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ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ
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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК РЕСПУБЛИКИ КАЗАХСТАН»
ЧФ «Халық»

NEWS

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

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DEVELOPMENT OF A TECHNOLOGICAL SCHEME OF A WASTE-FREE BIOENERGY PLANT FOR THE DISPOSAL OF WASTE

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Abstract. The article shows the results of research on the possibility and efficiency of disposal of human waste (municipal wastewater) and animals. Currently, there is a problem of energy supply to rural settlements in Kazakhstan. And if the supply of electric energy is stable enough, then there are big problems with heat supply: rural residents in most regions are forced to use coal for heating, which negatively affects not only the environment, but also the social situation, since fuel is getting more expensive every year, which is not to say about the income of the population. The purpose of the research is to develop technologies for obtaining thermal and electrical energy in the joint disposal of waste of the population and domestic animals. At the same time, such bioenergy installations should be inexpensive, energy efficient and environmentally friendly. Studies of the influence of various factors on the fermentation process have been carried out. The option of joint disposal of these wastes is being considered. A technological scheme of a biogas plant with complete utilization of biogas, with the production of methane and carbon dioxide, biohumus as products, has been developed. The scheme is waste-free. At the same time, municipal wastewater is separated and the biogas plant uses activated sludge together with the manure of domestic animals to produce biogas. An efficient bioreactor has been developed, horizontal with three compartments operating in automatic mode. The cycle of effective biogas production is 18 days. For every 10 m^3 of joint disposal of municipal wastewater and cattle waste, an estimated biogas output of 196 m^3, an estimated thermal power of 17 kW, and an estimated electrical power of 15 kW is expected. For example, the daily volume of municipal wastewater at the treatment facilities of Astana city averages about 180,000 m^3/day. Accordingly, the estimated maximum capacity of a biogas plant for biogas output is 3,528,000 m^3/day or 147,000 m^3/hour, for thermal power of 306 MW/day or 12.75 MW per hour, for electrical power of 270 MW/day or 11.25 MW per hour. The considered variant of waste-free waste disposal technology allows creating energy-efficient, inexpensive small biogas and bioenergy installations that allow combining either 8-10 rural courtyards or several buildings of an urban settlement into a single waste disposal unit.

Keywords: Waste-free production, waste disposal, municipal wastewater, household waste, manure, biogas plant, energy-efficient technologies, biogas, thermal energy, electric energy, technical nitrogen, carbon dioxide, greenhouse gases

Conflict of interest: *The authors declare that there is no conflict of interest.*

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ӨМІР ТІРШІЛІГІ ҚАЛДЫҚТАРЫН КӘДЕГЕ ЖАРАТУ ЖӨНІНДЕГІ ҚАЛДЫҚСЫЗ БИОЭНЕРГЕТИКАЛЫҚ ҚОНДЫРҒЫНЫҢ ТЕХНОЛОГИЯЛЫҚ СХЕМАСЫН ӘЗІРЛЕУ

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Аннотация. Мақалада адамнан бөлінетін нәжістерді (коммуналдық-тұрмыстық ағындар) мен жануарлардың қалдықтарын кәдеге жарату мүмкіндігі мен тиімділігін зерттеу нәтижелері көрсетілген. Қазіргі уақытта Қазақстанда ауылдық елді мекендерді энергиямен жабдықтау мәселесі өзекті болып отыр. Егер электр қуатымен қамтамасыз ету тұрақты түрде жүзеге асырылса, онда жылумен қамтамасыз ету кезінде үлкен мәселелер туындайды: көптеген аймақтардағы ауыл тұрғындары көмірді жылыту үшін пайдалануға мәжбүр, бұл тек экологияға ғана емес, сонымен бірге әлеуметтік ортаға да кері әсерін тигізеді, өйткені отын жыл сайын қымбаттап жатыр, бұл халықтың табысына келетін болсақ, мүлдем салыстыруға болмайтын нәрсе. Зерттеудің мақсаты — тұрғындар мен үй жануарларының қалдықтарын бірлесіп кәдеге жарату барысында жылу және электр қуатын алу технологияларын әзірлеу болып табылады. Айта кететін жайт, мұндай биоэнергетикалық қондырғылар арзан болып, энергияны үнемдейтін және экологиялық тұрғыдан таза болуы керек. Ашыту процесіне әртүрлі факторлардың әсері туралы зерттеулер жүргізілді. Бұл қалдықтарды біріктіріп отырып, жою мүмкіндігі қарастырылуда. Өнім ретінде метан мен көмірқышқыл газын, биогумусты ала отырып, биогазды толық кәдеге жаратумен биогаз қондырғысының технологиялық схемасы әзірленді. Схема қалдықсыз болып табылады. Бұл ретте коммуналдық-тұрмыстық ағындар бөлініп алынады, биогаз қондырғысында биогаз алу үшін белсенді тұнба және үй жануарларының көңі бірге пайдаланылады. Автоматты режимде жұмыс істейтін үш бөлімі бар көлденең тиімді биореактор әзірленді. Биогазды тиімді алу циклі 18 тәулікті құрайды. Әрбір 10 м^3 коммуналдық-тұрмыстық ағындар мен ірі қара мал қалдықтарын біріктіріп, кәдеге жаратудан 196 м^3 биогаздың есептік шығымы, 17 кВт есептік жылу қуаты, 15 кВт есептік электр қуаты жоспарлануда. Мысалы, Астана қаласының тазарту құрылғыларындағы коммуналдық-тұрмыстық ағындардың тәуліктік көлемі орташа есеппен алғанда, тәулігіне 180 000 м^3 құрайды. Тиісінше, биогаз қондырғысының биогаз шығысы бойынша болжамды максималды өнімділігі тәулігіне 3 528 000 м^3 немесе 147 000 м^3/сағ, жылу қуаты бойынша тәулігіне 306 МВт немесе сағатына 12,75 МВт, электр қуаты бойынша тәулігіне 270 МВт немесе сағатына 11,25 МВт құрайды. Қалдықсыз қалдықтарды кәдеге жарату технологиясының қарастырылған нұсқасы 8-10 ауылдық ауланы немесе қалалық елді мекеннің бірнеше ғимаратын қалдықтарды кәдеге жаратудың бірыңғай торабына біріктіруге мүмкіндік беретін энергияны үнемдейтін арзан шағын биогаз және биоэнергетикалық қондырғылар құруға мүмкіндік береді.

Түйін сөздер: Қалдықсыз өндіріс, қалдықтарды кәдеге жарату, коммуналдық-тұрмыстық ағындар, тұрмыстық қалдықтар, көң, биогаз қондырғысы, энергияны

үнемдейтін технологиялар, биогаз, жылу энергиясы, электр энергиясы, техникалық азот, көмірқышқыл газы, парниктік газдар

***Мүдделер қақтығысы**: Авторлар осы мақалада мүдделер қақтығысы жоқ деп мәлімдемейді.*

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РАЗРАБОТКА ТЕХНОЛОГИЧЕСКОЙ СХЕМЫ БЕЗОТХОДНОЙ БИОЭНЕРГЕТИЧЕСКОЙ УСТАНОВКИ ПО УТИЛИЗАЦИИ ОТХОДОВ ЖИЗНЕДЕЯТЕЛЬНОСТИ

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Аннотация. В статье показаны результаты исследований возможности и эффективности утилизации отходов жизнедеятельности человека (коммунально-бытовые стоки) и животных. В настоящее время в Казахстане есть проблема энергоснабжения сельских населенных пунктов. И если подача электрической энергии осуществляется достаточно стабильно, то с теплоснабжением возникают большие проблемы: сельские жители в большинстве регионов вынуждены использовать уголь для отопления, что негативно сказывается не только на экологии, но и на социальной обстановке, так как топливо дорожает с каждым годом. Целью исследований является разработка технологий получения тепловой и электрической энергии при совместной утилизации отходов жизнедеятельности населения и домашних животных. При этом такие биоэнергетические установки должны быть недорогими, энергоэффективными и экологичными. Авторы проводят исследование влияния различных факторов на процесс брожения, рассматривая вариант совместной утилизации данных отходов. В результате разработана технологическая схема биогазовой установки с полной утилизацией биогаза, с получением в качестве продукции метана и углекислого газа, биогумуса. Схема является безотходной. При этом коммунально-бытовые стоки разделяются и в биогазовой установке используется активный ил совместно и навозом домашних животных для получения биогаза. Разработан эффективный биореактор, горизонтальный с тремя отсеками, работающих в автоматическом режиме. Цикл эффективного получения биогаза составляет 18 суток. С каждых 10 м^3 совместной утилизации коммунально-бытовых стоков и отходов крупного рогатого скота ожидается расчетный выход биогаза 196 м^3, расчетная тепловая мощность 17 кВт, расчетная электрическая мощность 15 кВт. Например, суточный объем коммунально-бытовых стоков на очистных сооружениях города Астаны в среднем составляет около 180 000 м^3/сутки. Соответственно предполагаемая максимальная производительность биогазовой установки по выходу биогаза 3 528 000 м^3/сутки или 147000 м^3/час, по тепловой мощности 306 МВт/сутки или 12,75 МВт в час, по электрической мощности 270 МВт/сутки или 11,25 МВт в час. Рассмотренный вариант безотходной технологии утилизации отходов, позволяет создавать энергоэффективные недорогие небольшие биогазовые и биоэнергетические установки, позволяющие объединять или 8–10 сельских дворов или несколько зданий городского населенного пункта в единый узел утилизации отходов.

Ключевые слова: безотходное производство, утилизация отходов, коммунально-бытовые стоки, бытовые отходы, навоз, биогазовая установка, энергоэффективные технологии, биогаз, тепловая энергия, электрическая энергия, технический азот, углекислый газ, парниковые газы

Конфликт интересов: *авторы заявляют об отсутствии конфликта интересов.*

Introduction

The relevance of waste disposal in the energy sector is determined by the significant increase in the cost of traditional types of hydrocarbon fuels in recent decades. In many countries, one of the most important decisions taken recently in order to improve energy security is to increase the share of the use of local and renewable energy resources. At the same time, it is planned to increase the use of municipal waste, pet waste, sewage and secondary energy resources for generating electric and thermal energy for energy purposes, the introduction of biogas, wind power and solar installations, heat pumps, construction and restoration of hydroelectric power plants.

However, existing technologies make it possible to generate energy, while receiving new flue gases that pollute the atmosphere.

The pace of development of production and the welfare of society is determined by innovative developments in the field of energy. At the same time, in addition to economic attractiveness, modern energy facilities should have environmental safety. In the current conditions, it is extremely important to accelerate research and make decisions on the use of promising bioenergy technologies. One of the directions of biomass processing that has become widespread recently is the decomposition in anaerobic (without oxygen access) conditions of sewage sludge and other organic waste of plant and animal origin (biomass) in order to obtain biogas (Yanko et al., 1978; Repin 1995; Raven et al., 2007; Holm-Nielsen et al., 2009; Appels et al., 2008).

The purpose of the research is to develop a technology for the integrated disposal of human and animal waste with the production of electrical and thermal energy, vermicompost, with maximum utilization of the resulting flue gases and the production of finished products from gases in the form of food-grade carbon dioxide and nitrogen gas.

The problem of energy supply will be solved by recycling waste from the life of the population and animals, especially social remote objects – villages and auls at an affordable low price, the problems of supplying agriculture with cheap, high-quality vermicompost. At the same time, it is planned that the technology will be completely waste-free.

Experimental

Materials and methods. Theory. Biogas is poorly soluble in water, consists of methane (55÷85 %) and carbon dioxide (15÷45 %), there may be traces of hydrogen sulfide. Its calorific value ranges from 21 to 27.2 MJ/m^3. When processing 1 ton of fresh waste from cattle and pigs (at 85 % humidity), you can get from 45 to 60 m^3 of biogas, 1 ton of chicken manure (at 75 % humidity) - up to 100 m^3 of biogas. According to the heat of combustion, 1 m^3 of biogas is equivalent to: 0.8 m^3 of natural gas, 0.7 kg of fuel oil, 0.6 kg of gasoline, 1.5 kg of firewood (in a completely dry state), 3 kg of manure briquettes. Biogas, like natural gas, belongs to the cleanest types of fuel (Boyles 1987; Soufer et al., 1985).

The production of biogas from organic waste has the following features:

- sanitary treatment of wastewater (especially livestock and municipal) is carried out, the content of organic substances is reduced up to 10 times;
- anaerobic processing of animal husbandry, crop production and activated sludge leads to mineralization of the main components of fertilizers (nitrogen and phosphorus) and their preservation (unlike traditional methods of preparing organic fertilizers by composting methods, in which up to 30÷40 % of nitrogen is lost);
- with methane fermentation, the efficiency of converting the energy of organic substances into biogas is high (80÷90 %);
- biogas with high efficiency can be used to produce thermal and electrical energy, as well as in internal combustion engines;
- biogas plants can be located in any region of the country and do not require the construction of expensive gas pipelines (Eder et al., 2008; Sokolov, 2001; Forster, et al., 1990; Baader, 1982).

Biogas technologies allow the most rational and efficient conversion of the energy of chemical bonds of organic waste into the energy of gaseous fuels and highly efficient organic fertilizers, the use of which, in turn, will significantly reduce the production of mineral fertilizers, which consumes up to 30 % of the electricity consumed by agriculture.

The following factors are of particular importance for the wide spread of biogas technology (Belyaev, 1984; Zhabo et al., 1983):

– the cost of installation;

– specific productivity;

– completeness of processing of fermented mass and biogas into the most valuable products in comparison with the raw materials;

– efficiency in solving problems related to environmental protection;

– high operational reliability and ease of maintenance.

The cost of the installation is largely determined by the simplicity of its technological scheme and the absence of unique components in it.

At the present stage of biotechnology development, it is important to intensify the process of methane fermentation and reduce capital and operating costs due to this.

Despite the fact that a biogas reactor contributes the largest single share to the cost of the entire installation, its costs, as a rule, do not exceed 30 % of all costs for a bioenergy installation. As a result, it is more significant to increase the processing speed and the associated reduction in the volume of the reactor, which will ensure the necessary economic effect before there is a significant reduction in the cost of component equipment included in the bioenergy plant or a significant reduction in its nomenclature due to a significant simplification of installations.

The process of anaerobic digestion requires strict maintenance of certain parameters and depends on external conditions. To organize the necessary conditions and increase the metabolic activity of bacteria, the following factors should be taken into account that determine the efficiency of the fermentation process: anaerobic conditions in the reactor; fermentation temperature; composition of the feedstock (availability of nutrients); humidity of the feedstock; mixing of the fermented raw materials; fermentation time; loading value; acid-base balance; ratio of carbon and nitrogen content; absence of process inhibitors.

A number of microorganisms take part in the anaerobic process of splitting organic substrates. About 50% of the bacteria involved are aerobic or facultatively aerobic and require or tolerate oxygen well. Only methane bacteria are exclusively anaerobic. If oxygen is still present in the substrate, as, for example, in fresh manure, then aerobic bacteria primarily use it. This happens at the first stage of the biogas formation process. Therefore, a small amount of oxygen that penetrates during targeted injection of air for cleaning from sulfur or when opening inspection holes is not harmful (ST RK GOST R 52808–2010; Sokolov et al., 2011).

The redox potential is much more significant. The redox potential is the degree of readiness of ions to accept electrons. For the growth of anaerobic bacteria, this potential should be at a very low level (-0.1 V). Since oxygen has a high redox potential (+1.78), it initially harms anaerobic bacteria. However, if there are enough substances with low redox potential, then the anaerobic process can occur in the presence of oxygen.

Exclusion of light ingress into the substrate medium and taking into account the influence of fermentation temperature and fermentation time.

Although light is not lethal to bacteria, it slows down the process. In practice, it is possible to exclude the influence of light on the process by using a light-tight lid.

Methane bacteria manifest their vital activity within the temperature range of 0÷70 °C. If the temperature is higher, they begin to die, with the exception of a few strains that can live at ambient temperatures up to 90 °C. At subzero temperatures, they survive, but cease their vital activity.

Equipment

The principle of operation of the biogas complex. Manure in the cowshed room is dumped onto an automatic unloading conveyor from the room into a container for collecting and homogenizing raw materials 2, where it is crushed with electric knives and diluted with water to a consistency with 85% humidity. There is a node 3, with a conveyor belt, manual feeding of the initial dry manure from outside from other cowsheds and sources (Figure 1).

The prepared homogenized liquid raw materials are fed by a fecal pump 4 to the reactor - to the fermentation start section, with a volume of 50 tons of manure for a 5-day nominal capacity, where the fermentation of raw materials with the release of biogas takes place for 5 days, while the raw materials, at the time of adding a new fresh portion, are transferred to the to the residual fermentation section, with a volume of 50 tons of manure for a 5-day nominal capacity. In total, the raw materials emit biogas in the reactor for 18 days.

The processes of adding fresh raw materials and removing the fermented mass are carried out once a day at the same time.

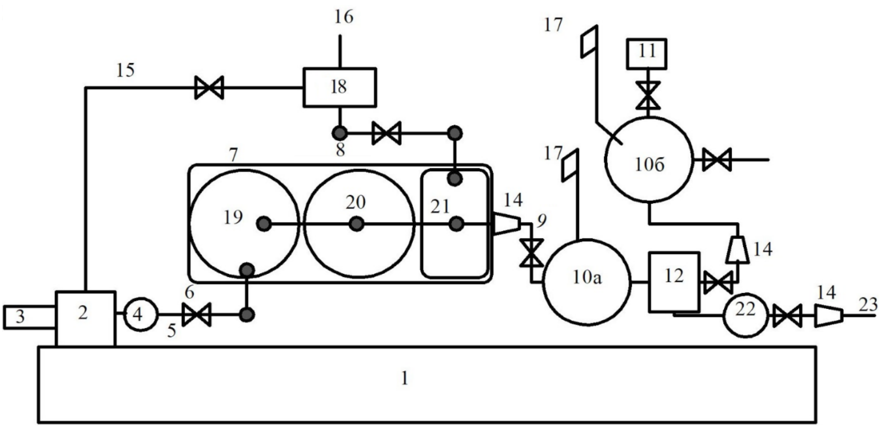

Fig. 1 – Technological scheme of a biogas plant

1 – farm with cattle; 2 – collection and homogenization capacity of liquid raw materials; 3 – filling unit of raw materials from the outside; 4 – fecal pump; 5 – feed line of ready–to-ferment raw materials into the reactor (with a diameter of at least 300 mm); 6 - unregulated valve; 7 – reactor with mixing device, heating jacket and an automatic temperature controller, biogas outlets and fermented mass, horizontal, consisting of 3 compartments. Approximate geometric dimensions: a total volume of at least 235.5 m^3,

a diameter of 5 meters, a length of 12 meters; 8 – a node for the removal and collection of fermented mass; 9 – a biogas collector with a compressor for feeding into a low–pressure gas tank; 10a – a low-pressure gas tank with a volume of at least 450 nm^3 for daily nominal capacity; 10b – a high-pressure gas tank with a volume of 30 - and daily nominal capacity, with a pressure of up to 20 MPa; 11 – a gas cylinder refueling unit with compressor; 12 – biogas purification unit from hydrogen sulfide and carbon dioxide; 13 – gas supply to the gas pipeline; 14 – compressor; 15 – the return line of the pressed water; 16 – the supply of dry residue for fertilizers; 17 – emergency candle; 18 – the dehydration unit of the fermented mass; 19 – The fermentation start section: up to 5 days, with a volume of 5-and daily nominal capacity – 50 tons of manure; 20 – The section of the main stage of fermentation, with a volume of 8-and daily nominal capacity – 80 tons of manure; 21 – Section of the remaining fermentation, with a volume of 5-and daily nominal capacity – 50 tons of manure; 22 – gas tank with carbon dioxide; 23 – line of injection of carbon dioxide into cylinders by compressor.

The fermented mass is discharged from the reactor to the dewatering unit 18, from where the pressed water is returned to the tank 2, and the dewatered mass is supplied for shipment as fertilizers.

Biogas from the reactors is supplied by a compressor to an intermediate low-pressure gas tank 10a, then to the carbon dioxide purification unit 12, from where the compressor 14 is pumped into the main gas tank 10b at a pressure of 20 MPa for storage and subsequent sale. Biogas is supplied from the gas tank by compressor 14 to the gas pipeline 13 to the consumer. A gas cylinder refueling unit 11 is also provided for sale to the consumer.

Carbon dioxide separated from biogas in node 12 enters a separate gas tank, with a storage capacity of 30 days, and is stored in it for a long or short term.

The amount of manure received per day with daily manure production from one cow is 50 kg per day: 200*50=10,000 kg/day.

The amount of biogas received from farm cattle per day, with a specific output of biogas from 1 ton of manure with a humidity of 85 % in the range from 38 to 51.5 m^3/t, we accept 44.75 m^3/t: 44.75*(10000/1000) = 447.5 m^3/day.

Hourly biogas consumption: 447.5/24=18.65 m^3/h.

Number of days of fermentation: 18 days.

Reactor volume, with a volume reserve for biogas above the fermentation mirror in 30 %: 1,3*18*10000=234 000 kg.

Reactor volume at a manure density of 1020 kg/m^3: 234 000/1020 =229.41 m^3.

The volume of the reactor, taking into account dilution with water in proportions of 3 to 1 to achieve a humidity of 85 % : 229.41 * 1.3 = 298.24 m^3.

The number of reactors is 1.

The reactor type is horizontal, consisting of 3 sections.

Preliminary overall dimensions: diameter – 5.5 m, length – 13 m.

The preliminary volume of the reactor is 308.7 m^3.

Obtaining biofertilizers.

With the help of anaerobic digestion, biogas technology allows you to quickly obtain a natural fertilizer containing biologically active substances and trace elements. The main advantage of biofertilizers, in comparison with traditional fertilizers, is the balance of all elements of nutrition, a high level of humification of organic matter.

The biofertilizer obtained in the process of anaerobic fermentation serves as a powerful energy material for soil microorganisms, therefore, after application to the soil, nitrogen-fixing and other microbiological processes are activated, resulting in improved physical and mechanical properties of the soil, and as a result, when using balanced biofertilizers, plant yields increase by 30–50 %.

Results

The speed of the fermentation process is very dependent on temperature. It is fundamentally important: the higher the temperature, the faster decomposition occurs and the higher the gas production. Thus, the decomposition time is reduced (Figure 2).

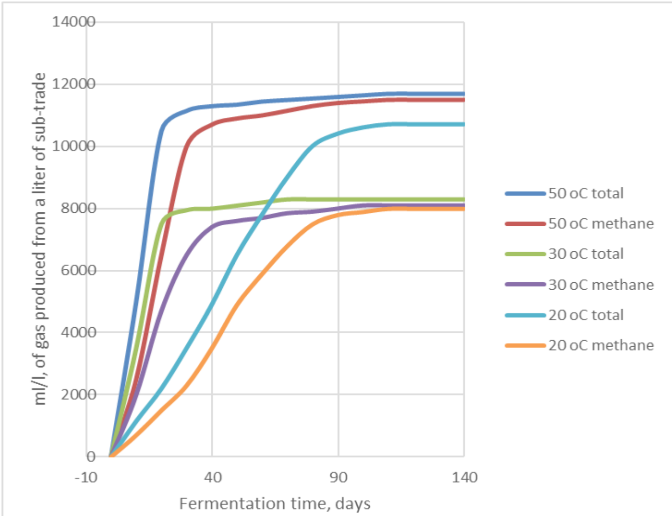

Fig. 2 – Effect of fermentation temperature and fermentation time on the amount of gas produced

As the temperature increases, the methane content in biogas decreases. This is due to the fact that at high temperatures, carbon dioxide dissolved in the substrate passes more intensively into the gaseous phase (into biogas), so that the relative methane content decreases. The amount of gas that can be extracted will be the same with a sufficient amount of fermentation time.

The dependence of the fermentation period of the substrate on the surface area of the raw material.

The principle is that the smaller the substrate, the better. The larger the interaction area for bacteria and the more fibrous the substrate, the easier and faster it is for bacteria to decompose the substrate. In addition, it is easier to mix, mix and heat it without the formation of a floating crust or sediment. Crushed raw materials have an effect on the amount of gas produced through the duration of the fermentation period. The shorter the fermentation period, the better the material should be crushed (Figure 3).

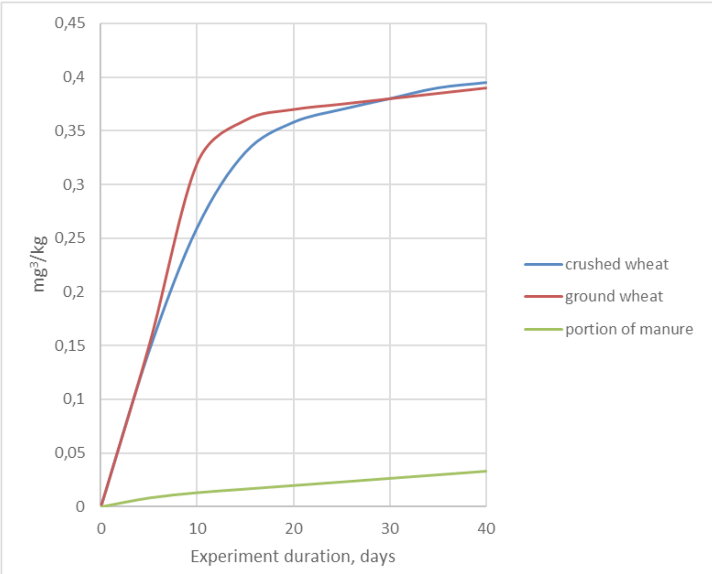

Fig. 3 – Duration of the fermentation period

With a sufficiently long fermentation period, the amount of gas produced will increase again. When using crushed grain, this has already been achieved after 15 days.

From every 10 m^3 of joint disposal of municipal wastewater and cattle waste:

- estimated biogas output: 196 m^3;
- estimated thermal power: 17 kW;
- estimated electrical power: 15 kW.

The daily volume of municipal wastewater at the treatment facilities of Astana city averages about 180,000 m^3/day. Accordingly, the estimated maximum capacity of the biogas plant:

- estimated biogas output: 3,528,000 m^3/day or 147,000 m^3/hour;
- estimated heat output: 306 MW/day or 12.75 MW per hour;
- estimated electrical capacity: 270 MW/day or 11.25 MW per hour.

Discussion of results

The developed technology of integrated waste disposal for the cold climate of Kazakhstan, Siberia and for a milder climate will allow obtaining not only thermal and electrical energy by burning biogas obtained from waste, vermicompost, as a fermented residue, but also to obtain finished products in the form of food carbon dioxide and nitrogen by utilizing flue gases (Razva, 2010; Glazyrin, et al., 1998; Glazyrin et al., 1999; Aidymbaeva et al., 2020).

Thus, the environmental problems of the accumulation of waste from the life of the population and animals of any state, regardless of the existing climate, as well as the environmental problem of the operation of thermal power plants, which will reduce the load and reduce the amount of emissions of harmful substances, will actually be solved. The social problem of energy supply of all settlements and villages, especially those remote from the central supply lines, is also being solved – they will stop burning coal and switch to waste-free technologies.

The main trends affecting the development of society and science related to the ongoing research within the framework of this Project are:

- solving social problems of energy supply to small settlements and - developing a "green economy";
- automation and robotization of technological processes of industrial enterprises;
- improving energy efficiency and reducing the energy intensity of production processes.

Utilization of waste from the population and animals with the production of thermal and electric energy, vermicompost without emissions into the atmosphere gives a triple environmental effect:

- reduction of wastewater and greenhouse gas emissions from waste disposal plants;
- reduction of the volume of accumulation of animal waste;
- reduction of harmful emissions into the atmosphere from coal-fired power plants, as there is a replacement of part of the energy generated at thermal power plants, and, accordingly, a reduction in the amount of solid fuel burned and emissions into the atmosphere from power plants.

Conclusion

The development and development of technology for the complete disposal of human and animal waste for the production of thermal and electrical energy and vermicompost gives a triple environmental effect to reduce wastewater from urban treatment facilities, the accumulation of animal waste and emissions into the atmosphere of thermal power plants;

1. Obtaining from every 10 m^3 of municipal wastewater: 17 kW of thermal energy, 15 kW of electrical energy, carbon dioxide with a purity of 99.9% and technical nitrogen with a purity of 99 %.

For example, with a daily volume of municipal wastewater of 180,000 m^3 (Astana city), the capacity of the biogas complex will be:

- electric - 11.25 MW*h;
- thermal – 12.75 MW per hour or 10.963 Gcal per hour.

The total annual income from the development and subsequent commercialization of the technology being developed at wastewater treatment plants (for example, Astana with a daily volume of 180,000 m^3) will be:

- from the generation of electric energy, taking into account the standard annual load factor of 80%, at an average daily price of 12.28 tenge/(kWh) [(8 hours* 3.62+16 hours*16.61)/24]: 1097.24 million tenge per year;
- from the generation of thermal energy at the minimum tariff for consumers with heat metering devices in 2147.91 tenge/Gcal for the heating period of 215 days: 121.51 million tenge for the heating period;
- Total total revenue from sales: 1,218.75 million tenge per year, excluding sales of carbon dioxide and technical nitrogen obtained from flue gases.

REFERENCES

Aidymbaeva Zh.A., Glazyrin S.A., Dostiyarov A.M., Glazyrin A.I. (2020). Method for cleaning flue gases of a drum-type energy boiler. Utility model patent of the Republic of Kazakhstan No. 5184.

Appels L., Baeyens J., Degre`ve J., Dewil R. (2008). Principles and potential of the anaerobic digestion of waste-activated sludge. Progress in Energy and Combustion Science. № 34. Pp. 755–781.

Baader W., 1982. Biogas theory and practice. Translated from German. Moscow: Kolos. 148 p. https://www.geokniga.org/books/25236

Belyaev S.S. (1984). Methane-forming bacteria and their role in the biochemical carbon cycle: Abstract of the thesis. ... doc. biol. Sciences. USSR, Pushchino. 45 p. https://www.geokniga.org/books/25236

Boyles D. (1987). Bioenergy: technology, thermodynamics, costs. Moscow: Agropromizdat. 152 p. https://www.geokniga.org/books/25236

Eder B., Schultz H. (2008). Biogas plants: a practical guide. Translated from German. Zürich: ZorgBiogas. 168 p. https://www.geokniga.org/books/25236

Forster C.F., Weiss DAJ. (1990). Ecological biotechnology. Leningrad: Chemistry. 384 p. https://www.geokniga.org/books/25236

Glazyrin S.A., Glazyrin, A.I. (1998). Options for the use of acid components of flue gases. Preparation of regeneration solutions (Flue gases acid components application options. Preparation of regeneration solutions), Kazakhstan, Pavlodar: Kazakh Scientific Research Institute of Scientific and Technical Information. 95–98, 96–98. 10 p.

Glazyrin S.A., Glazyrin A.I. (1999). Features of the regeneration of cation exchangers with aqueous solutions of flue gases, Materials of the scientific conference of young scientists, Kazakhstan, Pavlodar. Pp. 48-50

Holm-Nielsen J.B., Al Seadi T., Oleskowicz-Popiel P. (2009). The future of anaerobic digestion and biogas utilization. Bioresource Technology. №100. Pp. 5478–5484.

Sokolov E.Ya. (2001). Heat supply and heat networks. Moscow: Moscow Energy Institute. 472 p. https://www.geokniga.org/books/25236

Sokolov V.Yu., Sadchikov A.V., Naumov A.S., Goryachev S.V., Idigenov A.B., Nikonorov I.N., Kotova M.S. (2011). Metatank. Patent Russian Federation. 2011129524

Soufer S., Zaborsky O. (1985). Biomass as a source of energy. Moscow: Mir. 368 p. https://www.geokniga.org/books/25236

ST RK GOST R 52808–2010. — Non-traditional technologies. Energy of biowaste. Concepts and definitions. Date of introduction: 01-01-2012. Kazakhstan, Astana: KazInSt

Raven R.P.J.M., Gregersenb K.H. (2007). Biogas plants in Denmark: successes and setbacks. Renewable and Sustainable Energy Reviews. №11. Pp. 116–132.

Razva A.S. (2010). Environmental technologies in industrial heat power engineering. Tomsk: National Research Tomsk Polytechnic University. 30 p. https://www.geokniga.org/books/

Repin V.N. (1995). Modern technologies for anaerobic treatment of industrial wastewater. Water supply and sanitary engineering. №5. Pp. 27-29

Yanko V.G., Yanko Yu.G. (1978). Wastewater and sludge treatment in digesters. Kyiv: Budivelnik. 120 p. https://www.geokniga.org/books/25236

Zhabo V.V., Lebedev D.P., Moroz V.P. (1983). Reference book on heat supply of agricultural enterprises. Moscow: Kolos. 320 p. https://www.geokniga.org/books/25236

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