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Investigation of Afghanistan's Biogas Potential from Animal Waste

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Abstract

Due to the increasing population growth and energy requirement, the interest in renewable energy sources has increased in the recent years. Biogas is one of the sustainable energy resources in the world. In the cattle, ovine, and poultry farming, a large amount of fertilizer is produced in Afghanistan. These wastes are a big problem for businesses, and their evaluation is of great importance. One of the ways to utilize the wastes is the biogas production. In this work, the annual biogas and the total annual heat value potential of Afghanistan are determined depending on the number of animals. As a result, the Afghanistan's biogas potential between 2010 and 2017 is between 1172355870 m^3/y and 1282692614 m^3/y. According to the results obtained, the total annual heat value potential is between 29117122340 MJ/y and 26612478246 MJ/y. As a result, the widespread use of biogas in Afghanistan is of great importance in terms of both the waste disposal and the energy production.

Keywords: *Animal waste, Biogas, Total annual heat value, Renewable energy, Afghanistan.*

1. Introduction

Today, energy is an essential indicator of the development level and strength of the countries [1]. The energy sources are examined in two main groups as the non-renewable and renewable energy sources. The energy sources such as oil, coal, and natural gas are called the non-renewable energy sources [2-4]. The high rates of non-renewable energy and consumption have led to a growth in its cost and rapid exhaustion of its resources worldwide. It is predictable that the crude oil will last for 80 more years, coal for 230 years, and gaseous fuels for approximately 150 years [5]; these resources are concentrated in some regions of the world [6-8]. Energy sources such as wind, solar, water, and biomass are called the renewable energy sources, and these resources are abundant in Afghanistan [9]. Biomass is one of the most promising renewable energy sources utilized to generate different types of biofuels [10-11].

Afghanistan is a mountainous country located in the east of Iran, north and west of Pakistan, and in South-Central Asia. It is situated between the $29^{\circ}35'$ and $38^{\circ}40'$ north latitudes and the $60^{\circ}31'$ and $75^{\circ}00'$ east longitudes. Afghanistan has an arid and semi-arid climate, with cold winters and hot summers. The total land area is 652864 km^2 [12-13].

One of the products of the biomass resources commonly found in Afghanistan is biogas. Biogas characterizes the alternative fuels increased from renewable resources for electric and thermal energies, compared to the non-renewable fuels [14-15]. A benefit of biogas production is to provide a storable and sustainability-produced source of energy [16]. Unlike the other flammable gases, biogas is obtained only from sewage, landfill, livestock waste, organic waste, and energy crops. The calorific value of biogas is the methane gas that it contains. Obtaining biogas from the animal, vegetable, and industrial wastes contributes to the environment and its economic return [17]. The biogas technology, which enables these wastes to become harmless through different stages, and transform into energy, has an essential place in the energy sector today [18-19]. When the literature is examined, although there are many research works on the biogas, there is no work on the biogas potential of Afghanistan. Thus some of the studies on the biogas technology and its potential are given here. Noorollahi *et al*. [20] have investigated the potential of biogas production from animal manure in Iran. Li *et al*.

[21] have examined the biogas energy potential obtained from the waste of livestock and poultry living in rural China. Zareei [22] has evaluated the biogas potential to be obtained from the livestock manure in Iran using the geographic information systems. Gao *et al*. [23] have conducted a study on the biogas potential used in the China's Henan Province. Caliskan and Özdil, in their study [24], have investigated the potential of animal waste biogas and electricity generation in Turkey. Wawrzyniak *et al*. [25] have created a database system in order to estimate the biogas potential of beef and pig manure in Poland.

In the current work, the amount of biogas and the total annual heat value potential obtained from animal wastes (cattle, ovine, and poultry) in Afghanistan were analyzed between 2010 and 2017. Then its changes over the years were examined.

2. Biogas production

Biogas is a renewable energy resource that can resolve the world energy demands by decreasing the greenhouse gases and the wastes [26]. There are at minimum five significant sources of biomass. These are sewage, landfill, livestock waste, organic waste, and energy crops. In this work, the biogas potential was investigated using the livestock waste.

The quality and quantity of animal manure produced depend on the feed and the livestock's living conditions. It shows differences in the amount of gas produced per weight unit of livestock waste (Taiganides, 1978; Noorollahi, 2015) [27, 20]. Therefore, in this work, using the published scientific articles, the method used for biogas potential and total annual heat value is explained in the “method” section.

3. Materials and method

3.1 Animal quantity in Afghanistan

Within this study's scope, Afghanistan's data between 2010 and 2017 were taken from the Food and Agriculture Organization of the United Nations (FAOSTAT) website [28]. The location map of Afghanistan is given in figure 1.

The numbers of cattle (donkeys, camels, cattle, horses, and mules), sheep (goats and sheep), and poultry (chickens) between 2010 and 2017 in Afghanistan are presented in table 1.

Also the total number of animals by year is given in figure 2. This figure shows the percentage of animals fed between 2010 and 2017. When the table and figure were examined, it could be seen that there were the most animals in 2017.

Figure 1. Afghanistan location map [29].

Table 1. Number of animals in Afghanistan.

Animal	2010	2011	2012	2013	2014	2015	2016	2017
Cattle (head)	7490000	7368000	7043000	7048000	7156000	7109500	7073100	6665000
Ovine (head)	20075000	21897000	21131000	20178000	20544000	20941000	20713200	21464000
Poultry (head)	12888000	13378000	13212000	12053000	11098000	11863000	11899000	13573000

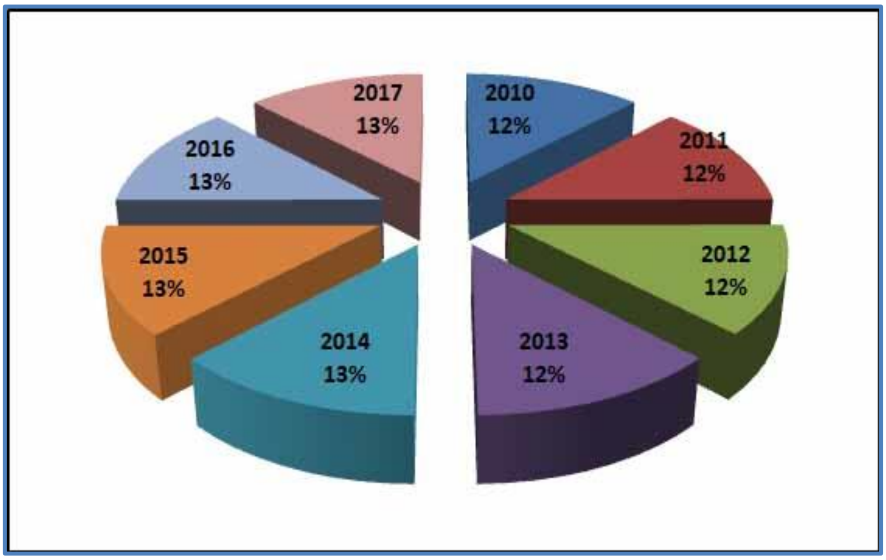

Figure 2. Annual total livestock in Afghanistan (%).

3.2. Method

The amount of manure obtained from animals varies according to the animal type (cattle, ovine, and poultry). The animal species used in this work and the amount of waste obtained are given in table 2.

In this work, equations 1-5 were used to calculate the amount of animal manure and biogas production [30-32, 17]. The total amount of manure that the animals could produce per day was determined by equation 1. In this equation, GM is the daily fertilizer production amount (t/day), HS is the number of animals, and HGUM is the daily fertilizer production amount per animal (kg/day.animal).

$$\mathbf{GM = (HS \times HGUM)/1000} \quad (1)$$

In equation 2, the daily solid fertilizer production amount is calculated. In this equation, GM_{solid} is the daily amount of solid fertilizer (t/day), and KGO is the solid fertilizer ratio (%).

$$\mathbf{GM_{solid} = GM \times (KGO/100)} \quad (2)$$

Equation 3 shows the total usable annual solid fertilizer amount. In this equation, $TKGM_{solid}$ is the total available solid fertilizer amount (t/year), and GKO is the fertilizer availability rate.

$$\mathbf{TKGM_{solid} = GM_{solid} \times (GKO) \times 365} \quad (3)$$

Using equation 4, the amount of biogas, and equation 5, the total annual thermal value could be calculated. In these equations, BM is the biogas amount (m^3/y), BDO is the solid manure biogas conversion rate (200 m^3/t), TID is the total annual heat value (MJ /y), and BID is the unit heat value of biogas (22.7 MJ/m^3).

$$\mathbf{BM = TKGM_{solid} \times BDO} \quad (4)$$

$$\mathbf{TID = BM \times BID} \quad (5)$$

Table 2. Manure amounts for cattle, ovine, and poultry [33].

Animal species	Fresh waste generation (kg/day.animal) (HGUM)	Solid fertilizers rate (KGO)	Solid waste generation (kgKM(day.animal)	Fertilizer availability rate (GKO)
Cattle	27.00	15	4.050	0.50
Ovine	2.50	30	0.750	0.13
Poultry	0.10	35	0.035	0.99

4. Result and discussion

In this work, the biogas potential was calculated using the fertilizer belonging to cattle, ovine, and poultry in Afghanistan between 2010 and 2017.

The numerical data of cattle, ovine, and poultry is given in table 1. The GM, GM_{solid}, and $TKGM_{solid}$ calculated using the data in tables 1 and 2 are presented in table 3.

The amounts of biogas obtained using the amount of manure belonging to cattle, ovine, and poultry between 2010 and 2017 in Afghanistan are given in figures 3 to 5. When figure 3 is examined, it can be seen that there is not much change between 2012 and 2016. However, there is a severe decrease in 2017. This result can be attributed to the decrease in the number of bovine animals in 2017. When figures 4 and 5 are examined, an increase is observed in the amount of biogas obtained from ovine and poultry in 2017.

Table 3. GM, GM_{solid}, and $TKGM_{solid}$ values of animal numbers in Afghanistan.

Year	Animal species	GM	GM_{solid}	$TKGM_{solid}$
2010	Cattle	202230	30335	5536046
	Ovine	50188	15056	714419
	Poultry	1289	451	162998
2011	Cattle	198936	29840	5445873
	Ovine	54743	16423	779259
	Poultry	1338	468	169195
2012	Cattle	190161	28524	5205657
	Ovine	52828	15848	751999
	Poultry	1321	462	167095
2013	Cattle	190296	28544	5209353
	Ovine	50445	15134	718085
	Poultry	1205	422	152437
2014	Cattle	193212	28982	5289179
	Ovine	51360	15408	731110
	Poultry	1110	388	140359
2015	Cattle	191957	28793	5254809
	Ovine	52353	15706	745238
	Poultry	1186	415	150034
2016	Cattle	190974	28646	5227905
	Ovine	51783	15535	737131
	Poultry	1190	416	150490
2017	Cattle	179955	26993	4926268
	Ovine	53660	16098	763850
	Poultry	1357	475	171661

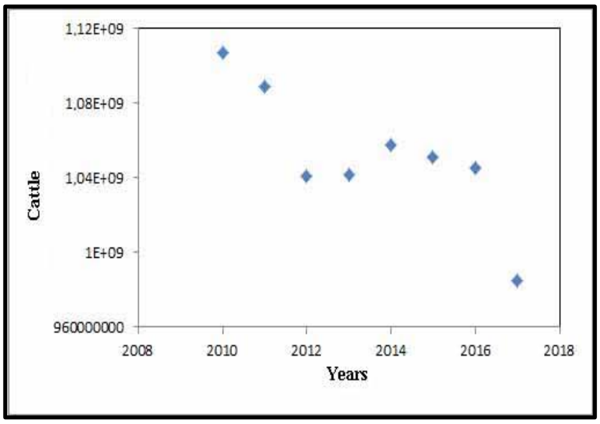

Figure 3. Biogas amount of cattle waste by years.

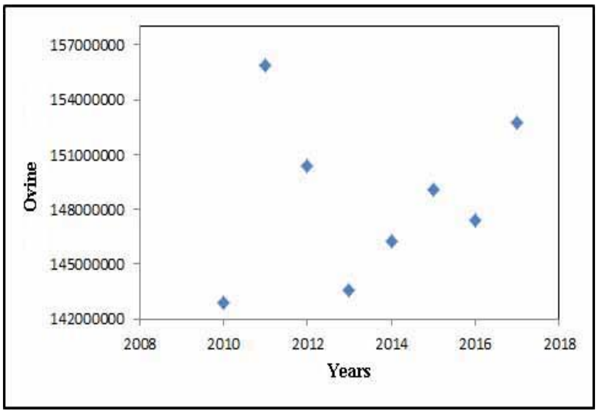

Figure 4. Biogas amount of ovine waste.

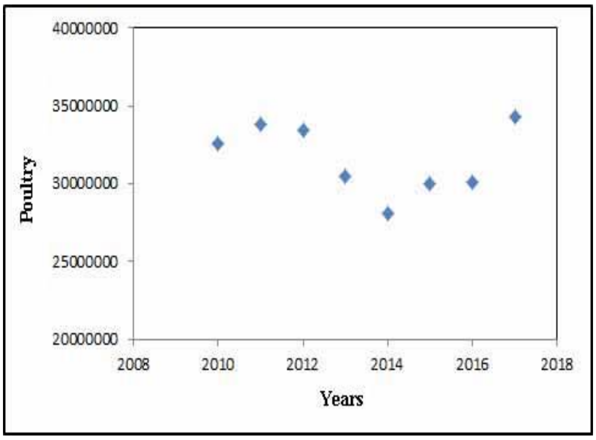

Figure 5. Biogas amount of poultry waste.

Figures 6 to 8 give the annual total heating values in Afghanistan by years. When figure 6 is examined, it can be seen that there is a severe decrease in the total annual heat value (TID), especially in 2017. However, it can be observed that there is an increase in the total annual heat value (TID) of ovine and poultry waste (figures 7 and 8).

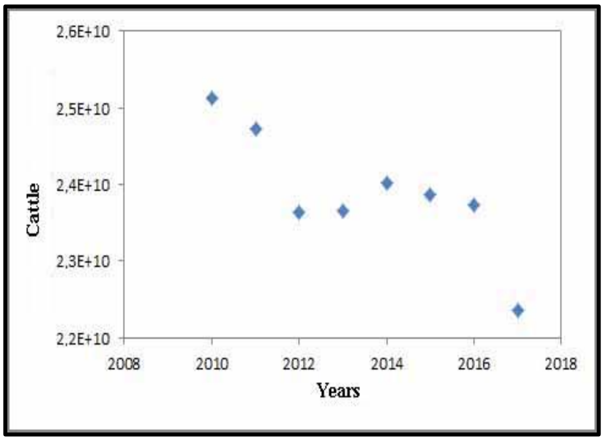

Figure 6. Total annual heat value of cattle waste.

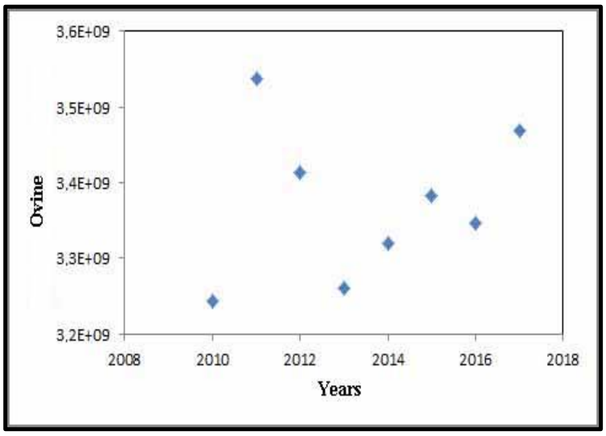

Figure 7. Total annual heat value of ovine waste.

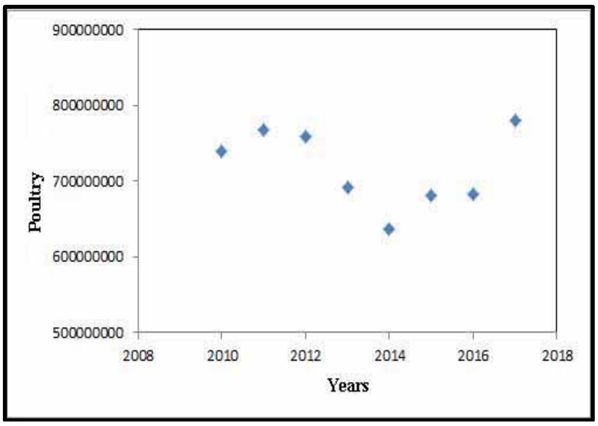

Figure 8. Total annual heat value of poultry waste.

The total annual biogas and total annual heat value potential of Afghanistan are given in table 4. According to this table, the total amount of biogas between 2010 and 2017 varies between 1172355870 $m^{3/}$y and 1282692614 $m^{3/}$y. The total annual heat value is between 29117122340 MJ/y and 26612478246 MJ/y.

Table 4. Afghanistan's total annual biogas and total annual heat value potential.

Years	Total annual biogas (m^3/y)	Total annual heat value (MJ/y)
2010	1282692614	29117122340
2011	1278865480	29030246387
2012	1224950461	27806375462
2013	1215974976	27602631952
2014	1232129456	27969338653
2015	1230016270	27921369337
2016	1223105134	27764486543
2017	1172355870	26612478246

5. Conclusions

The biogas use is one of the rapidly increasing renewable energy sources in the recent years. One of the products obtained from the biomass resources in Afghanistan is biogas. In this work, the biogas and annual heat values were calculated using the amount of manure obtained from animals fed in Afghanistan between 2010 and 2017. It was observed that the potential amount of biogas between 2010 and 2017 varied between 1172355870 m^3/y and 1282692614 m^3/y. The total annual heat value was determined to be between 29117122340 MJ/y and 26612478246 MJ/y.

As a result, it is essential to raise the awareness of the citizens living in Afghanistan about the biomass, where livestock is one of the livelihoods. Since it is thought that biogas can be obtained using the biomass, thus a clean environment will be provided and a considerable biomass potential will be prevented from being destroyed.

References

[1] Güler, E., Kandemir, S.Y., & Açıkkalp, E., 2020, Evaluation of the efficiencies of the energy distribution companies in Turkey with dea. BSEU Journal of Science, 7(1), 66-79.

[2] Külekçi, Ö.C. (2009). Place of Geothermal Energy in the Content of Renewable Energy Sources and its Importance for Turkey. Ankara University Çevrebilimleri Dergisi, 1(2), 83-91.

[3] Takan, M.A. & Kandemir, S.Y., 2020, Evaluation of geothermal energy in Turkey in terms of primary energy supply. European Journal of Science and Technology, 381-385.

[4] Mohsen, S., Pourfayaz, P., Shirmohamadi, F., Moosavi, R.S., & N. Khalilpoor (2020). Potential, current status and applications of renewable energy in the Energy sector of Iran: A review. Renewable Energy Research and Application.

[5] Utlu, Z. and Kocak, M. (2008). The effect of biodiesel fuel obtained from waste frying oil on direct injection diesel engine performance and exhaust emissions. Renewable Energy 33 (8):1936–1941. 10.1016/j.renene.2007.10.006.

[6] Demirbas, A. (2009). Progress and recent trends in biodiesel fuels. Energy Conversion and Management 50:14–34. doi:10.1016/j.enconman.2008.09.001.

[7] Demirbas, A. (2007). Importance of bio-diesel as transportation fuel. Energy Policy 35 (9): 4661–4670. doi:10.1016/j.enpol.2007.04.003.

[8] Bani-Hani, E., Alkhatib, F., Sedaghat, A., Alkhazzam, A., Al-Dousari, F., & Al-Saad, O. (2020). An Experimental Study on Producing a Sustainable Diesel-like Fuel from Waste Engine Oil. Renewable Energy Research and Application, 1(2), 143-150.

[9] Ershad, A.M. (2017). Institutional and policy assessment of renewable energy sector in Afghanistan. Journal of renewable energy, https://doi.org/10.1155/2017/5723152.

[10] R.C. Saxena, D.K. Adhikari, and H.B. Goyal, "Biomass-based energy fuel through biochemical routes: A review," Renewable and Sustainable Energy Reviews, Vol. 13, No. 1.

[11] Oyegoke, T., Sardauna, M.Y., Abubakar, H.A., & Obadiah, E. (2020). Exploration of Biomass for the Production of Bioethanol: "A Process Modelling and Simulation Study". Renewable Energy Research and Application.

[12] Ershad A.M. (2014). Potential of solar photo-voltaic and wind power plants in meeting electricity demand in Afghanistan," Renewable and clean energy: [dissertation]. Ohio: Dayton Univ.

[13] Ludin, G.A., Amin, M.A., Aminzay, A., & Senjyu, T. (2016). Theoretical potential and utilization of renewable energy in Afghanistan. Aims Energy, 5, 1-19.

[14] Weiland, P. Production and energetic use of biogas from energy crops and wastes in Germany. Appl. Biochem. Biotechnol. 2003, 109, 263–274. [Cross-Ref]

[15] Bacenetti, J., Fusi, A., Guidetti, R., Fiala, M. Life Cycle Assessment of maize cultivation for biogas production. J. Agric. Eng. 2013, 44, 579–582.

[16] Kintl, A., Elbl, J., Vítěz, T., Brtnický, M., Skládanka, J., Hammerschmiedt, T., & Vítězová, M. (2020). Possibilities of using White Sweet-clover Grown in Mixture with Maize for Biomethane Production. Agronomy, 10(9), 1407.

[17] Karaca, C. (2017). Determination of biogas production potential from animal manure in Hatay province. Journal of Agricultural Faculty of Mustafa Kemal University. 22(1):34-39

[18] Çağlayan, G. & Koçer, N. (2014). Evaluatıon of the potentıal of lıvestock breedıng ın the cıty of Muş for the research of biogas production. Muş Alparslan University Journal of Science, 2(1), 215-220.

[19] Kandemir, S.Y. & Açıkkalp, E., 2019. Investigation of Biogas Potential of Animal Wastes in Bilecik. BSEU Journal of Science, 6(1), 104-108.

[20] Noorollahi, Y., Kheirrouz, M., Asl, H.F., Yousefi, H., & Hajinezhad, A. (2015). Biogas production potential from livestock manure in Iran. Renewable and Sustainable Energy Reviews, 50, 748-754.

[21] Li, F., Cheng, S., Yu, H., & Yang, D. (2016). Waste from livestock and poultry breeding and its potential assessment of biogas energy in rural China. Journal of Cleaner Production, 126, 451-460.

[22] Zareei, S. (2018). Evaluation of biogas potential from livestock manures and rural wastes using GIS in Iran. Renewable energy, 118, 351-356.

[23] Gao, M., Wang, D., Wang, H., Wang, X., & Feng, Y. (2019). Biogas potential, utilization, and countermeasures in agricultural provinces: A case study of biogas development in Henan Province, China. Renewable and Sustainable Energy Reviews, 99, 191-200.

[24] Caliskan, M. & Ozdil, N.F.T. (2020). Potential of Biogas and Electricity Production from Animal Waste in Turkey. BioEnergy Research, 1-10.

[25] Wawrzyniak, A., Lewicki, A., Pochwatka, P., Sołowiej, P., & Czekała, W. (2021). Database System for Estimating the Biogas Potential of Cattle and Swine Feces in Poland. Journal of Ecological Engineering, 22(3).

[26] Awe, O.W., Zhao, Y., Nzihou, A., Minh, D. P., & Lyczko, N. (2017). A review of biogas utilization, purification, and upgrading technologies. Waste and Biomass Valorization, 8(2), 267-283.

[27] Taiganides EP. Animal waste management and waste watertreatment. In: Strauch D, editor. Animal production and environmental health. New York: Elsevier; 1978, p. 91–153.

[28] http://www.fao.org/faostat/en/#data/QA.

[29] Mostafaeipour, A., Dehshiri, S.J.H., Dehshiri, S.S.H., & Jahangiri, M. (2020). Prioritization of potential locations for harnessing wind energy to produce hydrogen in Afghanistan. International Journal of Hydrogen Energy, 45(58), 33169-33184.

[30] Başçetinçelik, A., Öztürk, H.H., Karaca, C., Kaçira, M., Ekinci, K, Kaya, D., Baban, A., Komitti, N., Barnes, I., Nieminen, M., 2006. Final Report of Exploitation of Agricultural Residues in Turkey. AGRO-WASTE-Exploitation of Agricultural Residues in Turkey. EU Life Program Project Project No: LIFE03 TCY/TR/000061.

[31] Ozsoy, G., Alibas, I. (2015). GIS mapping of biogas potential from animal wastes in Bursa, Turkey. Int J Agric & Biol Eng, 8(1):74－83.

[32] Ayhan A., 2015. Biogas production potential from animal manure of Bursa province. Journal of Agricultural Faculty of Uludag University, 29(2), 47-53.

[33] Yokuş, İ., 2011. Biogas potentıal from animal waste of Sivas province, Ankara University Graduate School of Natural and Applied Sciences Department of Agricultural Machinery, Master Thesis, Ankara.