The technology of processing and recycling organic waste

V M Nikolaeva and A I Borisov
North-Eastern Federal University, 58 Belinsky str, Yakutsk, Republic of Sakha (Yakutia), Russia, 677027
E-mail: tbbai@mail.ru

Abstract. The article presents the technology developed by the obtained patent for the invention. The liquid phase of the fermented waste is evaporated until dry concentrated fertilizers are obtained. Part of the homogeneous mass is burned, and the biogas is purified by passing through water to obtain biomethane. Water is saturated with organic substances. The air from the production facilities is collected and maintained by the combustion process. The waste gas is cleaned of solid volatile impurities and used to generate electricity. Water is saturated with minerals. The technology provides automation and process control. It provides an increased yield of biomethane, increase in thermal and electrical energy and environmental production.

1. Introduction
Recently, such areas as engineering ecology, industrial ecology, technical ecology, etc. have become widespread. Environmental engineering is a system of engineering and technical measures aimed at preserving the quality of the environment in conditions of growing production. This is not a new direction in the development of ecology; it is environmental engineering and nature conservation. Successful solution of environmental problems by engineering methods is possible only if the specialist has certain knowledge in the field of ecology. An engineer must be able to evaluate his production from an environmental perspective, i.e. have environmental thinking. Historically, nature conservation has developed as a system of measures aimed at preserving individual landscapes, natural monuments, rare plants and animals, organizing nature reserves and wildlife sanctuaries. Landscape is a natural geographical complex in which all the main components - relief, climate, water, soil, vegetation and wildlife - form a single system. In modern conditions, this is not enough. It is impossible to turn the whole Earth into a reserve. The use of natural resources is an inalienable property of man and the direction of activity of human society. Transformations in nature due to human activities are inevitable. The principle of non-interference in nature is unrealistic. Currently, the phrase “nature conservation” has a broader meaning: 1 - development of principles and methods for the restoration and conservation of natural resources (land, water, atmosphere, flora and fauna); 2 - a system of measures aimed at maintaining a rational interaction between a person and the environment. This system of measures should prevent the direct or indirect negative impact of the results of society on nature and human health. Specially, no one pollutes the biosphere; the impact on wildlife is always indirect. Adverse effects on nature - a consequence of the work of industrial and agricultural enterprises.

The side effect of production on the biosphere appears in two forms, discussed below. 1. Any technological processes are associated not only with the conversion and production of the necessary substances, but also with by-products that make up the so-called production waste. Evolution life on Earth passed in the absence of these substances, which appeared only as a result of industrial production. These substances, as a rule, are alien to the natural environment filled with living organisms. They are
called xenobiotics (Greek xenos - alien, bios - life). Other non-xenobiotic substances appeared in excessive concentrations (ozone, phenols, sulfur, nitrogen, phosphorus compounds, etc.). Modes of biochemical processes in living cells "worked out" during long evolution. If a xenobiotic or an ordinary substance in excess occurs in the biochemical cycle of a plant or animal cell concentrations then impaired intracellular metabolism or metabolism cells (Greek. metabole - change). This leads to sharp negative consequences for the body. The presence of xenobiotics leads to an incompatibility of the environment with the vital functions of the body, which causes diseases up to a fatal outcome. So, the appearance of sulfur in the air, fluorine, nickel, cobalt disrupts the photosynthesis of plants, which leads to their death. Discharges of phenols and other organics into rivers lead to the death of fish. 2. The environmental impact of production is not related only with the introduction of foreign substances. Life processes go at certain temperatures, humidity, pressure, illumination.

Discharge of hot water into water bodies, changes in the daily regime of illumination in cities, excessive noise from the work of industrial enterprises, construction equipment, vehicles, electromagnetic fields from electrical appliances and electrical equipment, from power lines cause undesirable consequences for living organisms. So, the electromagnetic field from industrial installations has a harmful effect on humans, causing disorders of the cardiovascular system, nervous system, and lowers human immunity. Therefore, near current transmission lines a sanitary protection zone is being established. If the power line has a voltage of 35 kV, it is dangerous to be close to 15 m. If 1150 kV - the sanitary protection zone is 55 km. The danger zone near the TV is about 1 m 20 cm.

Near the iron - 0.25 m. Near the electric radiator - 3 m. It is especially dangerous near microwave ovens. Confused, twisted into rings the wires from the desk lamp produce radiation equivalent to the lines power lines. One of the most dangerous for humans is radioactive radiation. Under the influence of radiation, the biochemical structure, the vitality of the body is deteriorating. Living organisms perceive the external environment using special receptors. The human body does not have such radiation receptors. Even upon receipt a person does not experience any fatal dose of radiation.

In large cities, noise levels reach 90–92 dB. Excessive noise causes nervous exhaustion. Diseases, psychological changes are known, the cause of which is an increased noise level. The life expectancy of people in cities is reduced by 8–10 years due to the increased noise background. Very strong noise with intensities greater than 100 dB leads to noise attenuation. The tissues of the body are destroyed, and above all - hearing aid. Women are less resistant to noise, in the conditions of auditory discomfort they have signs of nervous diseases. Weak household noises in the house to a greater extent destroy the nervous system of men, because for them, subconsciously, these sounds signal the presence of an opponent. This mechanism is preserved in humans from his animal ancestors. Loud noise is a physical drug. With the advent of basic cellular antennas in residential neighborhoods, electromagnetic radiation. These antennas operate mainly on residents of neighboring houses. In the house where such an antenna is installed, the radiation is relatively weak. These additional electromagnetic fields cause insomnia, disrupt the rhythm or completely remove from building pacemakers. Thermal pollution of water bodies leads to a change in the species composition of communities of microorganisms, fish, algae, other aquatic organisms. The smaller the body of water, the more dangerous the discharge of heated wastewater to living organisms.

The industrial production of meat faces the problem of organic waste that pollutes the air, water and soil. One of the main sources of pollution is manure that enters water, soil and atmosphere and contributes a significant amount of nutrients. The processing and disposal of manure, as well as other excreta, has long been a major problem for complexes specializing in meat production. It is known that microbial and general pollution in the area of livestock complexes is 8-10 times higher than the natural background pollution of soil and snow cover. The reason that organic waste has now become a serious environmental problem in all regions of Russia without exception, polluting soil, groundwater and air, is the lack of perfect technology for their processing and disposal. Environmental protection requires that significant amounts of organic waste produced by today's livestock farming be recycled using environmentally sound technologies.
2. Problem statement
The technology refers to the complete processing and recycling of organic waste with the production of electricity, thermal energy, recycled water and fertilizers.

There is known a way for processing of slurry waste water, for example, pork complexes, implemented as a line with technological operations of collection and separation of flow into liquid and solid fraction, aerobic treatment of liquid fraction, sludge processing, decontamination of flow, stabilization of sludge when bringing the degree of liquid fraction treatment to the parameters required for its discharge into water bodies. The disadvantages of this method are not getting biomethane, electric and thermal energy, liquid fertilizers because of the lack of biogas collection processes and processing of liquid and solid fractions into thermal and electric energy.

3. Findings
There is a known method for non-waste treatment of farm effluents, which allows to carry out methane fermentation of liquid fraction with biogas emission, its utilization with obtaining hot water, use of obtained hot water for heating of digestor, gasholder, dryers, treatment of biomass fermentation with separation of sludge disposed as fertilizer. The disadvantages of this method are: not getting biomethane as well as electricity and liquid fertilizers because of the lack of processing of the received heat energy into electricity, as well as burning of biogas instead of solid manure fractions during the production of heat energy.

The other method, closed to the developed technology, includes operations on collection of manure, digestion of manure in anaerobic environment with biogas production and collection, separation of fermented manure with obtaining solid and liquid fractions, used for fertilization, with utilization of waste gases and air from production facilities. However, this method has insufficient efficiency of waste processing and utilization processes.

The significant increase in the efficiency of processing and utilization of animal wastes due to the use of the biofuel produced, saving the biogas produced, increasing energy efficiency, obtaining mineral fertilizers and utilization of own wastes is achieved in a patented technical solution.

Key Technology Operations
The developed technology of organic waste processing and utilization, displayed in the functional flow diagram, includes 12 key operations:

- collection of manure and bedding material from, for example, an animal breeding complex;
- digestion of manure with the addition of methanogenic bacteria and lack of air access to biogas production;
- biogas treatment to produce biomethane and liquid organic fertilizers;
- separation of fermentation manure with solid and liquid phases;
- evaporation of the liquid phase of the fermented manure to produce dry organic fertilizers and circulating water;
- bedding resin shredding;
- mixing the solid phase of the fermented manure and shredded bedding material to produce solid organic fertilizers and a mixture for incineration;
- biofuel blend processing;
- purification of air collected from production facilities to produce liquid organic fertilizers and saturated air;
- combustion of biofuels in the supply of saturated air with the production of heat and electricity and dry mineral fertilizers;
- purification of waste gas from biofuel combustion by passing it through water to produce liquid mineral fertilizers;
- disposing of household waste.
It is necessary to collect manure and bedding material for further processing. The manure is fed for methane digestion, for example, by adding methane-depleting bacteria to the digested mass. Further biogas must be collected and fed, cleaned e.g. with water, and fed to the consumer. After the fermentation cycle has been completed, the manure is separated. After separation, the liquid phase is evaporated and condensed into water. The resulting water is returned to the complex or transported to the customer. The dry residue in the form of organic fertilizer is then collected and placed in storage.

The bedding material is shredded and then mixed with the solid phase of the fermented separated manure. The resulting mixture is divided into a mixture of incineration and solid organic fertilizer. The combustion mix undergoes an additional preparation process and is fed into the kiln as an environmentally friendly biofuel. The heat generated by burning biofuels with saturated air is used to convert water from outside into steam, which generates electricity in turbo generators. The dry residue from the combustion of biofuels is collected and transported to the warehouse as mineral fertilizer. The waste steam is used in the complex or fed to the consumer. Cold water is collected from the complex and from the user and is supplied.

Besides steam, hot air from the furnace is also used. After purification and cooling it generates electricity, for example in turbogenerators, and then it is fed into the greenhouse to dispose of the remaining combustion products. And the water used to clean the waste gas is then drained and used as a liquid mineral fertilizer.

As an example of technology implementation, a complex of cattle with 50 cows was considered. Each cow, on the average, gives 35-60 kg of litter per day. The complex also uses about 5-10 kg of hay/silage as bedding material and uneaten forage. Then, for 50 cows the output is: 1.75-3 tons of manure and 0.25-0.5 tons of bedding material. For digestion, it is necessary that the manure has a moisture content of more than 90% and the initial moisture content is about 80%. Then for 1.75-3 tons of litter it is necessary to add 220-380 litres of water. It is known that 40-60 m³ of biogas with 60% methane content is emitted from a ton of cattle manure during fermentation, and 24-36 m³ of biomethane is emitted from here.

Fermented manure is separated to 15% humidity. Assuming twenty percent weight loss of the fermented manure in the form of biogas yield and water evaporation, the solid phase yield of the fermented manure after separation will be 0.35-0.54 t. Further to this volume, bedding material should be added. Then, the total mass of the resulting mixture in the form of biofuel will be 0.6-1.04 t.

It is possible to calculate the energy balance according to the known parameters of heat emission during combustion of biogas and biofuel. Knowing the approximate density of biogas, its weight can be calculated: 1 cubic meter of biogas weighs 0.67 kg. When burning 1 kg of biogas, 34 mJ of energy is emitted, then we will obtain that approximately 911 to 1367 mJ of thermal energy will be produced per day.

Assuming that the energy release from the combustion of the resulting biofuel (mixture of solid phase fermented litter and bedding material) is approximately the same as from the combustion of wood, we obtain that approximately 6000-10400 mJ of thermal energy will be produced per day. The ratio of produced energy shows that the energy production from combustion of the produced biofuel is higher than from 7.6 to 9.4 times that from biogas combustion.

Knowing that the prototype technology burns biogas and produces heat and electricity, and assuming even a fifty percent loss of energy, it is clear that the efficiency of the proposed technology in terms of energy balance is 3.8 times higher. When determining economic benefits, it is necessary to take into account income from fertilizer production, waste gas utilization and biomethane sales.

Features of management of technological process on the basis of the controller with PID, which is the law of regulation supplemented by intellectually defined prediction component, are revealed. The research is one of components of a modern scientific direction equipped by the author "Technologies of intellectual control of natural and technogenic object condition".

4. Conclusion
Organic waste has now become a serious environmental problem in all Russian regions without
exception due to soil, groundwater and air pollution. Improving the efficiency of organic waste processing and utilization, mainly in the livestock sector, is an urgent scientific and technical problem.

The technology developed under the patent provides for: evaporation of the liquid phase of fermented waste, burning part of the homogeneous mass, obtaining biomethane from biogas with saturation of water with organic substances, collecting air from production facilities, purification of waste gas from solid volatile impurities with saturation of used water with minerals.

The developed technology is highly efficient, as it provides increased output of biomethane, increase in thermal and electrical energy, and meets the requirements of the environment.

Control of the technological process on the basis of the controller with proportional-integral-differential law of regulation, supplemented with intellectually determined each time forecast component, contributes to a significant increase in production efficiency.

Acknowledgements
I, Nikolaeva Vera Maximovna, express special gratitude to my scientific leader – Borisov Alexey Ivanovich for the significant comments and the most important advice on the writing and design of this article.

References
[1] Voroshilov Y I, Durybaev S D and Erbanova L N 1991 Animal breeding complexes and environment protection (Moscow: Agro-Industrial Publishing) p 205
[2] Puzankov A G et al 2001 Complex system for manure processing and other agricultural wastes Pat. of the Russian Federation No. 2169450 publ. 06.27.2001
[3] Glazkov I K, Kovalov A A and Losyakov V P 1997 Wastewater treatment of the farm effluents Pat. of the Russian Federation No. 2083510 publ. 07.10.1997
[4] Vasilenko I F, Shepovalov V D and Puzankov A G 2001 Complex system for manure processing and other agricultural wastes Pat. of the Soviet Union No. 836829 publ. 03.20.1984 Stat. 12
[5] Vladov Yu R, Kuvakov T R, Machnev D A 2001 Method for processing and utilization of the animal complex wastes Pat. of the Russian Federation No. 2410594 publ. 05.27.2011 Stat. 15
[6] Vladov Yu R and Vladova A Yu 2018 Control Signals of a Predictive Industrial PID Controller Russian Engineering Research 38(5) 399-402 DOI: 10.3103/S1068798X18050210
[7] Vladov Yu R and Vladova A Yu 2018 Two-stage workflow control witch a predictive component 17th IFAC Workshop on Control Applications of Optimization CAO-2018 (Yekaterinburg, Russia) IFAC-PapersOnLine 51(32) pp 712-6