J. BIOL. ENVIRON. SCI.,
2016, 10(29), 79-88

Original Research Article

Biogas Potential in Görükle Campus of Uludağ University

İlknur Alibaş[1*], Hilal Erdoğan[1], Aslıhan Yılmaz[2] and Kamil Alibaş[1]
[1] Uludağ University, Faculty of Agriculture, Department of Biosystems Engineering, Bursa, TURKEY
[2] Uludağ University, Graduate School of Natural and Applied Sciences, Bursa, TURKEY

Received: 03.09.2016; Accepted: 08.10.2016; Published Online: 16.10.2016

ABSTRACT

In this study, the potential of animal manure of the Application Research Centres of the Faculty of Agriculture and the Ranch of Veterinary Medicine and located within the boundaries of Görükle Campus at Uludağ University, the waste of rapeseed, sunflower, and wheat production of the Agricultural Research and Application Centre at the Agricultural Faculty and food waste of all dining halls, restaurants and cafeterias, particularly the Central Dining Hall, situated on the campus was determined in order to determine the biogas potential of the campus. As the dry matter, based on the organic waste potential, the biogas potential relating of the campus was calculated to be 499962.91 m^3. It was determined that 17.95% of this potential consisted of animal manure, 46.15% of it consisted of agricultural production waste and 35.90% of it consisted of food waste. It was calculated that the electric energy potential obtained by transforming the biogas potential into electric energy by means of a generator was 980.22 MWh.

Keywords: Animal manure, Biogas, Agricultural wastes, Electricity, Food wastes

INTRODUCTION

As world population continues to grow, energy requirements increase, fossil fuels begin to diminish and industrialization increases day by day, it may not be possible to provide the amount of energy demanded by the world (Kabir *et al.* 2013, Karray *et al.* 2016, Zhu and Hiltunen 2015). These problems have become much more important the use of renewable energy sources (Maghanaki *et al.* 2013). Biomass from agriculture wastes is used as a renewable energy source for bio fuels and biogas (Isoda *et al.* 2014). Agricultural wastes have a great value in terms of economic and ecological. Moreover, the use of these wastes reduces the pollution (He *et al.* 2016, Briassoulis *et al.* 2012).

In the last decade, biogas production has experienced a great development in the Europe. Today, 4% of used energy in the European is derived from biomass. The European Union aims to obtain 20% of the total energy consumption and 10% of the fuel used in transportation from renewable sources by 2020 (Havukainen *et al.* 2014). Besides, by 2020, the European countries should increase the use of biogas to 8% (Thöle *et al.* 2016, Lübbers *et al.* 2016). Even if the European countries is the most important producer of biogas, it has also a great interest in the biogas sector in the US, Latin America, Asia and Africa. Besides, the biogas sector is quickly emerging in India and China (Moreno *et al.* 2015).

Growth figures in Turkey's energy sector are quite high compared to developed countries. Turkey ranks first in Europe with regard to demand of natural gas and electricity for the last 10 years (Alibaş *et al.* 2015, Ozsoy and Alibaş 2015). Turkey's primary energy supply is composed of natural gas, coal, hydraulic, coal, liquid fuels and renewable sources with the rates of 47.9%, 30.2%, 16.1%, 0.9% and 4.9%, respectively. To reduce of dependence on foreign countries in energy, the share of renewable energy sources has been increasing in Turkey. The share of renewable energy production in Turkey was 0.3% in 2000 while this share increased to 4.9% in 2014 (TUIK 2016). In this regards, biogas within all renewable energy resources has also become a popular energy source in Turkey, nowadays. Seventy-two biogas plants have been established in Turkey. The installed power capacity and the annual energy production of these plants are 383 MW and 1858 GWh, respectively (Anonymous 2016).

Biogas, which is produced from renewable raw materials, is a feasible and easily storable energy source. Microbiological processes become active during the production of biogas resulting from anaerobic fermentation of waste organic substances (Agulier-Virgen *et al.* 2014, Koening and Dehn 2016, Pizzuti *et al.* 2016). Being composed of methane (50%-60%), carbon dioxide (40%-50%), nitrogen (N_2; 5%), hydrogen

[*] Corresponding author: ialibas@uludag.edu.tr

sulphide (N_2, <1%) non-methane organic components (NMOC; 2700 ppmv), biogas is colourless, odourless gas and lighter than air (Aguilar-Virgen *et al.* 2014, Barros *et al.* 2014, Amini *et al.* 2012, Schneider *et al.* 2012). Biogas, with a density of 0.83 and an octane number of 110, is also a gas burning through bright blue flame (Alibaş 1996). The heating value of natural gas and methane is 37.3 $Mj.m^{-3}$ whereas the heating value of biogas ranges between 26.7 – 29.8 $Mj.m^{-3}$ depending on content of methane (Ozsoy and Alibaş 2015, Alibaş *et al.* 2015).

Organic wastes are generally composed of animal manure, agricultural wastes, food wastes, human feces and household wastes. However, cattle manure contains methane bacteria that provide anaerobic fermentation, this manure has a great importance (Ozsoy and Alibaş 2015, Alibaş *et al.* 2015).

The aims of this study were to i) fix the annual waste potential as a solid matter from agricultural wastes, animal manure and food wastes ii) determine the annual biogas potential from waste potential as a solid matter and iii) identify the annual electricity from biogas potential in Görükle Campus of Uludağ University.

MATERIALS AND METHODS

Material

In the present study, animal populations, the amount of agricultural product and food wastes in all dining hall, cafeterias and restaurants in rural areas of Görükle Campus of Uludağ University. Data regarding to food wastes from all dining hall, cafeterias and restaurants in campus were regularly measured with electronic balance after dinner throughout two months. Animal populations and plant production's data were taken from declarations concerned contacts in Faculty of Agriculture and Veterinary Medicine.

Organic Animal Manure Calculation Methods

All calculations related to organic animal manure were taken from various researches in literature (Alibaş 1996, Alibaş *et al.* 2015). Daily manure production as a solid matter was calculated using the following equation Eq. (1):

$$\boldsymbol{DMP_{(SM)} = SM \times FM} \qquad \text{Eq. (1)}$$

where $DMP_{(SM)}$ is daily manure production as a solid matter ($kg_{(SM)}$ day^{-1} AU^{-1}), *SM* is solid matter content (%) and *FM* is fresh manure production (kg day^{-1} AU^{-1}).

In this study, the amount of total obtainable solid matter was calculated by the following equation Eq. (2):

$$\boldsymbol{TOSM = \gamma \times DMP_{(SM)}} \qquad \text{Eq. (2)}$$

where *TOSM* is the amount of total obtainable solid matter ($kg_{(SM)}$ day^{-1} AU^{-1}) and γ is staying time in the barn (%). Animal unit was determined using the following equation Eq. (3):

$$\boldsymbol{AU = (AP \times AAW)/LR_{AW}} \qquad \text{Eq. (3)}$$

where *AU* is animal unit (kg), *AP* is average animal population, *AAW* is average animal weight (kg) and LR_{AW} is the average weight of large ruminants (454 kg). Annual animal manure potential as a solid matter as $t_{(SM)}$ y^{-1} was calculated by the following equation Eq. (4):

$$\boldsymbol{AAWP_{(SM)} = ((AU \times TOSM)/1000) \times 365} \qquad \text{Eq. (4)}$$

where $AAWP_{(SM)}$ is annual animal manure potential as a solid matter ($t_{(SM)}$ y^{-1}). The annual amount of biogas from animal manure as m^3 y^{-1} was determined by the following equation Eq. (5):

$$\boldsymbol{ABA_{animal} = AAWP_{(SM)} \times BA_{a-sm}} \qquad \text{Eq. (5)}$$

where ABA_{animal} is the annual amount of biogas from animal manure (m^3 y^{-1}) and BA_{a-sm} is the amount of availability of biogas (m^3 t^{-1}). Annual theoretical electricity amount from animal manure was calculated by the following equation Eq. (6):

$$\boldsymbol{E_{t-animal} = (ABA_{animal} \times I)/3.6} \qquad \text{Eq. (6)}$$

where $E_{t\text{-}animal}$ is annual theoretical electricity amount from animal manure (kWh y^{-1}) and I is the heating value (Mj m^{-3}). The amount of annual effective electricity from animal manure as kWh y^{-1} was determined using the following equation Eq. (7):

$$\boldsymbol{E_{animal} = E_{t-animal} \times \eta} \qquad \text{Eq. (7)}$$

where E_{animal} is the amount of annual effective electricity from animal manure (kWh y^{-1}) and η is the average yield of electrical engines (25%).

2.3. Organic Agricultural Waste Calculation Methods

All calculations related to organic agricultural wastes were taken from various studies in literature (Alibaş 1996, Alibaş *et al.* 2015). The amount of moist agricultural waste as t y^{-1} was calculated using the following equation Eq. (8):

$$\boldsymbol{MVWA = OWC \times PA} \qquad \text{Eq. (8)}$$

where $MVWA$ is the amount of moist agricultural waste (t y^{-1}), OWC is the coefficient of organic waste and PA is the amount of average agricultural production. The annual agricultural waste potential as a solid matter was calculated by the following equation (Eq9):

$$\boldsymbol{AVWP_{(SM)} = [(100 - M_R)/100] \times MVWA} \qquad \text{Eq. (9)}$$

where $AVWP_{(SM)}$ is the annual agricultural waste potential as a solid matter ($t_{(SM)}$ y^{-1}) and M_R is the moisture ratio (%). The annual amount of biogas from agricultural wastes as m^3 y^{-1} was determined using the following equation Eq. (10):

$$\boldsymbol{ABA_{agriculture} = AVWP_{(SM)} \times BA_{v-sm}} \qquad \text{Eq. (10)}$$

where $ABA_{agriculture}$ is the annual amount of biogas from agricultural wastes (m^3 y^{-1}) and $BA_{v\text{-}sm}$ is the amount of available of biogas from agricultural wastes (m^3 $t_{(SM)}^{-1}$). The annual theoretical electricity amount from agricultural wastes was calculated by the following equation Eq. (11):

$$\boldsymbol{E_{t-agriculture} = (ABA_{agriculture} \times I)/3.6} \qquad \text{Eq. (11)}$$

where $E_{t\text{-}agriculture}$ is the annual theoretical electricity amount from agricultural wastes (kWh y^{-1}) and I is the heating value (Mj m^{-3}). The annual effective electricity amount from agricultural wastes was determined using the following equation Eq. (12):

$$\boldsymbol{E_{agriculture} = E_{t-agriculture} \times \eta} \qquad \text{Eq. (12)}$$

where $E_{agriculture}$ is the annual effective electricity amount from agricultural wastes (kWh y^{-1}) and η is the average yield of electrical engines (25%).

2.4. Food Wastes Calculation Methods

The daily humid food wastes from facilities in campus were regularly measured with electronic balance after dinner throughout two months. Moisture content of food wastes was to be 82.61% in this study (Ulusoy *et al.* 2016). Food wastes from all facilities in active and passive season were taken in Table 1. According to Table 1, active season was defined to be continued education and this season was considered to be 200 days. Passive season was consisted of semester and weekend holidays and this term was taken as 165 days in this study. Food wastes potential as a solid matter was calculated using the following equation Eq. (13):

$$\boldsymbol{AFWP_{(SM)} = [(100 - M_R)/100] \times MFWA} \qquad \text{Eq. (13)}$$

where $AFWP_{SM}$ is the annual food wastes potential as a solid matter ($t_{(SM)}$ y^{-1}), M_R is moisture content (%), $MFWA$ is the annual food wastes potential as a humid matter The annual amount of biogas from food wastes was determined by the following equation Eq. (14):

$$\boldsymbol{ABA_{food-wastes} = AFWP_{(SM)} \times BA_{f-sm}} \qquad \text{Eq. (14)}$$

where $ABA_{food\text{-}wastes}$ is the annual amount of biogas from food wastes (m^3 y^{-1}) and $BA_{f\text{-}sm}$ is the amount of availability of biogas (m^3 t^{-1}). Annual theoretical electricity amount from food wastes was calculated by the following equation Eq. (15):

$$E_{t-foodwastes} = (ABA_{food-wastes} \times I)/3.6$$ Eq. (15)

where $E_{t-foodwastes}$ is the annual theoretical electricity amount from food wastes (kWh y^{-1}) and I is the heating value (Mj m^{-3}). The annual effective electricity amount from food wastes was determined using the following equation Eq. (16):

$$E_{food-wastes} = E_{t-foodwastes} \times \eta$$ Eq. (16)

where $E_{food-wastes}$ is the annual effective electricity amount from food wastes (kWh y^{-1}) and η is the average yield of electrical engines (25%).
The annual theoretical electricity amount and the annual theoretical electricity amount from all organic wastes were calculated using the following equations Eq. (17) and Eq. (18):

$$E_t = E_{t-animal} + E_{t-agriculture} + E_{t-foodwastes}$$ Eq. (17)

$$E = E_{animal} + E_{agriculture} + E_{food-wastes}$$ Eq. (18)

where E_t is the annual theoretical electricity amount from all organic wastes (kWh y^{-1}) and E is the annual effective electricity amount from all organic wastes (kWh y^{-1}).

Table 1. Daily humid food wastes from all dining halls, cafeterias and restaurants in the Uludağ University Campus.

Facilities	**Daily Humid Food Wastes in Active season, kg**	**Daily Humid Food Wastes in Passive season, kg**
Central Dining Hall	4000	3000
Credit & Dormitories Intuition Dining Hall	750	5
Aytu Cafeteria & Restaurant	15	4
Unpa Cafeteria & Restaurant	30	15
Ilkim Cafeteria & Restaurant	10	5
Han Cafeteria	0.5	0.1
Kampus Cafeteria	0.5	0.1
Yagmur Cafeteria	0.5	0.1
ZiyadeInn Cafeteria & Restaurant	2	2
Agaoglu-1 Cafeteria & Restaurant	20	0.1
Agaoglu-2 Cafeteria & Restaurant	5	0
Ekim Cafeteria	0.5	0.1
Yildiz Cafeteria	1	0.25
Mimoza Cafeteria & Restaurant	7.5	2
Sinem Patisserie	2	1
Holiday Inn Hotel – Cafeteria & Restaurant	10	10
Besaş A.Ş. Factory & Cafeteria	3	3
Total	4857.5	3047.75

RESULTS AND DISCUSSION

The annual amount of organic wastes from animal manure as the dry matter obtained from the Ranch of the Faculty of Veterinary Medicine located on Görükle Campus of Uludağ University is given in Table 2, and the annual amount of biogas and the amount of electric energy obtained from this waste are given in Table 3. Accordingly, 54.90% of the biogas obtained from the Ranch of the Faculty of Veterinary Medicine can be obtained from poultry, 42.36% of it can be obtained from bovine animals and 2,17% of it can be obtained from sheep and goats. The biogas potential that can be obtained from the Ranch of the Faculty of Veterinary Medicine can cover approximately 1.67% of the natural gas spent for heating and electricity on the campus in 2015.

Table 2. Organic waste potential from animal manure as a dry matter in farm of Veterinary Medicine.

Animals	Fresh manure production (kg/dayAU)	Solid matter content (%)	Daily manure production as a solid matter (kg/dayAU)	Staying in the barn (%)	Total Solid Matter (kg/dayAU)	Animal Population (Unit)	Average Animal Weight (kg)	Animal Unit	Annual animal manure potential as a solid matter (ton/year)
Cattle	33.331	12.7	4.23	65	2.75	179	454	179	179.77
Chicken	25.292	25	6.32	99	6.26	15450	2	68.061	155.51
Goats	16.440	31.7	5.21	13	0.68	185	50	20.37	5.04
Pig	35.424	9.2	3.26	80	2.61	13	60	1.72	1.63
Quail	26.616	59.7	15.89	99	15.73	800	0.135	0.24	1.37
Sheep	16.440	25	4.11	13	0.53	93	50	10.24	2.00
Total						16720			345.31

Table 3. Annual biogas potential and electricity from animal manure in farm of Veterinary Medicine.

Animals	Annual animal manure potential as a solid matter (ton/year)	Amount of Availability of biogas (m3/ton)	Biogas Amount (m3/year)	Heating Value (Mj/m3)	Annual theoretical electricity from animal manure (MWh/year)	Annual electricity from animal manure (MWh/year)
Cattle	179.77	202	36313.05	27.0	272.35	68.09
Chicken	155.51	300	46652.52	28.9	374.52	93.63
Goats	5.04	270	1360.34	28.0	10.58	2.65
Pig	1.63	300	490.49	28.9	3.94	0.99
Quail	1.37	300	409.76	28.9	3.29	0.82
Sheep	2.00	251	501.36	28.0	3.90	0.98
Total	345.32		85727.52		668.58	167.16

Table 4. Organic waste potential from animal manure as a dry matter in the ranch of Faculty of Agriculture.

Animals	Fresh manure production (kg/dayAU)	Solid matter content (%)	Daily manure production as a solid matter (kg/dayAU)	Staying in the barn (%)	Total Solid Matter (kg/dayAU)	Animal Population (Unit)	Average Animal Weight (kg)	Animal Unit	Annual animal manure potential as a solid matter (ton/year)
Cattle	33.331	12.7	4.23	65	2.75	7	454	179	7.03
Goat	16.440	31.7	5.21	13	0.68	76	50	20.37	2.07
Quail	26.616	59.7	15.89	99	15.73	500	0.135	0.24	0.85
Sheep	16.440	25	4.11	13	0.53	238	50	10.24	5.11
Ostrich	26.616	25	6.65	25	1.66	13	100	2.86	1.74
Total						834			16.80

The annual amount of animal manure of the Ranch at the Faculty of Agriculture as the dry matter is given in Table 4, and the annual amount of biogas obtained from this amount of waste is given in Table 5. According to this, 45.60% of the annual biogas potential of the Ranch of the Faculty of Agriculture, which is 4039.63 m^3, is obtained from sheep and goats, 35.15% of it is obtained from bovine animals and 19.25% of it is obtained from poultry. The biogas potential that the Ranch at the Faculty of Agriculture can obtain from the animal manure can supply approximately 0.08% of the annual biogas consumption of our University. The annual biogas potential from the animal manure, which the ranches of both the Faculty of Veterinary Medicine and Agriculture will provide, corresponds to 1.75% of the total natural gas consumption spent for the total heating and electricity of the campus.

The organic waste potential of the Agricultural Application and Research Centre (TUAM) derived from the annual agricultural production as the dry matter is given in Table 6, and the annual potentials for biogas and electric energy which can be obtained from the plant waste are given in Table 7. Accordingly, 82.53% of the biogas potential, which can be obtained from the agricultural production, can be derived from wheat, 13.77% of it can be derived from canola and 3.70% of it can be derived from sunflower production wastes. The organic waste potential, which our university can provide from the agricultural production waste, has the potential to supply approximately 4.50% of the amount of natural gas consumed on the campus in 2015. The biogas potential, which the Faculty of Agriculture can derive from both the animal and agricultural production waste, has the value of 230759.27 m^3. This value can cover the energy of the Faculty of Agriculture. Also, this value constitutes approximately 4.60% of the total natural gas consumption of the university. Ozsoy and Alibaş (2015) determined the biogas potential, which can be derived from the wastes from animal manure in Nilüfer district of Bursa province, where the campus of Uludağ University is located, to be 5443164.57 m^3. According to the results of this study previously carried out, it can be said that the biogas potential which can be obtained from the organic waste of Agricultural Research and Application Centre of Faculty (TUAM) of Agricultural Faculty equals to approximately 4.24% of the agricultural biogas potential of Nilüfer district.

Table 5. Annual biogas potential and electricity from animal manure in the ranch of Faculty of Agriculture.

Animals	**Annual animal manure potential as a solid matter (ton/year)**	**Amount of Availability of biogas (m3/ton)**	**Biogas Amount (m3/year)**	**Heating Value (Mj/m3)**	**Annual theoretical electricity from animal manure (MWh/year)**	**Annual electricity from animal manure (MWh/year)**
Cattle	7.03	202	1420.06	27.0	10.65	2.66
Goat	2.07	270	558.84	28.0	4.35	1.09
Quail	0.85	300	256.10	28.9	2.06	0.52
Sheep	5.11	300	1283.05	28.9	9.98	2.50
Ostrich	1.74	300	521.58	28.0	4.19	1.05
Total	16.80		4039.63		31.22	7.82

Table 6. Organic animal waste potential from agricultural wastes as a dry matter in Agricultural Research and Application Centre of Agricultural Faculty.

Agricultural products	**Annual amount of agricultural production (t/year)**	**Moisture content (%)**	**Coefficient of organic wastes (%)**	**Moist agricultural wastes (t/year)**	**Annual agricultural waste potential as a solid matter (t /year)**
Rapeseed	105000	14.5	0.59	61950	52.97
Sunflower	28200	14.5	0.59	16638	14.23
Wheat	328000	14.0	1.50	492000	423.12
Total				570588	490.32

Table 7. Annual biogas potential and electricity from agricultural wastes in Agricultural Research and Application Centre of Agricultural Faculty.

Agricultural Products	***Annual agricultural waste potential as a solid matter (t /year)***	***Amount of Availability of biogas (m3/ton)***	***Biogas Amount (m3/year)***	***Heating Value (Mj/m3)***	***Annual theoretical electricity from agricultural wastes (MWh/year)***	***Annual electricity from agricultural wastes (MWh/year)***
Rapeseed	52.97	600.00	31780.35	29.80	263.07	65.77
Sunflower	14.23	600.00	8535.29	29.80	70.65	17.66
Wheat	423.12	450.00	190404.00	28.10	1486.21	371.55
Total	490.32		230719.64		1819.93	454.98

The waste values as the annual organic dry matter of dining halls, cafeterias, and restaurants located on Görükle Campus of Uludağ University and the amounts of biogas and electric energy that can be obtained from this waste are given in Table 8. According to this, 87.83% of the biogas potential which was calculated from the food waste to be 110578.41 m^3 can be derived from the Central Dining Hall, 10.23% of it can be derived from Credit and Dormitories Institution dining hall and 1.94% of it can be derived from other cafés and restaurants. The biogas potential, which can be obtained from the food waste, has the potential to cover 3.49% of the natural gas consumed in 2015 on the campus.

The biogas potential that the university can derive from all organic waste and the value of electric energy, which can be obtained from this potential, are given in Table 9. According to Table 9, 17.95% of the total biogas potential of the campus can be derived from animal manure, 46.15% of it can be derived from the agricultural production and 35.90% of it can be derived from the food waste. The biogas potential which can be derived from the animal, agricultural production and food wastes has the potential to cover 1.75%, 4.48% and 3.49%, respectively, of the amount of natural gas consumed in 2015 on the campus. All the organic waste can cover 9.71% of the natural gas consumption of the campus. The biogas potential obtained from the animal manure of Nilüfer district determined by Özsoy and Alibaş (2015) has a value that is equal to the amount of natural gas consumed for heating and electricity on the campus. In the forthcoming years, in case a high-capacity biogas plant is established within the boundaries of Uludağ University, it will be possible to utilize the organic waste which can be obtained from the agricultural areas of Nilüfer District in this plant. Likewise, in order for the feasibility of the biogas plant to be ensured, it is suitable for the organic waste to be transported from maximum 20 km distance as one way. The distance of Uludağ University to the borders of Nilüfer District is less than this value determined as approximately 20 km.

Table 8. Organic waste potential, annual biogas potential and electricity from food wastes in all dining halls, cafeterias and restaurants of Uludağ University.

Facilities	Annual food wastes as a humid matter (t/year)	Moisture content (%)	Annual food wastes as a solid matter (t /year)	Amount of Availability of biogas (m3/t)	Biogas Amount (m3/year)	Heating Value (Mj/m3)	Annual theoretical electricity from food wastes (MWh/year)	Annual electricity from food wastes (MWh/year)
Central Dining Hall	1295.00	82.61	225.20	700.00	157640.35	28.1	1230.47	307.62
Credit & Dormitories Intuition Dining Hall	150.83	82.61	26.23	700.00	18359.93	28.1	143.31	35.83
Unpa Cafeteria & Restaurant	8.48	82.61	1.47	700.00	1031.66	28.1	8.05	2.01
Agaoglu-1 Cafeteria & Restaurant	4.02	82.61	0.70	700.00	488.93	28.1	3.82	0.96
Aytu Cafeteria & Restaurant	3.66	82.61	0.64	700.00	445.53	28.1	3.48	0.87
Holiday Inn Hotel Cafeteria & Restaurant	3.65	82.61	0.63	700.00	444.31	28.1	3.47	0.87
Ilkim Cafeteria & Restaurant	2.83	82.61	0.49	700.00	343.89	28.1	2.68	0.67
Mimoza Cafeteria & Restaurant	1.83	82.61	0.32	700.00	222.77	28.1	1.74	0.44
Besaş A.Ş. Factory & Cafeteria	1.10	82.61	0.19	700.00	133.29	28.1	1.04	0.26
Agaoglu-2 Cafeteria & Restaurant	1.00	82.61	0.17	700.00	121.73	28.1	0.95	0.24
ZiyadeInn Cafeteria & Restaurant	0.73	82.61	0.13	700.00	88.86	28.1	0.69	0.17
Sinem Patisserie	0.57	82.61	0.10	700.00	68.78	28.1	0.54	0.14
Yildiz Cafeteria	0.24	82.61	0.04	700.00	29.37	28.1	0.23	0.06
Han Cafeteria	0.12	82.61	0.02	700.00	14.18	28.1	0.11	0.03
Kampus Cafeteria	0.12	82.61	0.02	700.00	14.18	28.1	0.11	0.03
Yagmur Cafeteria	0.12	82.61	0.02	700.00	14.18	28.1	0.11	0.03
Ekim Cafeteria	0.12	82.61	0.02	700.00	14.18	28.1	0.11	0.03
Total	1474.42		256.39		179476.12		1400.91	350.26

Table 9. Total Biogas potential and electricity from all wastes in Campus of Uludağ University.

	Annual Waste Potential as a dry matter (t/year)	Biogas Amount (m3/year)	Annual theoretical electricity (MWh/year)	Annual electricity (MWh/year)
Animal Manure	362.12	89767.15	699.80	174.98
Agricultural Wastes	490.31	230719.64	1819.93	454.98
Food Wastes	256.39	179476.12	1400.91	350.26
Total	1108.82	499962.91	3920.64	980.22

CONCLUSIONS

In this study, the biogas potential obtained from the organic waste of Görükle campus of Uludağ University was calculated to be 499962.91 m^3. It was determined that 17.95% of the biogas potential of the campus consisted of the animal manure obtained from the ranches of Faculty of Veterinary Medicine and Agriculture, 46.15% of it consisted of the agricultural production waste of Agricultural Research and Application Centre (TUAM) of Agricultural Faculty, and 35.90% of it consisted of the left and dumped food waste in the all dining hall, restaurant, and cafeterias located on the campus. It was determined that among all the organic waste potential, the wheat production waste had the biggest share with 38.08%, and this value was followed by the food waste of the central dining hall with 31.53% share. Furthermore, it was determined within the scope of this study that the biogas potential, which can be obtained from the organic waste, corresponded to approximately 10% of the natural gas spent for heating and electricity on the campus.

REFERENCES

Aguilar-Virgen Q, Taboada-González P, Ojeda-Benítez S, Cruz-Sotelo S (2014). Power generation with biogas from municipal solid waste: Prediction of gas generation with in situ parameters. Renewable and Sustainable Energy Reviews, 30: 412–419.

Alibaş I, Ozsoy G, Elicin AK (2015). Determination of Agricultural Biogas Potential in Diyarbakir. Journal of Agricultural Machinery Science, 11:75-87 (in Turkish).

Alibaş K (1996). The determination of biogas production at different digestion temperature with the thermophilic, mesophhyllic and psychrophilic digestion from the cow manure, poultry manure and barley straw: The determination of total energy losses from full mechanized biogas digesters at different ambient temperature and different digesters type. Uludağ University, Faculty of Agriculture, Search and Investigation Notes, no:13, Bursa (in Turkish)

Amini HR, Reinhart DR, Mackie KR (2012). Determination of first-order landfill gas modelling parameters and uncertainties. Waste Management, 32: 305–316.

Anonymous (2016). Enerji Atlası. www.enerjiatlası.com/biyogaz. Accessed on August 28th 2016.

Barros RM, Filho GLT, Rodrigo da Silva T (2014). The electric energy potential of landfill biogas in Brazil. Energy Policy, 65: 150–164.

Briassoulis D, Hiskakis M, Babou E, Antiohos SK, Papadi C (2012). Experimental investigation of the quality characteristics of agricultural plastic wastes regarding their recycling and energy recovery potential. Waste Management, 32: 1075-1090.

Havukainen J, Uusitalo V, Niskanen A, Kapustina V, Horttanainen M (2014). Evaluation of methods for estimating energy performance of biogas production. Renewable Energy, 66: 232-240.

He K, Zhang J, Zeng Y, Zhang L (2016). Households' willingness to accept compensation for agricultural waste recycling: taking biogas production from livestock manure waste in Hubei, P. R. China as an example. Journal of Cleaner Production, 131: 410-420.

Isoda N, Rodrigues R, Silva A, Gonçalves M, Mandelli D, Figueiredo FCA, Carvalho WA (2014). Optimization of preparation conditions of activated carbon from agriculture waste utilizing factorial design. Powder Technology, 256: 175-181.

Kabir H, Yegbemey RN, Bauer S (2013). Factors determinant of biogas adoption in Bangladesh, Renewable and Sustainable Energy Reviews, 28: 881-889.

Karray R, Hamza M, Sayadi S (2016). Production and characterization of enzymatic cocktail produced by *Aspergillus niger* using green macroalgae as nitrogen source and its application in the pre-treatment for biogas production from *Ulva rigida*. Bioresource Technology, 216: 622-628.

Konening A, Dehn F (2016). Biogenic acid attack on concretes in biogas plants. Biosystem Engineering, 147: 226-237.

Lübbers WG, Bergman H, Theuvsen L (2016). Potential analysis of the biogas production-as measured by effects of added value and employment. Journal of Cleaner Production, 129: 556-564.

Maghanaki MM, Ghobadian B, Najafi G, Galogah RJ (2013). Potential of biogas production in Iran, Renewable and Sustainable Energy Reviews, 28: 702-714.

Moreno VC, Papasidero S, Scorpani GE, Guglielmi D, Cozzani V (2016). Analysis of accidents in biogas production and upgrading. Renewable Energy, 96:1127-1134.

Ozsoy G, Alibaş I (2015). GIS Mapping of biogas potential from animal wastes in Bursa, Turkey. International Journal of Agricultural and Biological Engineering, 8: 74-83.

Pizzuti L, Martins CA, Lacava PT (2016). Laminar burning velocity and flammability limits in biogas: A literature review. Renewable and Sustainable Energy Reviews, 62: 856-865.

Schneider DR, Kirac M, Hublin A (2012). Cost-effectiveness of GHG emission reduction measures and energy recovery from municipal waste in Croatia. Energy, 48: 203–211.

Thöle AJ, Rudnicki R, Kluba M (2016). Development of energy crops cultivation for biomass production in Poland. Renewable and Sustainable Energy Reviews, 62: 534-545.

TUIK. 2016. Turkish Statical Institute. www.tuik.gov.tr. Accessed on August 28th 2016.

Ulusoy Y, Arslan R, Ulukardeşler AH, Kaplan C, Kul B, Arslan R (2015). Biogas Potential of Agricultural Organic Waste in Bursa and Investigation of Use of Biogas as a Fuel in Diesel Engines. Journal of Agricultural Faculty of Uludağ University, 29(2):39-45 (in Turkish).

Zhu LD, Hiltunen E (2016). Application of livestock waste compost to cultivate microalgae for bioproducts production: A feasible framework. Renewable and Sustainable Energy Reviews, 54: 1285-1290.