

# Assessment of the Gross Potential of Local Waste Based on Geoinformation Systems for Bioenergy Production

**S. G. Mamatkulova<sup>1\*</sup> and G. N. Uzakov<sup>2</sup>**

<sup>1</sup> Karshi Branch of the Tashkent University of Information Technologies named after Muhammad Al-Khwarizmi/Department of Information technology, Karshi, Republic of Uzbekistan

<sup>2</sup> Karshi Engineering and Economic Institute/Department "Heat power engineering", Karshi, Republic of Uzbekistan

\*E-mail of corresponding author: urisheva80@mail.ru

**Abstract:** This article analyzes the gross potential of local hydrocarbon waste and biomass using the example of the Republic of Uzbekistan with the aim of producing bioenergy. To calculate the raw material potential, we used official and reference data on the production and consumption of fuel, fertilizers and the formation of organic waste, the accumulation of municipal solid waste (MSW), the amount of saline land where halophytic plantations can be created, which can be considered as biomass. Based on the collected data, mathematical operations and calculations of the potential of biogas technology were performed. A block diagram has been developed that describes the steps of a Geo Information Systems (GIS) map. GIS maps have been created that give a visual representation of the spatial distribution of the gross potential of various types of waste in the regions of the republic and can serve as a tool in planning the distribution of biogas technology.

**Keywords:** GIS, biogas, solid household waste.

**Received** 27 January 2021

**Accepted** 04 March 2021

**Published** 03 June 2021

## 1. Introduction

There are a number of environmental problems in the Republic of Uzbekistan, such as salinization and soil degradation, air pollution, the accumulation of household waste, food pollution, significant greenhouse gas emissions, etc. To prevent these problems, the Government approved the Concept "On Environmental Protection of the Republic of Uzbekistan for the period until 2030" [1].

On the basis of the concept, approved a roadmap for the implementation of a number of works to improve the environmental situation in the Republic. In environmental pollution, the main problem is accumulated waste. Available types of waste can be divided into the following groups: industrial and municipal waste, human physiological waste, crop by-products, livestock waste. In general, municipal wastes, livestock and plant wastes, solid household waste (solid household waste) can, at least in part, be considered renewable fuels [1].

Obtaining biofuels from various wastes is a very urgent task all over the world. Processing waste into bioenergy, solve problems with environmental pollution and lack of natural energy. The concentration of poultry and livestock, as is known, is associated with the problem of the disposal of farm waste. Modern biotechnology provides for any transformation of the substrate into a feed product and vice versa [2]. After analyzing the

composition of the processed organic fertilizer by the Sanitary and Epidemiological Stations of the Ministry of Health of the Republic of Uzbekistan, the following were determined: organic nitrogen 89.7 mg / l, potassium 586.561 mg / l, calcium 303.0385 mg / l and phosphorus 60.436 mg / l [3]. By this content, processed manure after a biogas plant is suitable for fish feed composition.

## 2. Materials and methods

In order to assess the potential of raw materials for waste treatment using biogas technologies and the production of energy and biofertilizers, an analysis of the raw material potential is carried out on the example of the Republic of Uzbekistan as a whole. To calculate the raw materials, official and reference information on the production and consumption of fuel, fertilizers and the formation of organic waste were used. From tables 1.2, you can revise the types of resources. Uzbekistan has a high potential for converting various wastes into bioenergy.

In addition to the accumulation of different types of waste, which contribute to air pollution and the release of greenhouse gases, it also poses great risks from the effects of salinization of soil and fresh water, which are widespread and significant. As an increasing number of agricultural land and ecosystems are affected, more attention is being paid to this issue, especially in academia. Salt stress is one of the most important contributing factors to crop loss worldwide. While salinization of the soil reduces crop productivity, intensive agricultural practices can themselves become a source of increasing soil salinity.



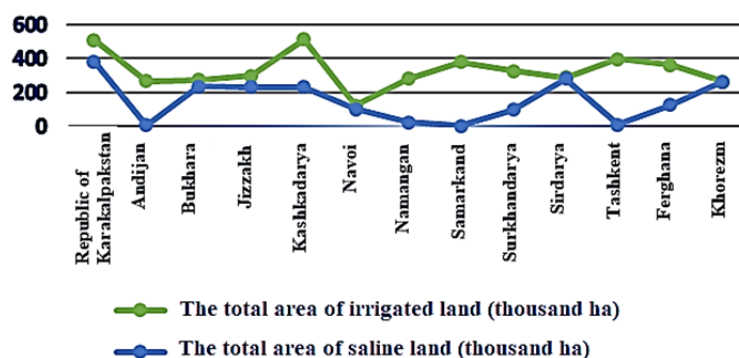
© The Author(s) 2021. Published by CIEES Association Press. This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 4.0 Generic License.

**Table 1.** Gross biomass potential from local waste. [4], [5].

| Name of region             | MSW landfills,<br>ha | landfills for industrial waste,<br>ha | Number of inhabitants,<br>thousand people |
|----------------------------|----------------------|---------------------------------------|-------------------------------------------|
| Republic of Karakalpakstan | 175.7                | 68.2                                  | 1889.8                                    |
| Andijan region             | 47.0                 | 7.0                                   | 3110.71                                   |
| Bukhara region             | 120.3                | 28.6                                  | 1915.9                                    |
| Jizzakh region             | 112.7                | 75.0                                  | 1374.4                                    |
| Kashkadarya region         | 156.9                | 124.4                                 | 3261.2                                    |
| Navoi region               | 76.8                 | 5223.6                                | 992.4                                     |
| Namangan region            | 76.2                 | 56.6                                  | 2795.6                                    |
| Samarkand region           | 92.9                 | 335.6                                 | 3857.0                                    |
| Surkhandarya region        | 203.4                | 55.0                                  | 2612.3                                    |
| Sirdarya region            | 49.5                 | 10.1                                  | 841.8                                     |
| Tashkent region            | 183.3                | 3451.8                                | 5484.6                                    |
| Ferghana region            | 138.5                | 25.1                                  | 3733.0                                    |
| Khorezm region             | 60.2                 | 16.5                                  | 1856.4                                    |

**Table 2.** Livestock and poultry by region, on October 1, 2019 [4].

| Name of region             | The number of cattle,<br>(thousand heads) | The number of cows,<br>(thousand heads) | Sheep and goats,<br>(thousand heads) | Birds, (thousand heads) |
|----------------------------|-------------------------------------------|-----------------------------------------|--------------------------------------|-------------------------|
| Republic of Karakalpakstan | 1088.9                                    | 318.6                                   | 1112.8                               | 4317.8                  |
| Andijan region             | 1048.5                                    | 360.1                                   | 1430.9                               | 7331.5                  |
| Bukhara region             | 1208.3                                    | 397.7                                   | 2133.9                               | 4696.1                  |
| Jizzakh region             | 873.6                                     | 256.8                                   | 2129.0                               | 3474.5                  |
| Kashkadarya region         | 1555.2                                    | 512.1                                   | 4575.6                               | 6107.0                  |
| Navoi region               | 469.1                                     | 201.1                                   | 2194.3                               | 2761.9                  |
| Namangan region            | 694.8                                     | 226.3                                   | 760.1                                | 4911.6                  |
| Samarkand region           | 1583.5                                    | 683.0                                   | 2486.2                               | 12196.1                 |
| Surkhandarya region        | 906.2                                     | 330.4                                   | 2280.5                               | 4942.4                  |
| Sirdarya region            | 437.6                                     | 154.9                                   | 318.4                                | 1823.1                  |
| Tashkent region            | 825.0                                     | 388.2                                   | 955.9                                | 15229.9                 |
| Ferghana region            | 998.2                                     | 360.1                                   | 850.3                                | 8280.9                  |
| Khorezm region             | 856.6                                     | 334.6                                   | 418.1                                | 5724.6                  |

**Information on saline lands on a scale of the Republic of Uzbekistan****Fig. 1.** Example for short figure.

Changing practices to reduce the risk or rate of salinization can improve results, but managing saline farmland after it is created is difficult and often leads to land abandonment [6].

According to the diagram shown in Figure 1. Based on the data presented [7], it can be seen that saline lands account for about 50% of irrigated land. By creating artificial plantations on a sufficiently large area, it is possible to combine with other useful halophytic plants or crops to get a sufficiently large crop of raw materials for biogas production and nevertheless to achieve a decrease in soil salinity.

For several years, in collaboration with the National University of Uzbekistan and Kitakiushu University (Japan), experiments were conducted to assess the potential of halophytic plants as a renewable source of alternative energy. It has been shown that the halomite biomass (vaults, salicornia, Caspian Karella, climaxoptera, atriplex, annual solyanka, etc.) growing on saline lands where it is impossible to grow ordinary crops can be used for biogas production [8]. From 1 ton of dry matter, up to 300-400 m<sup>3</sup> of biogas can be obtained [9].

Researchers [10] studied the anaerobic assimilation of halophytic biomass in experiments with a periodic test in a continuous mode: 130–366 ml of biogas was obtained from 1 g of DM of various halophytes at 35 °C; and 269–480 ml - at 55 °C.

In addition, 12-13 million m<sup>3</sup> of solid waste accumulates in Uzbekistan annually, of which 6.3 million m<sup>3</sup> comes from the population. The total number of

landfills in the Republic is more than 186 landfills and occupy more than 780 ha of land [11].

As a result of the studies [12,13], it was found that the total yield of pyrolysis products in the temperature range 350-600 C<sup>0</sup> weakly depends on temperature. Therefore, fuel consumption for own needs to maintain the temperature regime is up to 25-30% of standard fuel. Thus, the mass yield of pyrolysis products during slow heating of plant biomass (sawdust) in the range of temperatures studied was: coal - 45.7%, liquid products - 21.7%, biogas - 32.6%.

According to statistics, in 2017, 114.7 million tons of production and consumption wastes were generated in the republic, including toxic waste not recyclable - 41.6 million tons (36.2%) and toxic waste recyclable, - 42.8 million tons (37.3%). At the same time, the volume of non-toxic waste that could not be recycled amounted to 21.1 million tons (18.3%), non-toxic waste to be processed - 9.2 million tons (8%) [1].

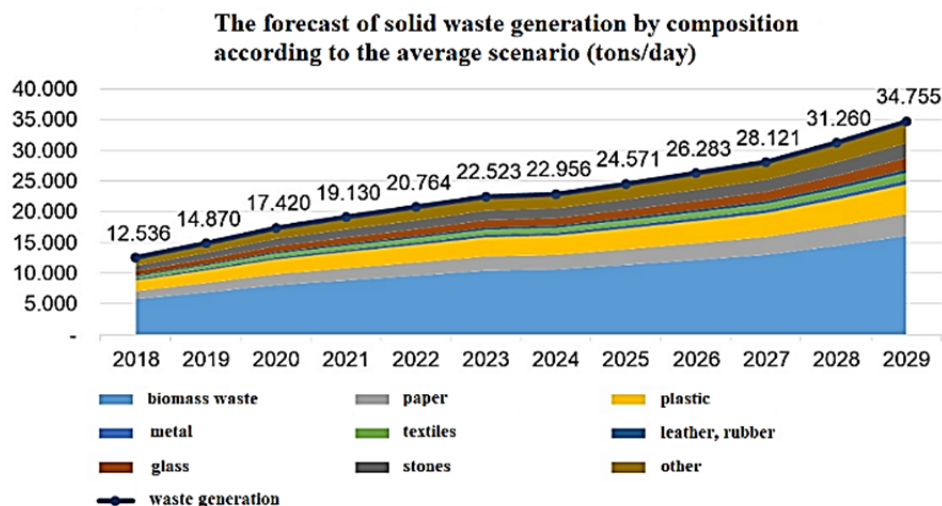
Thus, according to the diagram in Figure 2 provided from [11], it can be said that the landfills of the republic have significant potential for landfill methane.

### 3. Results and discussion

This article is devoted to the study of the development of GIS maps of the gross potential of local waste to ensure the convenience of bioenergy. The map developed by GIS technologies is the best way to attract investors in the development of waste treatment and bioenergy production.

**Table 3.** Biogas yield from various halophytic biomass [10].

| № | Name halophyte      | Green crop, t / ha | The output of dry biomass, t / ha | Biogas output, m <sup>3</sup> |
|---|---------------------|--------------------|-----------------------------------|-------------------------------|
| 1 | Salsola sclerantha  | 18.95              | 4.3                               | 1290÷1720                     |
| 2 | Climacoptera lanata | 23.10              | 5.75                              | 1725÷2300                     |
| 3 | Suaeda paradoxa     | 25.45              | 5.33                              | 1599÷2132                     |
| 4 | Kochia scoparia     | 44.10              | 11.3                              | 3390÷4520                     |
| 5 | Glycyrrhiza glabra  | 13.84              | 5.55                              | 1665÷2220                     |
| 6 | Nitrogen atriplex   | 42.05              | 10.55                             | 3165÷4220                     |



**Fig. 2.** The forecast of the formation of solid waste by composition according to the average scenario (tons/day).

To develop a GIS map software package for assessing the gross potential of various types of waste for bioenergy production, the following:

- studied the statistical data for the republic;
- - performed mathematical operations and calculations of the potential of biogas technology;
- developed a block diagram describing the stages of a GIS map;
- performed geoprocessing data;
- installed limitations;
- received usable card.

For this purpose, information was collected on the number of livestock for cattle breeding and poultry farming by region [4], the amount of saline land where halophytic plants for biogas production can be grown [7], and the amount of solid waste accumulated in which landfill gas is generated [5].

GIS project is carried out on the basis of the algorithm according to the block diagram presented in Figure 3. The flowchart describes all the stages of the development of GIS maps.

At the next stage of the GIS maps of biomass potential related to various types of waste were superimposed on the main maps. After that, it was necessary to introduce several restrictions.

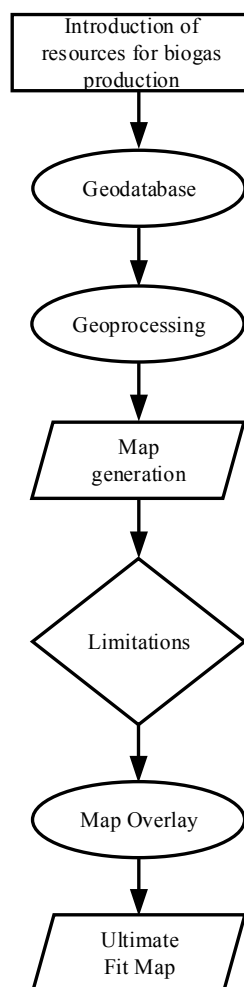


Fig. 3. A flowchart describing the stages of development of a GIS map.

For the specific application of restrictions, it can be taken into account that on a regional scale in the landscape and natural areas of the network, the installation of biogas plants is allowed only if the environmental impact assessment confirms that the territory can withstand the construction of the station.

The gross potentials of different types of waste of each region marked on the map for introducing bioenergy production in many cases reflect the required information much more clearly than dozens of pages of reports with tables. Based on the data in Tables 1 and 2, a GIS project database was created. Based on the map data, the final usable maps are generated and created, which are shown in Figures 4, 5, 6, 7, 8 and 9.

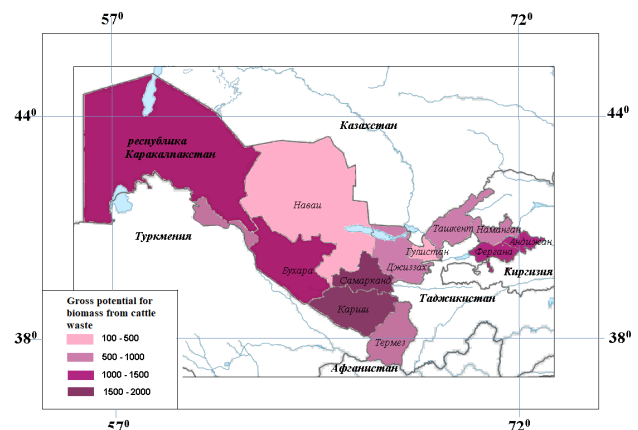


Fig. 4. Gross potential for biomass from cattle waste.

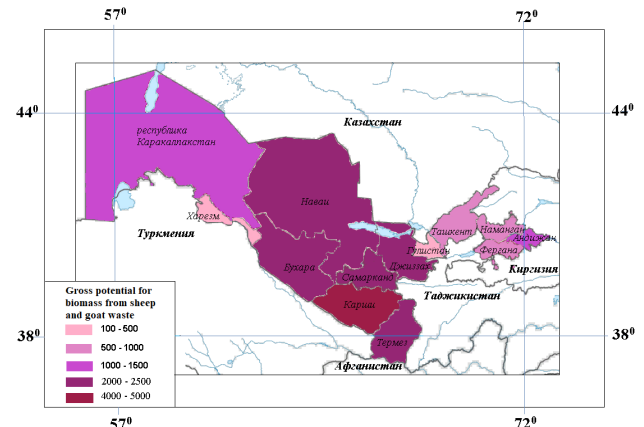


Fig. 5. Gross potential for biomass from waste sheep and goats.

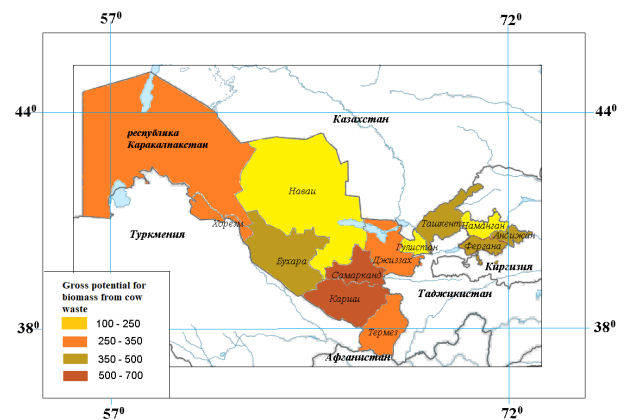


Fig. 6. Gross potential for biomass from cow waste.

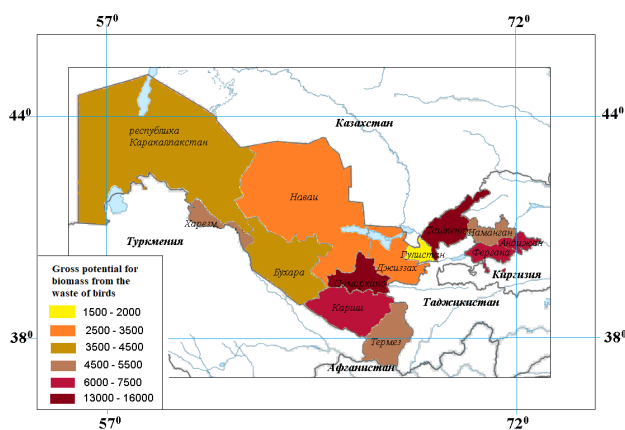


Fig. 7. Gross potential for biomass from bird waste.

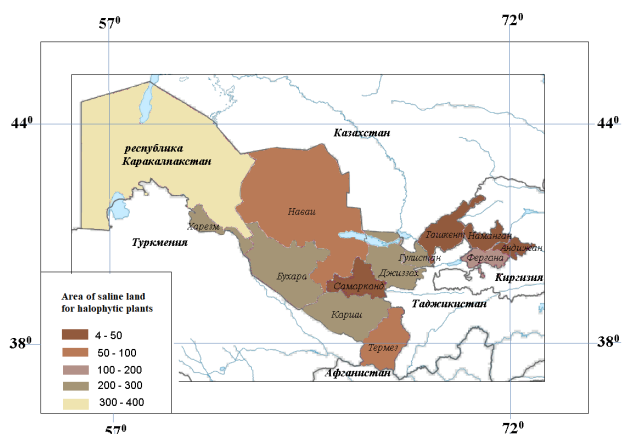


Fig. 8. Saline Land Area for growing halophytic plants.

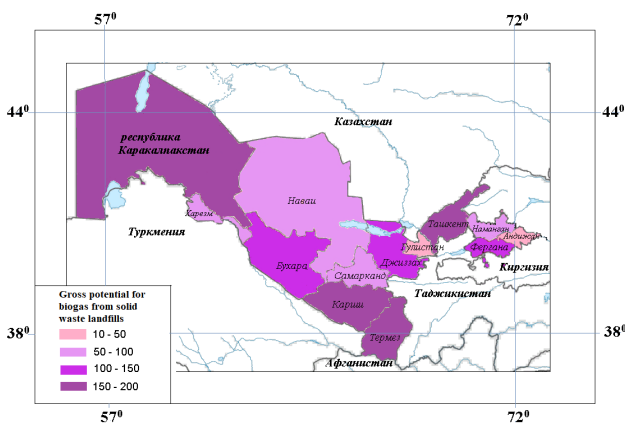


Fig. 9. Gross potential for biogas from solid waste landfills.

The presented thematic maps constructed in the GIS environment give a visual representation of the spatial distribution of the gross biogas potential in the regions of the republic and can serve as a tool in planning the placement of biogas plants.

#### 4. Conclusion

Although the Republic of Uzbekistan is rich in natural resources, the time has come to take care of environmental pollution. If waste disposal is not carried out at a high level with state support, the accumulation of solid waste every year, the area of saline land will increase from year to year.

In the regions of the Republic of Uzbekistan, there is a significant amount of different types of biomass waste available, such as livestock manure, rural household waste, halophytic plant biomass and MSW. Biomass can be used as a valuable renewable energy resource. In order to properly plan the energy scheme, it is necessary to estimate the amount of available organic material over the entire area. Therefore, in this study, the gross potential of different types of waste for the production of bioenergy from livestock and plant waste and other resources, as well as their distribution and suitability for the introduction of biogas technologies, were analyzed using GIS in all regions of the Republic of Uzbekistan.

Analyzing the agriculture of the Republic of Uzbekistan, its structure, industries and characteristics, as well as calculations of the gross potential of different types of waste for bioenergy production, they showed that the most valuable are:

1. The Republic of Karakalpakstan, Khorazm, Sirdarya, Navoi, Khorezm, Jizzakh and Bukhara oblasts have a high gross waste potential for producing bioenergy from halophyte plants, since in these areas the area of saline lands is much larger than in other areas;

2. The number of cattle exceeds in the Republic of Karakalpakstan, Kashkadarya, Samarkand, Bukhara and Andijan regions than the rest of the regions and they have a high potential for livestock waste to produce bioenergy from cattle biomass;

3. Kashkadarya, Samarkand, Bukhara, Andijan, Jizzakh and Navoi regions have a high potential for livestock waste to produce bio-energy from the biomass of sheep and goats, since the number of sheep and goats exceeds that in other regions;

4. Tashkent and Samarkand region have a high potential for the production of bioenergy from bird biomass, since the number of birds exceeds that in other areas.

#### References

- [1] Appendix to the Decree of the President of the Republic of Uzbekistan (2019). *On approval of the Concept of environmental protection of the Republic of Uzbekistan for the period until 2030*, (No. UP-5863), <https://cis-legislation.com/document.fwx?rgn=120270>.
- [2] Imomov, S. (2016) Biogas: ecology in organic matter. *Adabiyot Uchqunlari*, Tashkent, (in uzbek).
- [3] Test report No. 360/1. (2017). *Organic fertilizers after processing manure in a biogas plant in Karaulbazar-1 sample*. (According to MU 8m/254-2011), Ministry of Health of the Republic of Uzbekistan. Health Association. Sanitary and Epidemiological Station.
- [4] Socio-economic situation of the Republic of Uzbekistan for January-September 2019. (2019). [https://stat.uz/uploads/-doklad/2019/yanvar-sentyabr/ru/yanvar-sentyabr\\_2019\\_rus.pdf](https://stat.uz/uploads/-doklad/2019/yanvar-sentyabr/ru/yanvar-sentyabr_2019_rus.pdf)
- [5] State Committee of the Republic of Uzbekistan on Ecology and Environmental Protection. (2019). <http://uznature.uz/ru/legislation/ondata?legislationCategoryId=9>
- [6] Cuevas, J., Daliakopoulos, I. N., del Moral, F., Hueso, J. J. & Tsanis, I. K. (2019). A Review of Soil-Improving Cropping Systems for Soil Salinization. *Agronomy* vol. 9, no. 6: 295. <https://doi.org/10.3390/agronomy9060295>.
- [7] Ministry of Agriculture of the Republic of Uzbekistan. Available at: <http://agro.uz/uz/information/statistics/>

- [8] Toderich, K., Popova, V., Khujanazarov, T., Shoaib, I., Hasan, B., Mukimov, T., Zhapayev, R., & Shaumarov, M. (2016). Tests and best practices of bio-farming on saline soils in Central Asia and South Caucasus. <https://hdl.handle.net/20.500.11766/11331>.
- [9] Zavyalova, L. & Salihov, P. (2012). *Road map on development of biogas technology market in Uzbekistan*, UNDP, Tashkent. <https://mineconomy.uz/biogaz3.pdf>.
- [10] Akinshina, N., Azizov, A., Karasyova, T. & Klose E. (2016) On the issue of halophytes as energy plants in saline environment, *Biomass and Bioenergy*, vol91, 306–311, <https://doi.org/10.1016/j.biombioe.2016.05.034>
- [11] Appendix to the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan (2017). *On measures to expand the production and implementation of biogas plants in the republic in the period 2017 - 2019*. (June, 2017, No. 338)
- [12] Uzakov, G. N., Davlonov, H. A. & Holikov, K. N. (2018). Study of the Influence of the Source Biomass Moisture Content on Pyrolysis Parameters. *Appl. Sol. Energy*, vol. 54, 481–484. <https://doi.org/10.3103/S0003701X18060178>.
- [13] Uzakov, G. N., Davlanov, H.A. & Rabinov, R. (2017). Research of thermal processing of biomass for production of alternative fuel, *Geliotechnika*, vol. 3, 34–38 (in uzbek).