Journal of Geoscience and Environment Protection, 2025, 13(2), 1-9
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Basics of Biogas Production on the Absheron Peninsula

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How to cite this paper: Ali, R. S., & Ilgar, A. M. (2025). Basics of Biogas Production on the Absheron Peninsula. *Journal of Geoscience and Environment Protection, 13,* 1-9.
https://doi.org/10.4236/gep.2025.132001

Received: December 18, 2024
Accepted: February 8, 2025
Published: February 11, 2025

Abstract

Biogas production is an excellent solution to the problem of processing biological waste from livestock farms and generating additional profits for farming enterprises. Due to such a recycling cycle, it becomes possible to solve environmental problems associated with the concentration of large amounts of liquid and solid manure, rotting products of plant materials and household waste. In 2024, alternative energy in Azerbaijan is still not a priority, but continues to develop. The first stations were opened in the Absheron Peninsula and in the mountainous region of Sheki-Zagatala region. The study of biogas production from renewable energy sources in Azerbaijan has been one of the most important issues in recent years. This project is supported by the state and conditions have been created for young people to engage in scientific activities.

Keywords

Environmental Pollution, Biogas, Chemical Fertilizers, Decomposition, Benefits

1. Introduction

The collection and segregation of biodegradable waste from households in large cities is a real problem (Ahmadov & Sadigov, 2019). The problem is the odors generated during their decomposition, the most troublesome in areas with compact single-family housing (Sadigov et al., 2022b). Collection of this fraction of waste is usually every two weeks. Especially in the spring and summer period, too infrequent collection of waste from households is a problem. Due to high air temperatures, biodegradable waste decomposes quickly, which causes rotting of the organic matter and the creation of nuisance odors (Aliyeva et al., 2023). For this reason, it is often thrown into mixed waste, contaminating it, which makes it difficult to dispose of and poses a threat to people and the environment. As is known, only a small part of the manure accumulated in farms is used as fertilizer for plants in agrocenoses. Most of the manure is also collected and dumped on farms. For the country's energy supply, it is important to prevent the dumping of such biologically pure products and to profit from their efficient use (Al-Hazmi et al., 2024). Alternative energy, also non-traditional energy, is a sector of energy that includes the development and use of advanced installations, technologies and fuels for obtaining energy that, for economic and technical reasons, are less common than traditional ones (**Figure 1**). Biogas prevents environmental pollution base to the use of waste (Cornejo & Wilkie, 2010). Because it is a natural gas, it causes less greenhouse gas emissions than fossil fuels. Biogas plants reduce the amount of organic waste going to landfills and prevent the formation of garbage. Biogas consists mainly of methane (50% - 80%), carbon dioxide (15% - 50%) and a small amount of ammonia, hydrogen sulfide, nitrogen oxides and other substances.

The biomethane used in production is obtained by cleaning it from impurities (Davis et al., 2006). Its only distinguishing feature from natural gas is that it comes from natural decomposable sources. Anaerobic processing of organic waste (a significant proportion of which consists of biopolymers) to produce biogas, energy, and fertilizers is a resource and energy-saving technology. Currently, the state has taken a course to increase the energy and resource efficiency of the country's economy. More and more countries are striving for environmental stabilization based on alternative energy sources. This means that not only in the area of electricity supply, but also in other areas (for example, in heat and fuel supply) industry is forced to abandon fossil fuels. Depending on climatic, geographical and other features, the methods of using biogas as an alternative fuel differ in different regions. However, more than 90% of the biogas produced worldwide in 2020 was used to generate electricity and heat (Graunke & Wilkie, 2008). The remaining 9% used as fuel. This raises the question of what the future will look like and what role biogas technologies will play in it. There is a possibility of expanding the use of biogas by converting it into useful energy. The purpose of this article was to present the results of an analysis of various methods of using biogas with an emphasis on the advantages and disadvantages of each of them, identifying patterns in the development of the biogas industry and the impact on environmental pollution. Biogas is a renewable energy source (**Figure 2**). It can be obtained by a variety of methods from virtually any waste that is generated as a result of life activity, which indicates the feasibility of its further use as a resource (Hasanova et al., 2021a). Currently, the state has taken a course to increase the energy and resource efficiency of the country's economy, including the conservation of natural resources, the elimination of energy resource losses and increasing the efficiency of their use. Energy and, subsequently, resource conservation are not only an economic and business problem, but also, largely, an environmental one: a huge amount of fuel is burned to generate electricity, provide hot water and heat buildings. This leads, in addition to the depletion of one of the types of natural resources, to colossal emissions into the atmosphere, to the pollution of soil, surface and ground water (Nasirova et al., 2022). Consequently, one of the advantages of increasing energy efficiency is a reduction in the level of environmental pollution. Biogas production from silage and green waste also means a faster fermentation process and a higher yield of biogas from 1 ton of substrate (**Figure 3**).

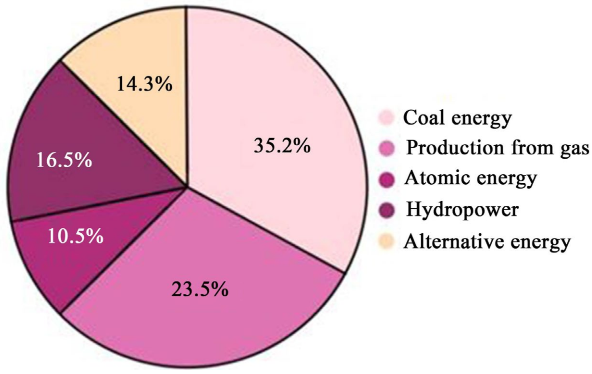


Figure 1. Structure of world energy production by sources.

The environmental benefits of biogas production and utilization are both global and local (Ošlaj & Muršec, 2022). Global benefits include reducing the consumption of fossil fuels and thereby extending their lifespan; obtaining a virtually inexhaustible source of energy, since biomass (including bioorganic waste) is constantly renewed; no replenishment of greenhouse gases in the atmosphere and thus climate protection.

For specific areas, the main environmental benefits of using biogas technologies: reducing the amount of waste and the volume of its accumulation and, accordingly, environmental pollution; reducing local air pollution due to fewer harmful emissions compared to fossil fuels; environmental safety of the area located in proximity to agro-industrial complex enterprises; reducing the content of organic matter in waste and wastewater; ecological isolation of production; reducing the areas allocated for storage and disposal of waste, and in rural areas—more rational use of agricultural land; increasing soil fertility or restoring disturbed lands through the use of fermented sludge; reducing the time for disposal of livestock waste; solving a number of sanitary and hygienic problems, such as improving the epidemiological situation as a result of the death of pathogenic microflora contained in the waste, reducing unpleasant odors.

2. Methods

2.1. Decomposition

A mixture of animal and plant waste is loaded into a reactor where it is mixed with live microorganisms. Hydrolytic, acid-forming and methane-forming bacteria participate in the decomposition process (Hasanova et al., 2021b). They initiate anaerobic fermentation. Bacteria consume the biomass and convert it into biogas.

It is collected under the reactor dome in a gas holder and then pumped into a cleaning compartment. To maximize the methane yield, animal components are mixed with plant components. Grass, post-alcohol stillage, brewer's grains, fruit and berry pulp added. This speeds up the fermentation process (Hasanova et al., 2025). The raw materials are loaded into the reactor through a pipeline and optimal conditions are created. To increase the speed and degree of decomposition, it is recommended to pre-prepare the waste for processing.

The raw material can be divided into fractions, crushed, heated and homogenized. Biochemical or biological treatment is also sometimes carried out. This requires special equipment. A biogas plant processes liquid and solid waste. In this case, preparatory work should be carried out separately for each type of substrate. After that, they can be mixed before feeding into bioreactors, or fed in separate streams. Obtaining biogas from waste takes an average of 40 - 60 days. This is a completely waste-free process, which is a big advantage of this method of processing. When fermentation is complete, a dry and liquid product remains. It does not smell and contains a large amount of minerals that are easily absorbed by plants (Hasanova & Abasova, 2024).

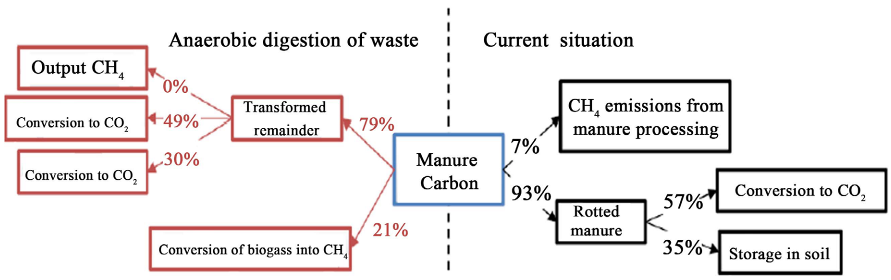


Figure 2. Anaerobic digestion of waste.

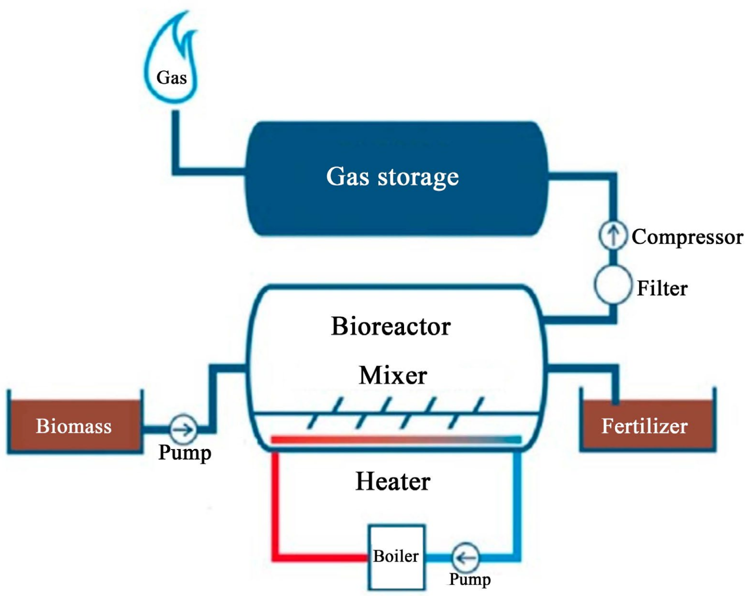


Figure 3. Scheme of a simple biogas plant in Absheron.

2.2. Biogas Production

Biogas, like natural gas, is one of the cleanest fuels. Its production prevents methane emissions into the atmosphere. Processed manure is used as fertilizer in farming, which reduces the use of chemical fertilizers and reduces the load on groundwater. Biogas production is made possible by processing some types of bacteria by others in a certain sequence (Figure 4 and Figure 5). Since biogas is a gas obtained by hydrogen or methane fermentation of biomass, methane decomposition of biomass occurs under the influence of three types of bacteria. In the food chain, subsequent bacteria feed on the waste products of the previous ones. The first type is hydrolytic bacteria, the second is acid-forming, the third is methane-forming, all these bacteria function in the body of animals. List of organic waste suitable for biogas production: manure, bird droppings, grain and molasses distillery dregs, brewer's grain, beet pulp, faecal sludge, fish and slaughterhouse waste (blood, fat, intestines, kanyga), grass, household waste, dairy waste—salted and sweet whey, biodiesel production waste—technical glycerin from rapeseed biodiesel production, juice production waste—fruit, berry, vegetable pulp, grape pomace, algae, starch and molasses production waste—pulp and syrup, potato processing waste, chip production—peelings, skins, rotten tubers, coffee pulp.

The biogas yield depends on the dry matter content and the type of raw material used (Figure 6, Figure 7).

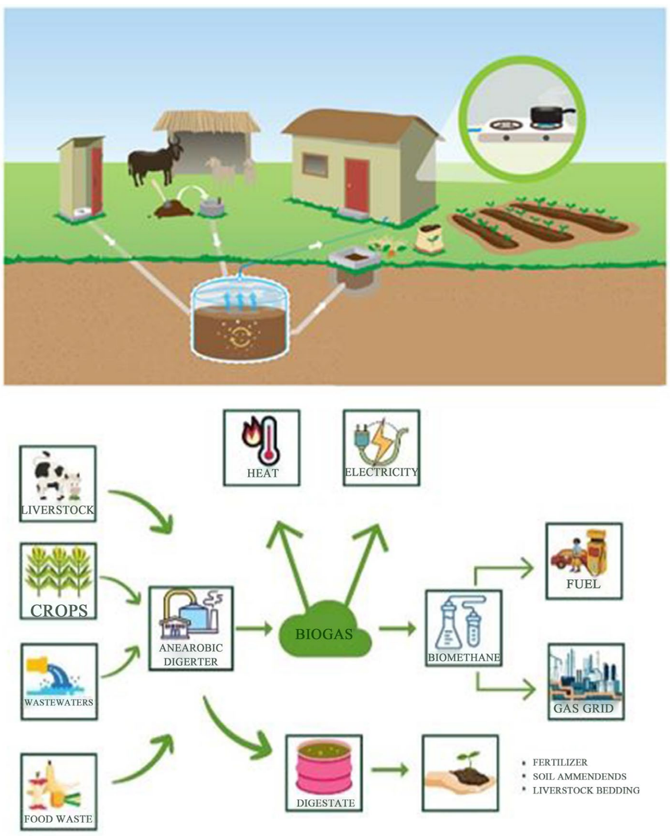


Figure 4. General figure of biogas production and use.

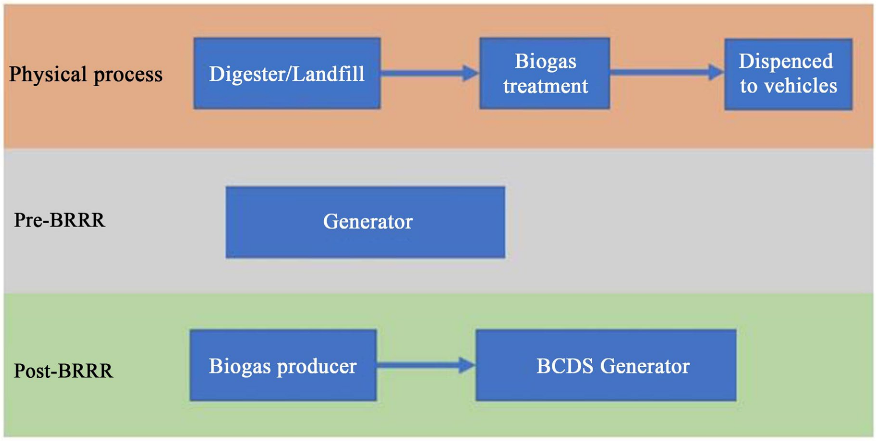


Figure 5. Parties of biogas closed distribution system. Note: BCDS – Biogas Closed Distribution System; BRRR – Biogas Regulatory Reform Rule.

3. Results

Biogas is a combustible gas obtained from natural biomass as a result of its anaerobic (without air access) fermentation. Three types of microorganisms actively participate in the decomposition process: hydrolysis; acid-forming; methane-forming (Ošlaj & Muršec, 2022). Agricultural complexes have invaluable energy sources such as: manure, litter, brewer's grain, beet pulp, faecal sediment and a huge amount of other organic waste, from which biogas is obtained after a certain technological process. This type of fuel is economical, since in terms of combustion heat, 1 m^3 of biogas is equivalent to: 0.8 m^3 of natural gas, 0.7 kg of fuel oil or 1.5 kg of firewood. Row materials (animal manure) for biogas in Absheron peninsula are goat, cattle, sheep and hen manures (**Figure 7**). Clean energy is renewable energy that does not consume the resources accumulated in the region. This topic allows young investigators to understand that without switching to alternative energy sources we are approaching an ecological catastrophe.

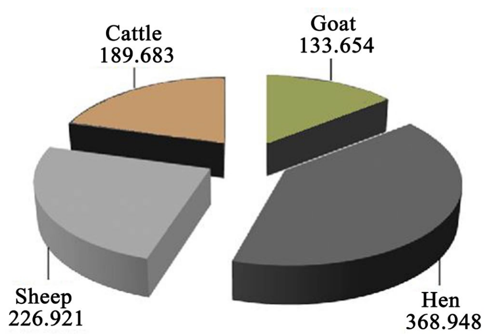
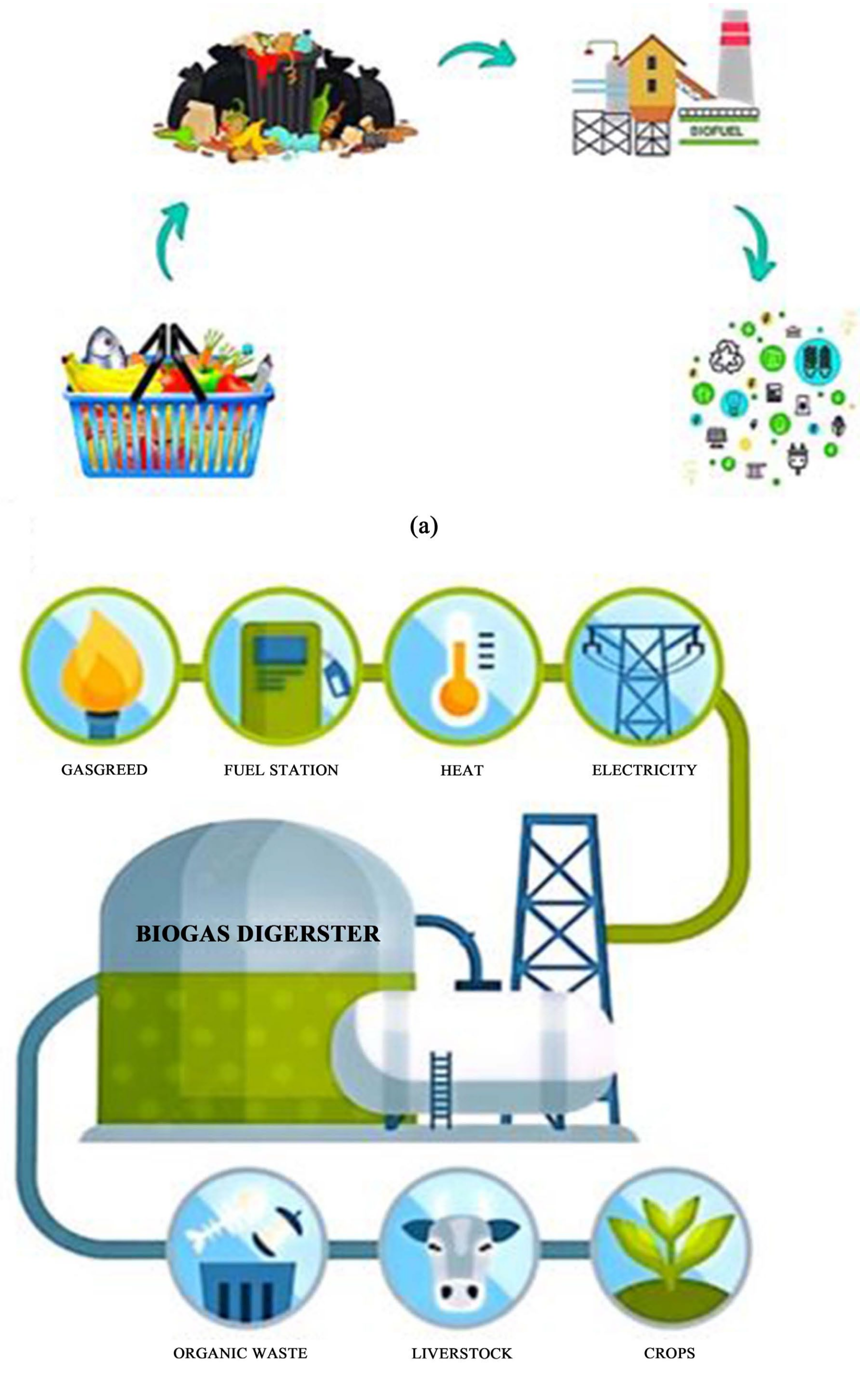


Figure 6. Row materials for biogas production in Absheron peninsula.

Biogas is compressed for feeding to gas-using units: power plant drive engines, heating boilers. Biogas pressure can be close to atmospheric, therefore, depending on the required output pressure, the following can be used to feed the unit:



(a) (b)

Figure 7. (a) Compressed biogas a sted towards clean energy; (b) Waste to energy.

- liquid ring vacuum compressors as independent compressors (output pressure up to 14 bar excess).
- liquid ring vacuum compressors as a preliminary stage of gas compression before a higher-pressure compressor—usually a rotary, screw piston compressor.
- centrifugal multi-stage compressors (output pressure up to 1 bar excess, capacity up to $45 \cdot 10^3$ m^3/h).

Another important aspect favoring the operation of a biogas plant using biodegradable municipal waste is its location. Starting the production of energy from biogas requires taking into account several important spatial conditions at the concept development stage.

In addition to waste, biogas can be produced from specially grown energy crops, such as silage corn or silphium, as well as algae, where the gas yield can reach up to 300 m^3/t.

4. Conclusion

Biogas consumption for household needs: Cooking a portion of food for one person—0.15 - 0.3 m^3; Boiling water—0.03 - 0.05 m^3; Heating a room—0.2 m^3 per day. Kitchen biowaste will be regularly delivered to the biogas plant and unloaded into a silo from where it will be directly used in the biogas production process. Biogas production is of great economic importance for obtaining biofuels, heat, electricity, fertilizers, helps prevent methane emissions into the atmosphere, and can also be used as automobile fuel.

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Acknowledgements

The authors express gratitude for the support of the scientific and technological research project to the Ministry of Science and Education of Azerbaijan Republic and to the Center for Organization of Laboratory Work in Azerbaijan State University of Economics

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Ahmadov, S. A., & Sadigov, R. A. (2019). *Applied Ecology—The Textbook for High Schools*

(p. 321). Sabah.

Al-Hazmi, H. E., Hassan, G. K., Kurniawan, T. A., Śniatała, B., Joseph, T. M., Majtacz, J. et al. (2024). Technological Solutions to Landfill Management: Towards Recovery of Biomethane and Carbon Neutrality. *Journal of Environmental Management, 354,* Article ID: 120414. https://doi.org/10.1016/j.jenvman.2024.120414

Aliyeva, N. T., Sadigov, R. A., Mamedova, R. I., & Ibadova, S. Y. (2023). Analysis of the Content of Heavy Metal Ions in the Coastal Zones of the Northern Part of the Apsheron Peninsula. *Bulletin of the Karaganda University "Biology medicine geography Series", 109,* 176-183. https://doi.org/10.31489/2023bmg1/176-183

Cornejo, C., & Wilkie, A. C. (2010). Greenhouse Gas Emissions and Biogas Potential from Livestock in Ecuador. *Energy for Sustainable Development, 14,* 256-266. https://doi.org/10.1016/j.esd.2010.09.008

Davis, J. A., Farrah, S. R., & Wilkie, A. C. (2006). Selective Growth of *Staphylococcus aureus* from Flushed Dairy Manure Wastewater Using Acriflavine-Supplemented Mannitol Salt Agar. *Letters in Applied Microbiology, 42,* 606-611. https://doi.org/10.1111/j.1472-765x.2006.01915.x

Graunke, R. E., & Wilkie, A. C. (2008). Research and Solutions: AASHE Student Award-Winning Paper: Converting Food Waste to Biogas. *Sustainability: The Journal of Record, 1,* 391-394. https://doi.org/10.1089/sus.2008.9914

Hasanova, T. A., Mammadova, G. I., Bunyatova, L. N., & Gahramanova, A. Y. (2021a). Importance of Biodiagnostics and Irrigation Gray-Brown Soils. *Universal Journal of Agricultural Research, 9,* 63-69. https://doi.org/10.13189/ujar.2021.090301

Hasanova, T., & Abasova, N. (2024). Statistical Analysis of the Soil Activity in Sheki-Zagatala Economic Region. *EUREKA: Life Sciences, 3,* 3-11. https://doi.org/10.21303/2504-5695.2024.003564

Hasanova, T., Mirzezadeh, R., & Asgarova, G. (2025). Comprehensive Studies of Greater Caucasus River Valleys Soils. *EUREKA: Life Sciences, 1,* 11-18. https://doi.org/10.21303/2504-5695.2025.003654

Hasanova, T., Mammadova, G., & Asgarova, G. (2021b). Phytomass of Gray-Brown Soils Forming in Arid Ecosystem of Azerbaijan. *Bulletin of Science and Practice, 7,* 110-115. https://doi.org/10.33619/2414-2948/70/11

Nasirova, A. I., Alieva, M. M., Mammadova, R. N., & Hasanova, T. A. (2022). Bioecological Edificators of Gray-Brown Soils in Ganja-Gazakh Massif (Azerbaijan). *Environment and Ecology Research, 10,* 392-397. https://doi.org/10.13189/eer.2022.100307

Ošlaj, M., & Muršec, B. (2022). Biogas as a Renewable Energy Source. *Tehnicki vjesnik—Technical Gazette, 17,* 109-114.

Sadigov, R. A., Tarlan, A. N., Abdullaeva, M. Y., & Ibragimov, S. K. (2022). Environmental Assessment of the Gray-Brown Soils of the Coast of the Absheron Peninsula. *Journal World Science, 4,* 1-5.