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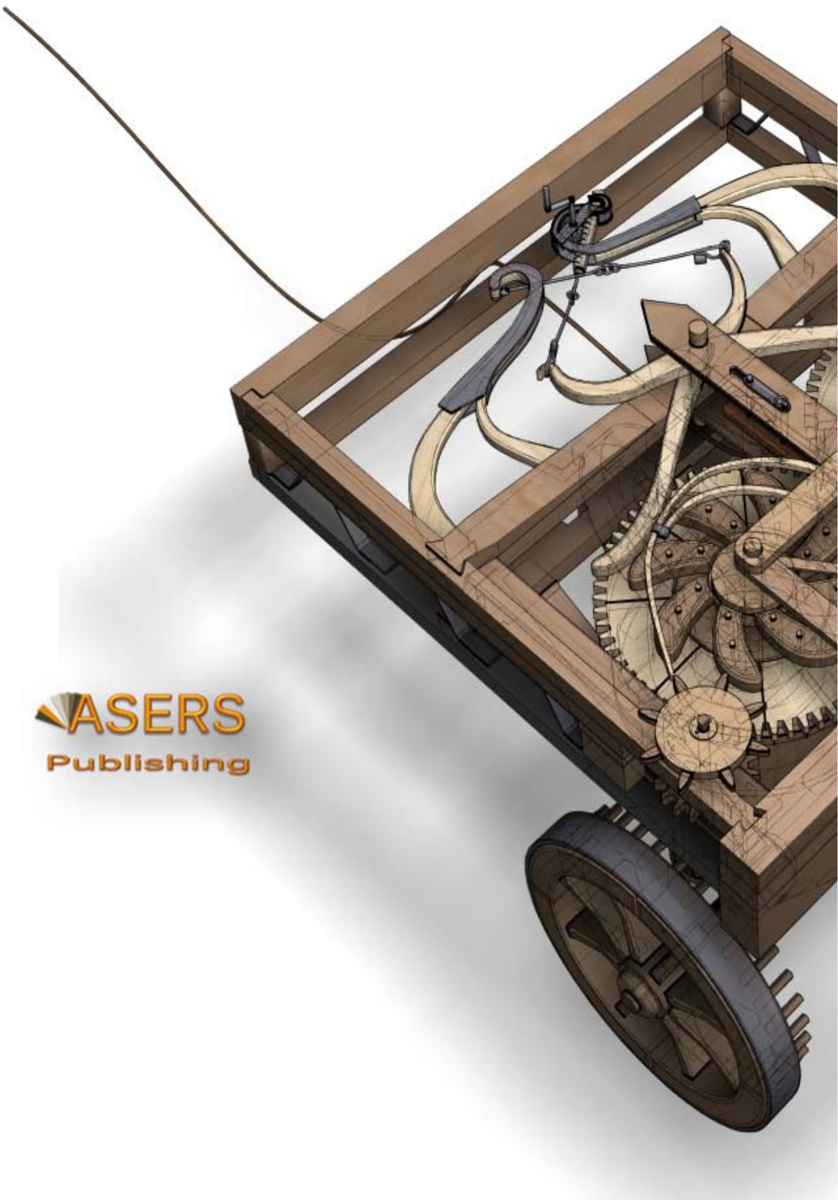

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Call for Papers
Fall Issues 2020
Journal of Environmental Management and Tourism

Journal of Environmental Management and Tourism is an interdisciplinary research journal, aimed to publish articles and original research papers that should contribute to the development of both experimental and theoretical nature in the field of Environmental Management and Tourism Sciences.

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The Waste-Free Production Development for the Energy Autonomy Formation of Ukrainian Agricultural Enterprises

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Abstract:

Agriculture has been considered as one of the priority countries sectors in our research; the share of agriculture in the gross domestic product of the world leading countries was investigated. The theoretical and practical aspects of non-waste agricultural production development using animal waste and crop residues fermented in biogas plants are revealed. The authors substantiate the relevance and potential of the introduction of waste-free technology which has considerable advantages of energy autonomy both for the enterprise and the country. The state of humus content in soils of Ukraine is also considered. International experience has been evaluated, which consists in the ability of agricultural waste both to produce alternative sources of energy and to use the products of their processing as organic fertilizers that significantly increase crop yields.

The first steps of the Ukrainian agricultural enterprises to introduction of non-waste production on the example of the company LLC Organic-D have been presented; it heats and electrifies the complex, dries crops, and also uses organic fertilizer (digestate) due to waste processing in the biogas station. As a result of the research, it was found that the application of organic fertilizer can have a positive effect on soil recovery, because the soil acidity has changed from a level of weak acid (5.4 pH) to a level close to neutral (6 pH) for one year of its application. To conclude, the obtained results prove the relevance of the research problem.

Keywords: agriculture; waste; digestate; biogas; soil acidity; autonomy of agricultural enterprise.

JEL Classification: O13; Q16; Q 42.

Introduction

Nowadays the issue of enterprise energy autonomy is quite urgent in the modern conditions; it requires deep research and analysis. The key to ensuring the enterprise energy autonomy is the introduction of non-waste production, which involves the processing of agricultural waste in a biogas plant for biofuels and organic fertilizer (digestate). The use of agricultural waste allows the agrarian and industrial complex to provide energy autonomy solving a number of environmental problems and obtaining additional economic benefits.

It should be mentioned that both domestic and foreign scientists researched a wide range of issues related to the impact of non-waste production on the financial status and production efficiency of the enterprise, environmental and energy security of the country. We should name scholars who have paid considerable attention to research on this subject, *i.e.* Bulgakov, V. *et al.* (2019), Kaletnik, G. (2018), Koszel, M., Lorencowicz, E. (2015), Kung Ch.-Ch., Wu T. (2020), Malovanyi, M., Tymchuk, I. (2012), Melnyk, N. (2019), Merefianskyi, H. (2020), Muhmood, A. *et. al.* (2018), Mukhuba, M. *et al.* (2018), Palamarchuk, V. *et al.* (2018), Riya, S. *et al.* (2020), Shpykuliak, O., Bilokinna, I. (2019), Stuchynska, N. (2016), Varchenko, O.M. *et. al.* (2020) and others.

Considering considerable potential of these scientists' researches, we think that this topic is a subject to study and requires further scientific research.

1. Literature Review

Modern theoretical views of leading scientists on the development of non-waste agricultural production and energy autonomy of enterprises are overflowing with various ideas, tendencies, methods, or recommendations for the effective utilization of agricultural waste (crop residues, animal manure, food waste) digested in biogas plants.

Researching the physical and chemical properties of the digested substance in a biogas plant, Koszel, M., Lorencowicz, E. (2015) consider that waste disposal usage as a fertilizer (digestate) is one of the main ways of its utilization. Scientists used digestate in growing alfalfa. They have examined the content of macronutrients before and after digestate application to the soil, the analysis showed an increase in the content of macronutrients in alfalfa leaves and an increase in yield.

According to Muhmood, A., Majeed, A., Niaz, A. and others (2018), the integrated use of mineral and organic fertilizers is crucial for sustainable crop production and soil fertility stabilization. This is confirmed by a three-year field study to evaluate the potential of anaerobic digestion or its integration with mineral fertilizers to improve wheat production and soil fertility. In addition, scientists have concluded that about half of the nitrogen fertilizers (urea) can be eliminated through the attraction of mineral fertilizers and digestion of organic fertilizers.

Nowadays, constant use of mineral fertilizers has led to a gradual decline in soil fertility and environmental pollution. Mukhuba, M., Roopnarain, A., Adeleke, R., Moeletsi, M., Makofane, R. (2018) investigated the issue of anaerobic digestion leading to the production of two valuable products, *i.e.* biogas and digestate, a fertilizer rich in nutrients. The scholars evaluated undigested manure and digestate as a fertilizer. Both manure and digestate contain heavy metals and nutrients. However, the digestion process caused a decrease in the content of heavy metals and some potential pathogenic bacteria in the manure. In addition, undigested manure contained pathogens; they could impair plant morphological features and cause human diseases. Thus, digestate has more potential than undigested manure as an organic fertilizer increasing humus content in soils.

Riya, S., Meng, L., Wang, Y., Lee, C.G., Zhou, S., Toyota, K. and Hosomi, M. (2020) investigate anaerobic digestion as a technology for treatment of organic wastes, which can biologically decompose carbohydrates, proteins, and lipids in the absence of oxygen and produce biogas (CH_4 and CO_2). Nutrients are retained in the residue of anaerobic digestion, called digestate. Digestate can be applied to agricultural land as a fertilizer for production of crops or forages since it contains nutrients. Recycling raw materials as a fertilizer can reduce chemical fertilizer production, hence reducing fossil fuel consumption and CO_2 emission.

Melnyk, N. (2019) has considered energy dependence and the possibility of using renewable energy sources as a driving force for the development of bioenergy in Ukraine; the scholar argued that Ukraine has significant opportunities both in biomass cultivation and in bioenergy fuels application making it an energy-independent country in the world and providing consumers and manufacturers with the required amount of liquid, gaseous and solid fuels.

Renewable energy (biogas), thermal energy, electricity and organic fertilizer (digestate) can be produced from agricultural waste. According to Kaletnik, G. (2018), there are several reasons for the formation and development of the Ukrainian biofuels market, starting from energy security considerations, diversifying national production, supporting innovation, and ending with the economic and social efficiency of biofuels market development based on the high motivation for the growth of the agricultural sector, the positive social shift in rural employment growth and environmental security through renewable energy.

In order to reduce the current level of CO_2 emissions into the atmosphere and conserve fossil fuels, Kung Ch.-Ch., Wu T. (2020) analyzed the use of agricultural resources for biofuel production examining how the selection of bioenergy crops and bioenergy technologies affect the amount of clean production of bioenergy. The authors substantiate the potential of agricultural waste processing in ensuring environmental safety.

Varchenko, O.M., Krysanov, D.F., Shubravska, O.V., Khakhula, L.P., Gavryk, O.Y., Byba, V.A., Honcharuk, I.V. (2020) proved the need to concentrate government support for the development of small agricultural products. Carrying out a cluster analysis of small farms, scientists have found that it is advisable for state to support the development of farms making profit from crop products. The necessity to develop regional support programs for small farms growing energy crops to produce alternative energy sources is substantiated; they would provide compensation of material costs for its production in the amount of 50% of the cost norms.

Shpykuliak, O., Bilokinna, I. (2019) proved that "green" cooperatives play an important role in the formation of an institutional mechanism of development of alternative power engineering in the agrarian sector of the Ukrainian economy. Villagers and agricultural producers can secure their energy independence through the creation of green cooperatives, reduce energy costs, and make money by selling energy and fuel. It will increase the production and utilization of alternative energy sources in the agricultural sector of the country, and significantly affect the development of rural areas and agricultural enterprises.

Palamarchuk, V., Honcharuk, I., Honcharuk, T., Telekalo, N. (2018) have researched the technology of corn cultivation and the efficiency of starch as a biological raw material for bioethanol production in Ukraine, it has proved the dependence of productivity, starch content and yield of bioethanol on the seeding depth and the size of the seed fraction.

The researchers Bulgakov, V., Kaletnik, H., Goncharuk, T., Rucins, A., Dukulis, I., Pascuzzi, S. (2019) conducted a detailed study of the criteria for assessing the stability of a mechanical system used in agriculture and allowing them to be widely used to study the performance of a soil tillage system when it is affected by random forces that were not taken into account in the original model. Having considered the example of determining the stability of the movement of a towed cultivator, they found that this method of research can be successfully used for practical purposes in the cultivation of energy crops.

Scientists Bulgakov, V., Kaletnik, H., Goncharuk I., Ivanovs, S., Usenko, M. (2019) have carried out an experimental comparative research of the performance indicators of the working body of the soil tillage with a flexible harrow with teeth loosening for energy crops cultivation, they have come to the conclusion that the soil cultivation processes significantly affect the growth of these crops. In the course of comparative experimental studies of plows with standard flexible harrow and experimental active harrow with teeth loosening, the soil roughness and the water permeability of the obtained soil structure were evaluated. Thus, the improvement of different designs and combinations of plows is an actual practical and scientific task, its solution will affect the increase of energy crops yield.

2. Methodology

Calculation, experimental, comparative, economic and statistical methods were used for the scientific research.

The calculation method was used in forecasting and planning the production and economic processes of agroindustrial development, in particular processing agricultural waste into biofuels. It involves the development of several options for solving the problem under study, their evaluation, followed by the choice of the best of them. This method involves many forecasts and targets.

Economic and statistical method is used to study mass phenomena, processes, facts and identify trends and patterns of their development using statistical data. The share of agroindustrial complexes in the gross domestic product of the leading world countries, the main indicators of agriculture of Ukraine, the state of maintaining the content of organic matter (humus) in the soils of Ukraine were analyzed, and the dynamics of their changes was analyzed accordingly. This method allowed to establish quantitative influence of individual factors on the investigated result, to identify the main factors that caused changes in the course of economic processes of the agroindustrial complex.

The experimental method involves the experimental activities carried out in the research process, they are considered as a practical step to validate theoretically valid problems. The experiment is based on accurate calculations and real research. The function of experiments is to confirm the correctness of theoretical developments, to refine them or to refute them. Using this method, the effect of application of mineral fertilizers on corn yield, the use of organic fertilizer (digestate) with half the amount of mineral fertilizers on corn yield were investigated (base of research was LLC Organic-D, Vinnytsia region, Ukraine). The comparative method was simultaneously used with the experimental one to perform a comparative analysis of the obtained results and formulate appropriate conclusions and suggestions.

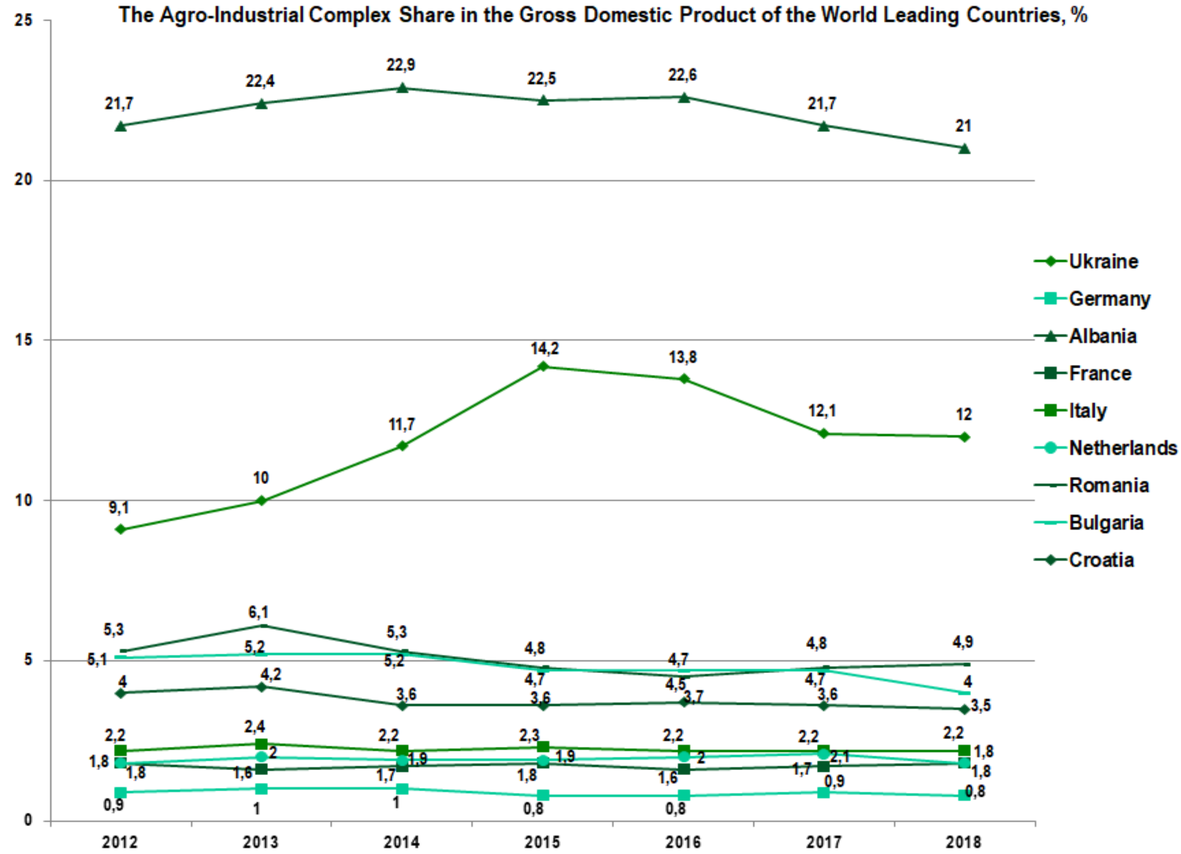
3. Case Studies

Agriculture is one of the major economic sectors of any country. The agro-industrial complex is the driving force of the national economy and the food security guarantor of Ukraine and the world; it is confirmed by its share in the world countries gross domestic product. According to the United Nations Economic Commission for Europe (UNECE), the share of agriculture in the EU's gross domestic product varies from 2 to 5%. In Ukraine, agriculture accounts for more than 12% of gross domestic product; the dynamics of statistics show that agriculture is gradually coming out on top and is the only stable industry in the country's economy (Figure 1).

The share of agricultural production amounted to 39.8% or $ 18.8 billion in total Ukrainian exports in 2018. The agro-industrial complex employs about 3 million people (excluding seasonal workers), and a third of the population resides in rural areas. According to the monitoring report Sustainable Development Goals: Ukraine, a promising task for agricultural development in Ukraine is to double agricultural productivity due to innovative technologies application. The agricultural productivity target is $ 10.0 thousand per employee and the agricultural product index is up 102% in 2020 (Table 1).

The variety of products produced by the agro-industrial complex ranges from food, feed and raw materials to the processing industry and animal breeding. Agriculture has been increasingly considered as a source of electricity, heat and biofuels for biomass utilization in recent years.

Figure 1. The Agro-Industrial Complex Share in the Gross Domestic Product of the World Leading Countries



Source: formed by the authors according to United Nations Economic Commission for Europe 2018 data

Table 1. The Main Indicators of Ukrainian Agriculture

Country	Year			
	2015	2016	2017	2018
Labor productivity in agriculture, $ 1,000 per employee	8.68	8.71	9.30	10.89
Agricultural production index, %				
Agricultural products (farms of all categories), including:	95.2	106.3	97.8	108.1
crop products	94.8	109.9	97.0	110.7
livestock products	96.3	98.0	100.1	101.5

Source: data from Monitoring report "Sustainable Development Goals – Ukraine 2019"

Conducting agricultural production, a large number of by-products and waste is generated. Many types of such waste are pollutants to the environment. There are serious risks to water, air, soil, biodiversity and human health.

According to the Intergovernmental Panel on Climate Change, the industrial anthropogenic greenhouse gas emissions are 21%, transport are 14%, energy and extraction are 35%, and the housing sector are 6%, agriculture, forestry and land utilization are 23%. Worldwide, agriculture, forestry and land utilization emissions consist of 13% of carbon dioxide (CO_2), 44% of methane (CH_4), and 82% of nitric oxide (N_2O).

Most world countries are struggling with the reduction of carbon dioxide emissions. According to the German Government Climate Action Plan 2050, an assessment of existing climate scenarios and transformation analysis was carried out, the general goals, principles, milestones and transformation measures for each branch of the country's economy, i.e. energy, construction, transport, industry, agriculture etc. were determined. German total greenhouse gas emissions should be reduced at least by 55% by 2030 compared to 1990 (reference value: total CO_2 emissions equivalent to 1,248 million tons).

Modern agriculture must always responsible utilize natural resources. Taking into account the global development of the world population today the agro-industrial complex should work efficiently increasing production volumes, and grow production at sustainable level of environmental pollution. There are standards for soil and sewage pollution by fertilizers and food waste in the European Union.

In accordance with the 2050 Climate Action Plan, Greenhouse gas emissions from agriculture were 72 million tons of CO_2 equivalents in 2014 (8% of all CO_2 emissions). The largest sources are nitrogen oxide emissions from nitrogen fertilizers application (25 million tons of CO_2 equivalent), methane emissions from animal manure (25 million tons of CO_2 equivalent), fertilizer emissions and plant protection products (10 million tons of CO2 equivalent) and greenhouse gas emissions from the use of fuel in agricultural machinery and vehicles (6 million tons of CO_2 equivalent). In 2014 emissions from agriculture were about 18 percent below the 1990 level. The substantial declines from 1990 to 1994 were primarily due to reduction in livestock carbon dioxide emissions and reductions come from improvements in fertilizer management. Most agricultural greenhouse gas emissions are caused by natural physiological processes, so the ability of technical measures to reduce them is limited. Twenty percent of land used for agricultural should be organically farmed by 2050, up from 6.3 percent in 2014. The government has developed an overall strategy to reduce greenhouse gas emissions from livestock and improve farming through organic fertilizers, introducing a standard of state support for farms that have 2 heads of farm animals per 1 ha of arable land (Climate Action Plan 2050).

Such measures of German agrarians are very relevant for agriculture in Ukraine because some agricultural formations don't adhere to the rules on environmental management of agriculture in Ukraine; the uncontrolled waste management of some agricultural enterprises continues leading to environmental catastrophe in some regions of the country.

In Ukraine, the percentage of plowed agricultural land is increasing every year; it is 53.9% on January 1, 2020. The share of areas treated with organic fertilizers to the total area of agricultural land is small and it is less than 1%. However, mineral fertilizers application is increasing every year. The volume of mineral fertilizers applied per unit area of agricultural land has doubled for the last four years causing the mineralization of the soils of Ukraine (Table 2). This is a negative indicator because such large volumes of mineral fertilizers destroy the macro and trace elements in the soil increasing the acidity of the soil and other negative consequences.

Table 2. Organic Matter (Humus) Content in Soils of Ukraine

Indicator	Year				Deviation 2018/2015 (+, -)
	2015	2016	2017	2018	
Agricultural area, million ha	41.5	41.5	41.5	41.5	-
Mineral fertilizers application					
Total amount of applied mineral fertilizers, 1,000 t N, P_2O_5 and K_2O	1,415.0	1,728.9	2,028.1	2,346.3	931.3
Mineral fertilizers applied per unit area of agricultural land, kg N, P_2O_5 and K_2O / ha	34.1	41.7	48.9	56.5	22.4
Areas treated with mineral fertilizers, million ha	14.5	15.7	16.5	16.1	1.6
Percentage of areas treated with mineral fertilizers, %	34.9	37.8	39.8	38.8	3.9
Organic fertilizers application					
Organic fertilizers application, 1,000 t	9,662.7	9.162.9	9,273.9	11,648.9	1,986.2
Organic fertilizers applied per unit area of agricultural land, kg / ha	232.8	220.8	223.5	280.7	47.9
Areas treated with organic fertilizers, million ha	0.4	0.5	0.5	0.8	0.4
Percentage of areas treated with organic fertilizers, %	1.0	1.2	1.2	1.9	0.9
Area under organic production, thousand ha	410.55	381.2	289	-	-
Land tilling					
Area of tilling land (arable land), thousand ha	32,531.1	32,541.3	32,543.5	32,544.2	13.1

Source: formed by the authors on the basis of data State Statistics Service of Ukraine

From an agroecological point of view, quantitative and qualitative composition of mineral fertilizers including impurities, their impact on soils complex including acid properties of soil solution, processes of leaching and migration of biogenic elements and toxicants, activity of microbiological and biochemical processes in soil, impact on the quality of agricultural products are important for the assessment of the possible negative impact of mineral fertilizers on the environment (Malovanyi and Tymchuk 2012).

The organic fertilizers application and the cultivated area should be increased in order to improve environmental safety and promote the non-waste production of agricultural enterprises.

Agriculture can make an important contribution to combating climate change through sustainable production and protection of natural resources by processing of food waste, crop residues and animal manure for biofuels.

For example, waste of agricultural enterprises, livestock and poultry farms, food and processing industry enterprises, various waste of vegetable and animal origin are used for the biogas production. First of all, it concerns waste prone to biodegradation.

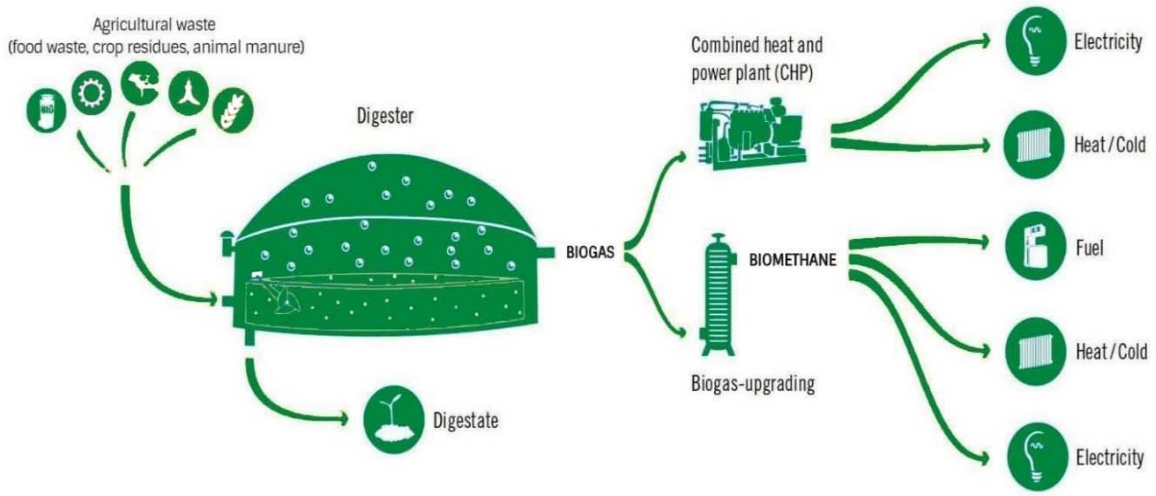
Biogas produced from biomass is used as fuel and it is not harmful to the environment because it does not cause additional greenhouse gas CO_2 emissions and reduces the amount of organic waste. Biogas can be produced regardless of climatic and weather conditions unlike wind energy and solar radiation. In Ukraine biogas has a renewable potential of 3.2 billion m^3 which remains unused unlike fossil fuels (State Agency on Energy Efficiency and Energy Saving of Ukraine).

Biogas as a biodigestion product with a high methane content can be converted into electricity to sell at a green tariff, heat (for enterprise needs or for sale), and hot water, organic waste of the biogas plant (digestate) can be also used as a fertilizer (Figure 2).

Digestate is the residue of biogas production from organic mass. Biogas is formed as a result of organic matter methane fermentation. The gas is only 10% of the total production biomass. The other 90% of biomass comes for digestate. It contains such components as 2.3-4.2 kg/t of nitrogen, 0.2-1.5 kg/t of phosphorus, and 1.3-5.2 kg/t of potassium. This substance is similar to compost in its chemical composition, so it can be used as an additional fertilizer to increase soil fertility.

Digestate can be both liquid and solid. Liquid digestate is applied into the soil, and the digestate solid fraction can be dried, granulated and combined with other wastes. It is convenient to combine it with other waste or organic products, such as wood chips and sawdust. Digestate improves crop yields by providing additional nutrients and helping to maintain the necessary soil moisture. Mineral fertilizers are absorbed only by 35-50%. However, biofertilizers are absorbed by almost 99%. That's why farmers are now increasingly appreciating digestate as an alternative fertilizer (Merefianskyi 2020).

Figure 2. Technological Scheme of Biogas Production at an Agricultural Enterprise



Source: Digestate as Fertilizer, 2018

European agricultural experience shows that the processing of agricultural waste for renewable energy sources can provide the company with energy resources and ensure its autonomy because the processing of agricultural waste to biogas will provide the company with energy resources, heat, and quality organic fertilizer (digestate), which helps to reduce the production cost and increase the yield and profitability of crop production.

Waste-free agricultural production in Ukraine is a driving force for food, environmental protection, and energy and economic security.

The young agricultural enterprise LLC Organic-D in Vinnytsia is a vivid example of effective utilization of recyclable waste from its own production, it operates on the principle of non-waste production using its own biogas station.

The sequence of station operations within the algorithm is as follows: animal residues from the premises are drained into a biogas plant and fermented for 30 days. As a result of the biogas station operation the company receives:

- biogas output (1,200 m^3/day);
- volume of electricity (250-300 kW) and thermal energy (300-350 kW);
- organic fertilizer digestate (60 t/day) to enrich their own agricultural land.

The main indicators, the content of micro and trace elements (Table 4) were determined after the result of agrochemical analysis of organic fertilizer (digestate) obtained from the biogas plant.

As a result of the research, it was found that the application of organic fertilizer can have a positive effect on both yields and soil recovery, because the soil acidity has changed from a level of weak acid (5.4 pH) to a level close to neutral (6 pH) for one year of its application.

Thus, as a result of the research it was found that corn yield was 11.9 t/ha when digestate was used in variant A, it was 9.6 t/ha without using digestate, it is by 2.3 t/ha less than in field A. Besides increasing corn yield on the field applied with digestate the fertilizer purchase costs adecreased significantly by UAH 3,798.67 per ha because mineral fertilizers were significantly reduced in field A due to digestate application.

Table 3. Capacities of agricultural enterprise LLC Organic-D

Cropland, ha	300 ha including 60 ha of irrigation fields	120 ha are vegetables, 180 ha are maize (used for biogas production)
Vegetable warehouse	3,000 t	
Warehouses	1,200 m^2	
Enterprise territory	25,000 m^2	
Pig population, heads	6,000	Animal residues from the premises are drained into a biogas plant. The manure stored in the biogas station ferments for 30 days.
Manure output	8 kg/day per 1 head	
Biogas output, m^3	1,200 m^3/day	It is not sold at the green tariff, but it is used to meet enterprise`s needs.
Digestate output, t	60 t/day	It is used as a field fertilizer to replenish humus content, reduces soil acidity, reduces fertilizer application and improves yields
Volume of electricity, year	250-300 kW	Electrification of production; drying cereals
Volume of heat energy, year	300-350 kW	Heating pigsties

Source: formed by the authors according to LLC Organic-D data

Table 4. Agrochemical Analysis Results of Organic Fertilizer (Digestate)

No.	Indicators, units of measure	Experiment results
1	Salts pH	8.5
2	Moisture mass fraction, %	98.4
3	Dry matter, %	1.6
4	Natural ash content, %	0.60/37.3
5	Natural organic matter content, %	1.00/62.7
6	Nitrate nitrogen content, mg/kg	18.2
7	Ammonium nitrogen content, %	0.23
8	Total nitrogen mass fraction, %	0.29
9	Total phosphorus mass fraction, %	0.09
10	Total potassium mass fraction, (K_2O), %	0.32
Micro- and macro elements content		
11	Copper, mg/kg	4.6
12	Zinc, mg/kg	32
13	Manganese, mg/kg	20
14	Iron, mg/kg	120
15	Magnesium (MgO), %	0.042
16	Calcium (CaO), %	0.35

Source: formed by the authors according to LLC Organic-D data

This research confirms the real utility and efficiency of the digestate utilization in agriculture. Using digestate we can:

- halve the use of the required amount of mineral fertilizers;
- provide plants with macro- and microelements that are part of the agrochemical composition of organic fertilizers;
- restore the humus layer;
- to reduce the acidity of the acid soils;
- increase both crop productivity and the enterprise profitability.

According to the Bavarian State Science Center for Agriculture, it is most effective to use digestate with mineral fertilizers, because this combination leads to the maximum yield increase.

Table 5. Soil Samples Analysis before and after Digestate Application at agricultural enterprise LLC Organic-D

Indicator	Units of measure	Soil analysis before digestate application (2018)		Soil analysis after digestate application (2019)	
		Field average	Supply ratio	Field average	Supply ratio
Exchangeable acidity	-	5.40	Slightly acidic	6.00	Near neutral
Organic matter	%	1.81	Weak	2.52	Average
Mineral nitrogen	mg/kg	14.20	Weak	20.70	Average
Mobile phosphorus	mg/kg	131.50	Slightly strong	170.70	Strong
Exchangeable potassium	mg/kg	105.00	Average	210.60	Strong
Exchangeable calcium	mg/kg	2,152.70	Slightly strong	2,461.00	Slightly strong
Exchangeable magnesium	mg/kg	149.70	Average	153.00	Average
Mobile sulfur	mg/kg	4.50	Weak	6.50	Average
Electric conductance	MS/m	6.05		10.20	

Source: formed by the authors according to LLC Organic-D data

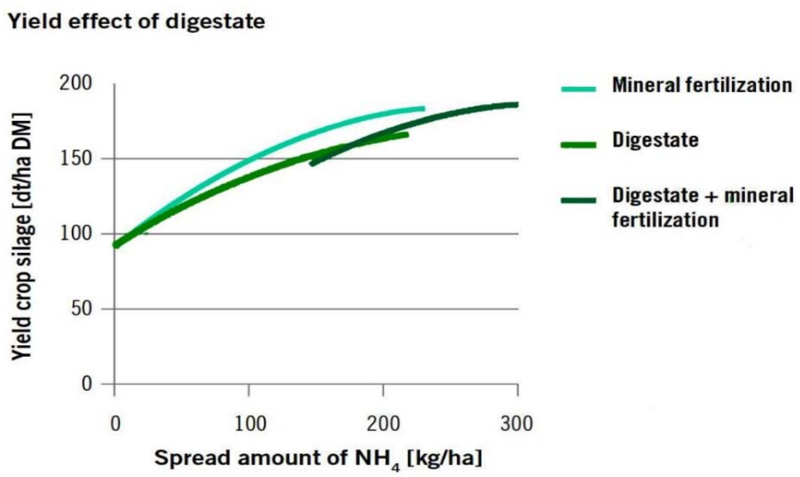
Table 6. Comparison Table of Corn Yields Using Digestate at Application at agricultural enterprise LLC Organic-D in 2019

Indicator	The field applied with digestate and mineral fertilizers (variant A)			The field applied with mineral fertilizers (variant B)		
Field area, ha	7.68			9.95		
Yield, t/ha	11.9			9.6		
Applied mineral fertilizers:	Kg	UAH	UAH/ha	kg	UAH	UAH/ha
Nitrogen-phosphorus-potassium (9-25-25)	884.787	11,562.5	1,505.53	1,144.731	14,959.38	1,503.46
Carbamide	1,269	13,705.2	1,784.53	1,691	18,262.8	1,835.46
Kaliimah				2,488	21,372.75	2,148.02
Ammonium nitrate				2,360	2,5725.7	2,585.50
YaraMila Complex				492	8,417.45	8,45.97
Magnesium sulfate				30	301.02	30.25
Zinc				9.956	896.4	90.09
Digestate	230,400	1,4976	1,950			
Total	232,553.8	40,243.7	5,240.07	8,215.69	89,935.50	9,038.74

Source: formed by the authors according to LLC Organic-D data

In most cases digestate is more cost-competitive than mineral and other organic fertilizers enabling farmers to save significantly on one of the costliest items of production. Building biogas plants farmers can produce fertilizers for their own land and even sell them through waste processing. This can provide an additional source of income for farmers and thus ensure their own economic independence.

Figure 3. The Effect of Digestate Applying



Source: Data from the Bavarian State Science Center for Agriculture, Digestate as Fertilizer, 2018

According to the Italian Biogas Association, Italy produces about 30 million tons of digestate a year, which saves 400 million euros on organic fertilizers. In Ukraine, most farmers are little informed (or even misinformed) about the benefits of digestate. This point of view should be changed; at the state level they should promote the use of digestate and also implement state programs of biofuels producers support (European Biogas Association).

The use of waste-free production technologies by Ukraine's agricultural companies is a driving force for energy security. Today energy security is one of the most important components of economic security of any country. The full functioning of all economic institutions of the state is possible due to reliable provision of fuel and energy resources.

Energy is a special sphere of economy due to its technological specificity caused by the physical complexity of the processes of energy production, distribution and consumption, intra-industry features (high capital intensity of energy objects, long terms of their construction and operation), branched and interconnected relationships dependence of extractive, processing, production and transport processes on the level of their energy supply. This conclusion applies to any country in the modern world, regardless of its geographical coordinates. That is why ensuring energy security is one of the key factors for Ukraine's existence as an independent state (Stuchynska 2016).

Ukraine is an agrarian country with a great future in this field, and biogas is an important and necessary business direction that has many positive points. At first, through the construction of biogas plants, environmental issues are solved. Secondly, energy-related issues are eliminated, because today all companies dream of becoming energy independent considering prices for gas and electricity. Thirdly, processing waste we get digestate, it is an organic fertilizer, and if it is used properly it gives a very tangible effect on yield. Thud, we will help to realize our enormous potential.

Conclusion

The results of the conducted researches prove that in modern economic conditions stimulating prospects of effective agricultural enterprises development are, first of all, determined due to the innovative approach, i.e. rational use of wastes from own production. The variety of waste includes many food and crop residues, and livestock manure. Considering the European experience, an enterprise processing waste at a biogas plant can achieve energy autonomy by providing itself with heat, fuel, electricity and organic fertilizers; it can significantly increase both the yield and financial performance of the entity. As a result, several other macro-level benefits were identified, i.e. socio-economic development of rural areas (increased employment, infrastructure improvements), conservation and improvement of environmental and energy security of the country.

Considering this innovative approach, an important role for ensuring the energy autonomy of entrepreneurial activity in the agrarian sphere is played by the state, which must implement clear regulation, apply incentive methods (state support) and provide legal protection.

Thus, adopting a modern approach to the non-waste production at Ukrainian agricultural enterprises, we will be able to ensure a stable high level of agriculture in the country's gross domestic product (12%) and increase it significantly.

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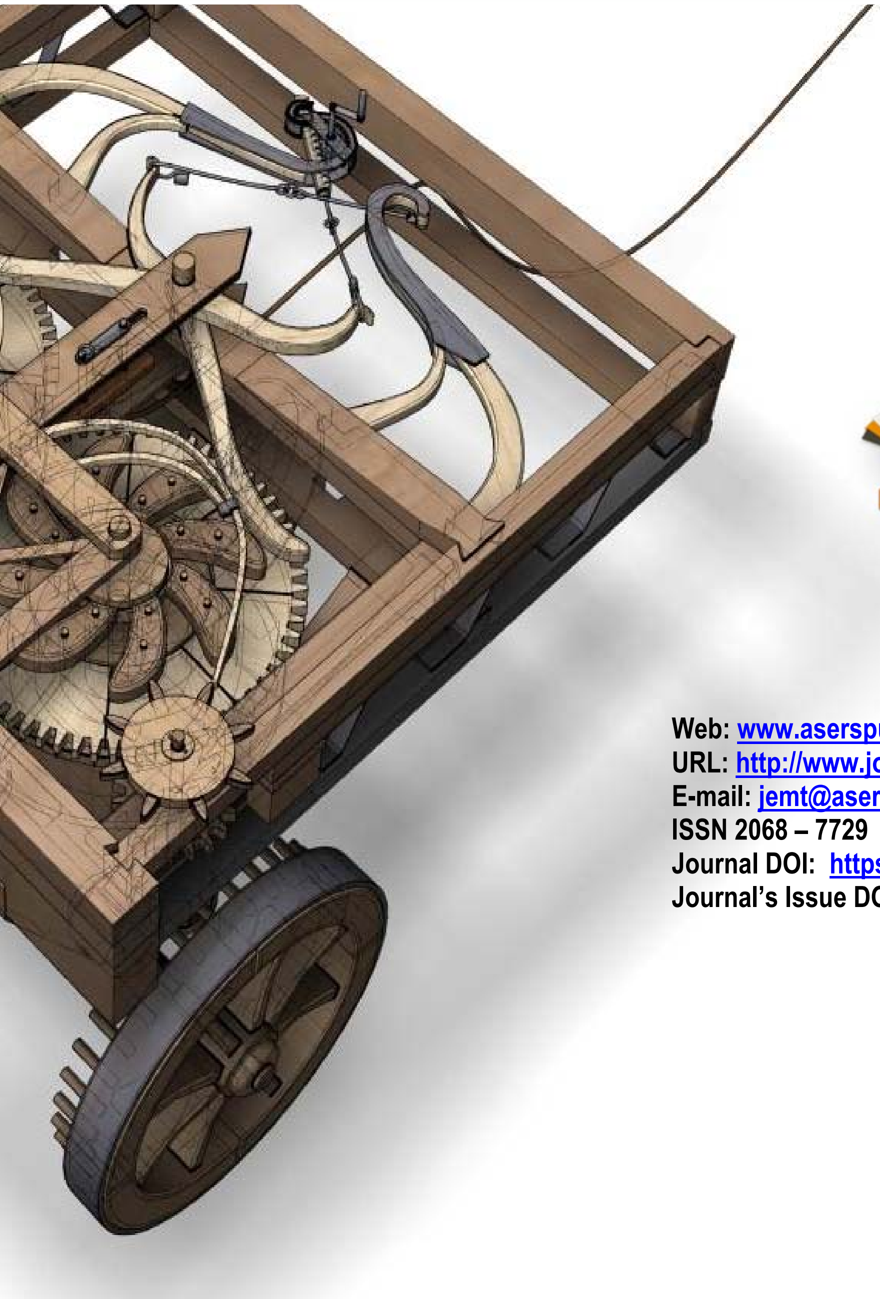

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