 306,032                     | 1,438,352              | 1,061,932      | 229,524          | 201,981         |
|            | Ovine          | 1,525,356                   | 7,169,174              | 5,292,986      | 1,144,017        | 1,006,735       |
|            | Poultry        | 88,212                      | 414,598                | 306,097        | 66,159           | 58,220          |
| Mezitli    | Bovine         | 105,550                     | 496,086                | 366,259        | 79,163           | 69,663          |
|            | Ovine          | 599,872                     | 2,819,398              | 2,081,555      | 449,904          | 395,915         |
|            | Poultry        | 1,674,202                   | 7,868,748              | 5,809,480      | 1,255,651        | 1,104,973       |
| Mut        | Bovine         | 993,789                     | 467,081                | 3,448,449      | 745,342          | 655,901         |
|            | Ovine          | 2,977,104                   | 13,992,388             | 10,330,550     | 2,232,828        | 1,964,889       |
|            | Poultry        | 293,546                     | 1,379,666              | 1,018,604      | 220,159          | 193,740         |
| Silifke    | Bovine         | 620,394                     | 2,915,851              | 2,152,766      | 465,295          | 409,460         |
|            | Ovine          | 3,335,459                   | 15,676,657             | 11,574,042     | 2,501,594        | 2,201,403       |
|            | Poultry        | 319,229                     | 1,500,376              | 1,107,725      | 239,422          | 210,691         |
| Tarsus     | Bovine         | 1,848,761                   | 8,689,176              | 6,415,200      | 1,386,571        | 1,220,182       |
|            | Ovine          | 4,589,469                   | 21,570,503             | 15,925,456     | 3,442,101        | 3,029,049       |
|            | Poultry        | 21,151,628                  | 99,412,653             | 73,396,150     | 15,863,721       | 13,960,075      |
| Toroslar   | Bovine         | 284,893                     | 1,338,998              | 988,579        | 213,670          | 188,029         |
|            | Ovine          | 1,010,429                   | 4,749,016              | 3,506,188      | 757,822          | 666,883         |
|            | Poultry        | 2,985,287                   | 14,030,847             | 10,358,944     | 2,238,965        | 1,970,289       |
| Yenişehir  | Bovine         | 81,635                      | 383,683                | 283,272        | 61,226           | 53,879          |
|            | Ovine          | 467,253                     | 2,196,090              | 1,621,369      | 350,440          | 308,387         |
|            | Poultry        | 405,418                     | 1,905,464              | 1,406,800      | 304,063          | 267,576         |
| **Total**  |                | **59,486,428**              | **279,586,210**        | **206,417,900**| **44,614,820**   | **39,261,041**  |
Table 7. The value of the financial savings in US dollars (May 2019) that can be obtained from the use of other fuels through the production of biogas in Mersin (1 TL=0.168)

| Districts | Animal Species | Electricity ($/year) | Wood ($/year) | Gasoline ($/year) | Diesel ($/year) |
|-----------|----------------|----------------------|---------------|------------------|----------------|
| Akdeniz   | Bovine         | 224,955              | 179,550       | 539,426          | 433,714        |
|           | Ovine          | 462,325              | 369,009       | 1,108,622        | 891,364        |
|           | Poultry        | 987,558              | 788,229       | 2,368,094        | 1,904,015      |
| Anamur    | Bovine         | 51,364               | 40,997        | 123,167          | 99,031         |
|           | Ovine          | 226,288              | 180,614       | 542,622          | 436,284        |
|           | Poultry        | 32,623               | 26,038        | 78,228           | 62,898         |
| Aydınçık  | Bovine         | 7183                 | 5733          | 17,224           | 13,848         |
|           | Ovine          | 218,501              | 174,398       | 523,950          | 421,270        |
|           | Poultry        | 1920                 | 1533          | 4605             | 3702           |
| Bozyazı   | Bovine         | 19,194               | 15,320        | 46,026           | 37,006         |
|           | Ovine          | 181,610              | 144,954       | 435,488          | 350,145        |
|           | Poultry        | 2898                 | 2313          | 6950             | 5588           |
| Çamlıyayla| Bovine         | 27,630               | 22,053        | 66,255           | 53,271         |
|           | Ovine          | 533,715              | 425,990       | 1,279,811        | 1,029,005      |
|           | Poultry        | 133                 | 1533          | 4605             | 3702           |
| Erdemli   | Bovine         | 144,842              | 115,607       | 347,322          | 279,257        |
|           | Ovine          | 1,266,553            | 1,010,912     | 3,037,104        | 2,441,919      |
|           | Poultry        | 166,238              | 132,684       | 398,625          | 320,506        |
| Gülnar    | Bovine         | 106,438              | 84,955        | 255,231          | 205,213        |
|           | Ovine          | 530,519              | 423,439       | 1,272,147        | 1,022,843      |
|           | Poultry        | 30,680               | 24,488        | 73,569           | 59,152         |
| Mezitli   | Bovine         | 36,710               | 29,301        | 88,029           | 70,778         |
|           | Ovine          | 208,635              | 166,524       | 500,293          | 402,250        |
|           | Poultry        | 582,287              | 464,758       | 1,396,284        | 1,122,653      |
| Mut       | Bovine         | 345,640              | 275,876       | 828,820          | 666,395        |
|           | Ovine          | 1,035,437            | 826,444       | 2,482,905        | 1,996,327      |
|           | Poultry        | 102,095              | 81,488        | 244,817          | 196,840        |
| Silifke   | Bovine         | 215,773              | 172,221       | 517,408          | 416,011        |
|           | Ovine          | 1,160,073            | 925,923       | 2,781,773        | 2,236,625      |
|           | Poultry        | 111,028              | 88,618        | 266,237          | 214,062        |
| Tarsus    | Bovine         | 642,999              | 513,216       | 1,541,867        | 1,239,705      |
|           | Ovine          | 1,596,217            | 1,274,036     | 3,827,616        | 3,077,514      |
|           | Poultry        | 7,356,536            | 5,871,692     | 17,640,458       | 14,183,436     |
| Toroslar  | Bovine         | 99,086               | 79,086        | 237,601          | 191,037        |
|           | Ovine          | 351,427              | 280,495       | 842,698          | 677,553        |
|           | Poultry        | 1,038,283            | 828,716       | 2,489,729        | 2,001,814      |
| Yenişehir | Bovine         | 28,393               | 22,662        | 68,083           | 54,741         |
|           | Ovine          | 162,511              | 129,710       | 389,689          | 313,321        |
|           | Poultry        | 141,004              | 112,544       | 338,118          | 271,857        |
| Total     |                | 20,689,380           | 16,513,432    | 49,611,680       | 39,889,218     |

4. CONCLUSIONS

In this study, considering the number of registered bovine, ovine and poultry in the districts of Mersin Province; the amounts of animal manure that can be collected, the related theoretical biogas production values and the energy data obtained from equivalent fuels, the financial gain values, the amount of bio-fertilizer production was calculated. According to the calculations, it was determined that biogas could be produced over 59 million m³ per year from the total of animal fertilizers produced in a year. Approximately 280 million kWh of electricity will be generated from this biogas annually. With this value, it is calculated that a profit of 128,609,656 TL ($20,495,234) can be achieved in electricity consumption in the province. Also, it is predicted that the cooking needs of 106,606 families living in Mersin province can be met by biogas production. Bio-fertilizer production after producing biogas is an important advantage. In this
case, with the sale of bio-fertilizer that are formed after biogas production in Mersin province 59,754,200 TL; 253,219,540 TL and 247,170,600 TL can be earned selling of bovine, ovine and poultry bio-fertilizers, respectively.

As a result, considering the livestock potential of Mersin Province, if animal waste is evaluated in biogas and then in bio-fertilizer production, it will reveal many social, economic and environmental positive effects on provincial basis. For this purpose, biogas production should be encouraged and supported by feasibility studies by taking into consideration the animal numbers and operating conditions in the province.

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