

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Satbayev University

**SERIES
OF GEOLOGY AND TECHNICAL SCIENCES**

2 (446)

MARCH – APRIL 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген № KZ39VPY00025420 мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология және техникалық ғылымдар бойынша мақалалар жариялау.*

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19, 272-13-18

<http://www.geolog-technical.kz/index.php/en/>

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Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

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«Известия НАН РК. Серия геологии и технических наук».

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан № KZ39VPY00025420, выданное 29.07.2020 г.

Тематическая направленность: публикация статей по геологии и техническим наукам.

Периодичность: 6 раз в год.
Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19, 272-13-18

<http://www.geolog-technical.kz/index.php/en/>

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Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

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News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan No. **KZ39VPY00025420**, issued 29.07.2020.

Thematic scope: *publication of papers on geology and technical sciences.*

Periodicity: 6 times a year.

Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19, 272-13-18,

<http://www.geolog-technical.kz/index.php/en/>

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Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty.

NEWS

OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN

SERIES OF GEOLOGY AND TECHNICAL SCIENCES

ISSN 2224-5278

Volume 2, Number 446 (2021), 151 – 158

<https://doi.org/10.32014/2021.2518-170X.47>

UDK 504.06

O. V. Rozhkova^{1,2}, M. T. Yermekov¹, Ye. T. Tolysbayev¹, S. G. Maryinsky³, A. V. Vetyugov⁴¹ Parasat Scientific and Technological Center JSC, Nur-Sultan, Kazakhstan;² Saken Seifullin Kazakh Agrotechnical University, Nur-Sultan, Kazakhstan;³ Tyumen industrial University, Tyumen, Russia;⁴ Bentonit Ltd., Moscow, Russia.E-mail: yermekov.m@parasat.kz**PROBLEMS OF STORAGE, REFINERY AND DISPOSING OF DRILLING WASTE OF THE EXPLORATION AND PRODUCTION SECTOR OF KAZAKHSTAN. ARRANGEMENT AND OPERATION FEATURES OF SLUDGE COLLECTORS AND OIL STORAGE PITS**

Abstract. A lot of drilling wastes with various content of oil products is formed annually during production of hydrocarbons in the result of accidents at the facilities of transportation and oil production, soil is polluted. So, main contaminants of the environment are drilling wastes such as drilling, drilling waste water, waste drilling fluid and places of their disposition - sludge pits. Total amount of the oil slurry annually formed at enterprises of the oil sector of Kazakhstan is about 100 thousand ton, and resources of these wastes are estimated in more than 40 mln. ton. The wastes are placed in special sludge pits equipped with watertight screen. However, in spite of the available modern technologies for arrangement of waterproof finish of the drilling waste disposal facilities, high level of soil pollution is still observed. As a rule, pollutions are related to violation of the requirements of the standards during construction and operation of sludge pits, products pipelines, tailing dumps, sludge collectors and temporary storages. Therefore it is necessary to build reliable storages for temporary placement of the formed wastes until their delivery for recovery or disposing, during operation of which there will be no migration of pollutants to the environment.

It is suggested to use bentonitic mats as waterproof finish of such facilities - this is innovative by properties, multifunctional composite material, which is combination of textile materials with the layer of the natural self-recovering mineral component - bentonite.

Key words: oil slurry, drilling wastes, bentonitic mats, oil contaminated soil, environmental protection.

Oil and gas sector is the leading sector of economy of Kazakhstan. Nowadays there are more 250 oil and gas deposits with the total volume of oil resources about 30.0 Bbbl or 1.7% of the world reserves. The Republic of Kazakhstan takes the twelfth place in the world [1] by the explored reserves. With the growth of oil extraction, increase in the volumes of its processing and transportation, the problems of disposal of the ever-increasing oil and other toxic waste, negatively affecting the environment, are aggravated. According to the Ministry of Environment of the Republic of Kazakhstan, soil pollution with oil and oil products is noted on the territory of more than 1.5 mln. ha.

Exploration, drilling of oil, gas and gas condensate deposits are environmentally dangerous kinds of work and are accompanied by:

- mechanical terrain disturbance;

- chemical pollution of soils, surface and underground natural waters, phyto- and zooplankton, atmospheric air, flora;

thermal abuse of exogenous geological processes (thermokarst, thermal erosion, settlement, etc.) with their possible adverse event (open flowing, gryphon formation, well walls collapses),

- contamination of the subsoil and the environment in the result of interformational cross flows and fluid exit from abandoned wells to the surface [2].

The main sources of the environmental pollution during wells drilling are: block of preparation and chemical treatment of drilling and cement slurries; wellhead; storage containers of drilling fluid; drilling waste (drill cuttings, drilling waste water, used drilling mud) and their placement (sludge pits); domestic sewages; solid household waste.

Among all oily wastes which have a harmful influence on the components of the natural environment, particularly, surface and underground natural waters, soil and vegetation cover, atmospheric air, not only oil slurries (oil sludges) - complex physical and chemical mixtures consisting of oil products, mechanical impurities (clay, metal oxides, sand) and water [3], are of special hazard, but also drilling waste, which are part of the main volume of the drilling waste.

Total amount of the oil slurry annually formed at enterprises of the oil sector of Kazakhstan is about 100 thousand ton, and resources of these wastes are estimated in more than 40 mln. ton [4]. They are placed in special sludge pits equipped with watertight screen made of a geomembrane, which can effectively prevent the migration of pollutants into ground water. The structure diagram of the pit is shown in figure 1.

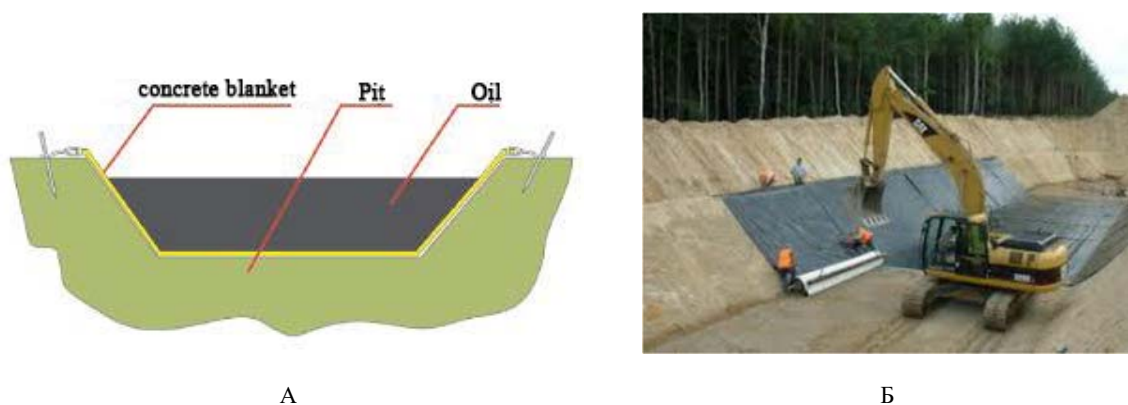


Figure 1 – Pit arrangement:
A – structure section of the pit with oil slurries; B – pit arrangement with roll waterproof material

In spite of the available modern technologies for waterproofing of the drilling waste disposal facilities/oil slurries, there is a high level of soil pollution with oil products, which is 194 thousand hectares of lands only in the Western Kazakhstan, and the volume of spilled oil is more than 5 mln. tons, and Atyrau area accounts for - 59%, Aktyubinsk - 19%, West-Kazakhstani - 13% and Mangistau - 9%. Maximum content of oil products is 172 480 mg/kg at very bituminous areas with the maximum permissible concentration (MPC) for soil in the Republic of Kazakhstan of 100 mg/kg. High levels of soil pollution with oil products have been identified near the deposits Makat, Dossor, Komsomolskoye, Tanatar, Tenteksor, Iskenes. Here, the registered oil products' concentrations in the soil vary from 24 to 138 mg/kg.

As a rule, pollutions are related to violation of the requirements of the standards during construction and operation of sludge pits, products pipelines, tailing dumps, sludge collectors and temporary storages.

To improve the situation in the largest Kazakhstani companies, which main activity is extraction of crude oil and accompanying gas, waste management programs are being developed and implemented. Mining waste management is one of the most important environmental aspects for the whole Kazakhstani oil-extracting complex. Criticality is, firstly, in the significant volumes of accumulated and formed hazardous waste peculiar to the whole oil industry [1-3].

Taking into account the huge role of the contractors during the waste recycling and disposal, the Companies try to increase the criteria for selection of the potential suppliers to guarantee the performance of work at high level and with complete transparency of the cycle - from waste generation and transportation to recycling and final disposal.

The largest Kazakhstani company Tengizchevroil (hereinafter - TCO), which total explored reserves is 3.2 billion tons (25.5 Bbbl) in Tengiz reservoir and 200 million tons (1.6 Bbbl) in the deposit Korolev, invested 3.1 bln. USD in the environmental projects since 2000. Main production wastes from activity of

TCO are: oil sludge, drilling waste, dry and liquid chemicals, activated carbon, spent catalysts, molecular sieves and caustic-containing sludge [1, 5]. 64% of the waste formed in Tengiz was transferred for recycling or to the specialized companies for processing and storage in 2018. TCO implemented a program on reduction of waste generation prohibited to disposal at landfills, and began to expand the area for temporary storage of materials which are subject to secondary use and recycling at Tengiz Eco Center. TCO transfers more than 25 kinds of waste for recycling. The total share of the recycled waste as of the third quarter of 2019 was 68.42%.

Expired chemicals and oily waste are subject to burning and heat treatment, and oily waste is subject to biological cleaning. In general, the volume of recycled and disposed waste is increasing every year. Waste management facilities "TengizEcoCentre" were founded. The company uses the first landfill in Kazakhstan equipped with a double geomembrane coating, collecting system of evolved gases and filtrate, and leak detection system.

The largest Kazakhstani Company "KazMunayGas" (hereinafter - KMG), the volume of waste from oil production in 2018 amounted to 288.3 thousand tons, among which waste classified as "hazardous" - 268.9 thousand tons, and "non-hazardous" - 19.4 thousand tons, respectively. The most part of the hazardous waste - 67% - is drilling waste (drill cuttings and waste drilling fluids). More 80% of all waste is transferred for disposal by the specialized companies. Other significant waste management methods are burning, placement at a landfill and recovery. The single roadmap was formed in 2019 by all historical pollution at the deposits of KMG, and the Company is going to liquidate them completely by 2024.

The Company MI SWACO has been working in the market of Kazakhstan since 1993, and joint Kazakh-American venture, Kaz M-I SWACO LLP, was founded in 2008, the activity of which is aimed at drilling waste recycling, and also production and sale of drill fluids (water, hydrocarbon and synthetic-based), supply of oil fields reagents and pipeline additives, equipment for mechanical cleaning of hole shank, renders drilling services with the controlled pressure.

So, the relevant task of all modern enterprises of the Republic of Kazakhstan is disposal and processing of oil and drill cuttings within the oil production facilities, as the main carriers of the considered pollutant. Taking into account the current situation with the global depletion of energy resources, the processing of oily waste can become one of the options for the economic use of the total reserves of hydrocarbons on the planet. Moreover, the analysis of the qualitative and quantitative composition of oil and slime waste demonstrated that they contain up to 80% of hydrocarbon raw materials, which is a valuable fuel and energy resource, which means that processing of such waste can be economically sound and reasonable [6].

However, despite the fact that the disposal of oil slurries is aimed at improvement of the environmental situation, it can be much more harmful to the environment than its absence. Many methods of disposal and recycling of waste containing oil products cause direct or indirect damage to the environment. So, for example, a significant part of harmful fumes directly enters the atmospheric air [5, 6] during thermal treatment of oil sludge (evaporation).

A common disadvantage of all known technologies for disposal and processing of oil sludge is their low productivity and high material, energy and financial costs for their implementation. Therefore, enterprises shall organize the process correctly to ensure the profitability of the used methods [7,8]. Introduction of one or another processing technology depends, first of all, on the composition of the raw materials used, the nature of oil sludge, the ratio of organic and inorganic components in them, environmental requirements, and also on specific conditions - the profile of the enterprise, its technical capabilities, etc. All these factors makes the complete and intensive processing of sludge with the maximum environmental safety for the environment difficult [9].

In this regard, the problems of safe placement and storage of oil slurries, construction and operation of sludge collectors and sludge pits, taking into account the long-term functioning and mitigation of their negative impact on the environment, come at an opportune time. There is a need to strengthen the requirements to the design and operation of sludge collectors and pits, using modern technologies and materials which enable long-term storage with the guaranteed exclusion of pollutants migration from waste to soil.

The analysis of the legislative norms in the Republic of Kazakhstan demonstrated that the modern requirements are aimed at exclusion of drilling waste penetration on the territory of the drilling site and

the migration of toxic substances into the natural objects. These requirements stipulate for engineering systems for organized collection, storage and waterproofing of the technological sites. Moreover, deposits construction stipulate for application of method for preparation and cleaning of drilling fluid, processing of drilling waste using method "under bench". Construction of sludge collectors and pits is allowed only in agreement with the relevant state bodies, including the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan. If the deposits are built in specially protected natural areas, only drilling method without pits shall be used. Drilling deposits in terms of absorption, it is prohibited that solutions and materials enter layers containing domestic potable water. Quick-setting mixtures, various devices and technological processes are used, such as drilling using aerated solutions, foams, etc.

Main materials used in the oil industry for insulation during construction of oil facilities are bitumen based and imported materials and polymer materials with thickness of 1.0-2.5 mm based on high and low density of polyethylene, polyvinyl chloride, etc. Also geomembrane is used for waterproofing - based on high and low pressure polyethylene.

Bituminen-containing membranes (GSB) can be classified depending on kind of the basis: with cardboard basis - roofing board is impregnated with a bituminous binder, most often from oxidized bitumen and filler (Filler). Mineral dressing can be applied from top; with the basis of glass-fiber mat, glass tissue or polyester, which is usually impregnated with modified bitumen. Polymer watertight screens have a number of incontestable advantages, including simplicity of arrangement, relative cheapness, however, application of geosynthetic membranes does not exclude an essential disadvantage of this kind of material, which consists in reducing the strength factor of the material due to creep in the course of long-term operational time-temperature factors [10-12].

Taking into account visco-elastic nature of synthetic polymers, of which the most geosynthetic materials are made [13-15], and also taking into account all positive and negative aspects of the waterproofing technologies application using polymer materials and bitumen-based materials, in our opinion, the best solution for waterproofing, sludge collectors, reservoirs, pits for storage of oil slurries and fuels and lubricants is the use of bentonite mats - innovative in properties, representing a combination of textile materials with the layer of natural self-recovering mineral component - bentonite [16].

Bentonite mats are a multifunctional composite material in the form of a needle-punched bracing made of polypropylene fibers, which has inside powder or granules of sodium bentonite - one of the montmorillonite clay types of natural origin, with mat sizes 4-5 m wide and up to 40-50 m long (figure 2).

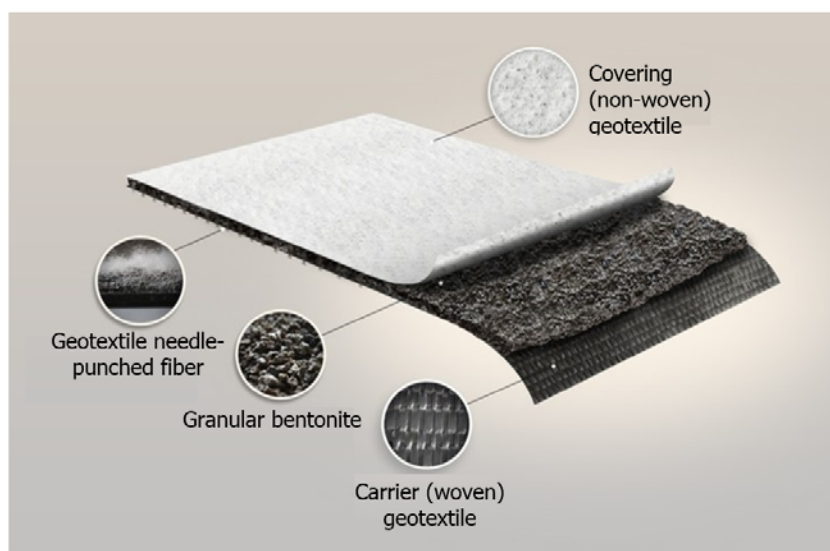


Figure 2 – Bentonite Mat Structure

Mats are used in the oil industry as a reliable waterproofing material for various storage facilities and technological sites. Also they act as watertight screen, which is designed for protection against penetration of various pollutants from sludge pits into the soil and groundwater from sludge pits, tanks for oil and fuels and lubricants storage.

The use of bentonite mats has tremendous advantages during construction and operation of sludge pits, tanks for oil and fuels and lubricants storage:

- one layer of bentonite mat (thickness 6 mm) substitutes clay waterproofing layer (clay retainer) with thickness 1.0 m;
- can sustain high hydrostatic pressure (up to 70 m w.c.);
- bentonite clay, which is component of mat, absorbs oil products well;
- very low permeability coefficient (1×10^{-6} m/day);
- able to self-healing due to swelling (in contact with water) of clay matter and filling the cavities with gel in the result of mechanical damage and cracks at the base;
- possibility to work at low temperatures (up to -20 °C);
- sustain large number of cycles "freeze - thawing" and "hydration - dehydration", without significant change in consumer properties (for example, after exposure to variable temperatures, 10 cycles: tensile strength, decreased by 3% for certain bentonite mats).

All these factors stipulate the wide application of this material by large companies operating in the area of subsoil use in the Russian Federation and abroad, such as: PJSC NC Rosneft, PJSC Gazprom Neft, LLC Gazprom Burenie and PJSC Surgutneftegaz and other.

There is a need to consider the requirements to arrangement of impervious protective screens in the modern practice of construction and operation of sludge collectors and pits for oil slurries, which shall minimize the pollution of the environmental components. Introduction of such regulatory requirements with the development of the National Standards of the Republic of Kazakhstan, specialized Recommendations on application of bentonite mats for design, construction and other designated organizations could contribute to the development of local production of the innovative domestic materials based on bentonite deposits in Kazakhstan.

For instance, on the basis of the Taganskoye deposit in East Kazakhstan, which is represented by three industrial horizons of alkaline, alkaline-earth and pharmaceutical bentonites [17].

They are one of the high quality in terms of their technical characteristics not only in Kazakhstan, but also abroad. Due to its unique chemical composition, Taganskiy bentonite has a wide range of applications in the various industries [18]. High efficiency of the clays of the deposit Taganskoye with respect to the oil products sorption was proved during the laboratory tests (2020) carried out on the basis of the laboratory of the Ministry of Natural Resources of the Russian Federation - the Federal State Budgetary Institution "Centre of Laboratory Analysis and Technical Metrology in the Ural Federal District". The results of the tests demonstrated that the content of oil products is reduced by 3-4 times compared to the initial pollution.

The rights for development of the deposit Taganskoye are owned by the Group of Companies Bentonite (Russian Federation), one of the five world producers of bentonite products, one of subdivisions is Altai Materials LLP. The Group of Companies Bentonite has an great experience in production of bentonite mats under BentIzol brand, which is a new multifunctional material for arrangement of watertight screens (figure 3) not only during construction and reclamation of landfills of industrial and

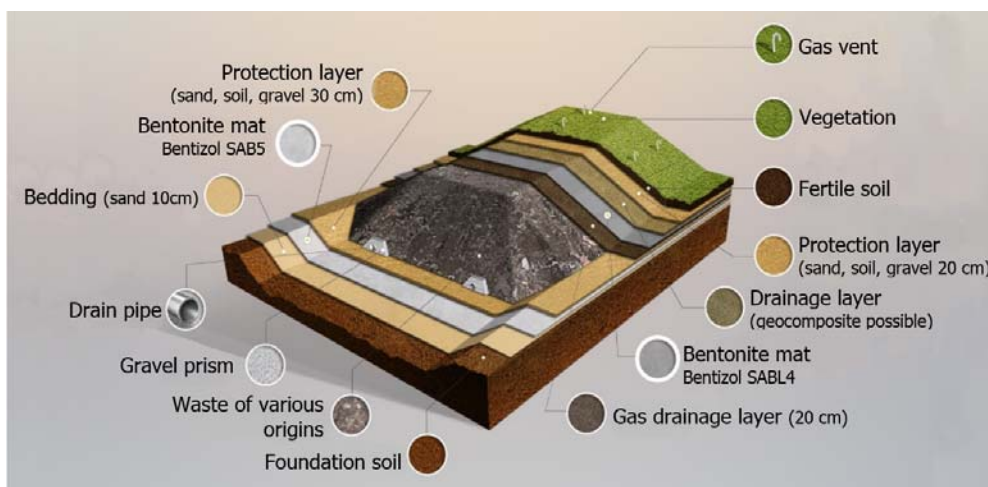


Figure 3 – BentIzol Bentonite Mats Application Scheme during construction and reclamation of the landfill

solid domestic waste of various origins, but also during creation of engineering safety barriers during conservation and burial of radioactive waste and nuclear and radiation hazardous facilities. Bentonite mats are the most effective compared to the traditional and polymer materials (figure 2), which production can be developed in Kazakhstan if there is an appropriate market niche.

Thus, strengthening the norms for arrangement of waterproofing and watertight screens during construction dumping facilities of production and consumption waste, on the one hand, enables solving the problems of their reliability and reducing the impact on the environment in the long term, on the other hand, it contributes to the creation of a new own innovative production with additional job opportunities.

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ҚАЗАҚСТАННЫҢ МҰНАЙ ӨНДІРУ САЛАСЫНДАҒЫ ҚАЛДЫҚТАРДЫ БҰРҒЫЛАУ, САҚТАУ, ӨНДЕУ ЖӘНЕ ҚАЙТА ӨНДЕУ МӘСЕЛЕЛЕРІ. МҰНАЙ ҚОЙМАЛАРЫН ЖӘНЕ ШЛАМ ЖИНАҚТАҒЫШТАРДЫ ПАЙДАЛАНУ ЖӘНЕ ҚҰРЫЛЫМ ЕРЕКШЕЛІКТЕРІ

Аннотация. Мақалада біз мұнай өнімдерінің құрамында әр түрлі бұрғылау қалдықтарының көп мөлшерін қалыптастыру, сондай-ақ тасымалдау және мұнай өндіру объектілерінде топырақтың ластануына әкелетін төтенше жағдайларды қарастырдық. Қоршаған ортаның ластануының негізгі көздері, ең алдымен, бұрғылау шламы, бұрғылау ағынды сулары, бұрғылау қалдықтары және олардың орналасқан жері - шлам қоймалары сияқты бұрғылау қалдықтары екені белгілі.

Қазақстанның мұнай өнеркәсібі кәсіпорындарындағы жыл сайынғы шығарылатын мұнай шламының жалпы мөлшері шамамен 100 мың тоннаны құрайды, ал бұл қалдықтардың ресурстары 40 миллион тоннадан асады. Қалдықтар фильтрге қарсы экранмен жабдықталған арнайы шлам қоймаларына орналастырылады. Алайда, бұрғылау қалдықтарын орналастыру қондырғыларын гидроизоляциялаудың қолда бар заманауи технологияларына қарамастан, топырақтың ластануының жоғары деңгейі сақталуда. Әдетте, бұл ластану шлам қоймаларын, өнім құбырларын, қалдық қоймаларын, шлам тоғандарын және уақытша сақтау қоймаларын пайдалану кезінде, сондай-ақ құрылыс кезінде стандарттар талаптарының бұзылуымен байланысты. Сондықтан, пайда болған қалдықтарды оны өңдеуге немесе көмуге жібермес бұрын уақытша орналастыру үшін, қоршаған ортаға ластаушы заттардың қоныс аударуы болмайтын сенімді сақтау қоймаларын салу қажет.

Осылайша осындай объектілерді салу және пайдалану кезінде гидроизоляциялауға арналған фильтрге қарсы бентонит төсеніштерін экран ретінде пайдалану ұсынылады, бұл қасиеттері бойынша инновациялық, көпфункционалды композициялық материал, ол табиғи өзін-өзі қалпына келтіретін минералды компоненттің қабаты бар тоқыма материалдарының үйлесімі – бентонит. Сондай-ақ, қазіргі уақытта шлам жинағыштар мен қоймаларды жобалау және пайдалану үшін ұзақ мерзімді сақтауға мүмкіндік беретін заманауи технологиялар мен материалдарды қолдануға қойылатын талаптарды қатаңдатудың өткір проблемасы бар. Сондықтан жобалау, құрылыс және басқа мамандандырылған ұйымдар үшін бентонит төсеніштерін пайдалану бойынша ұлттық стандарттар мен мамандандырылған ұсыныстарды әзірлеумен Қазақстан Республикасындағы нормативтік талаптарды қайта қарау қажет.

Түйін сөздер: мұнай шламы, бұрғылау қалдықтары, бентонит төсеніштері, мұнаймен ластанған жерлер, қоршаған ортаны қорғау.

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ПРОБЛЕМЫ ХРАНЕНИЯ, ПЕРЕРАБОТКИ И УТИЛИЗАЦИИ ОТХОДОВ БУРЕНИЯ НЕФТЕДОБЫВАЮЩЕЙ ОТРАСЛИ КАЗАХСТАНА. ОСОБЕННОСТИ УСТРОЙСТВА И ЭКСПЛУАТАЦИИ ШЛАМОНАКОПИТЕЛЕЙ И НЕФТЯНЫХ АМБАРОВ

Аннотация. В статье нами рассмотрена проблематика образования большого количества отходов бурения с различным содержанием нефтепродуктов, а также аварийных ситуаций на объектах транспортировки и нефтедобычи, в результате которых происходит загрязнение почв. Известно, что основными источниками загрязнения окружающей среды являются, прежде всего, отходы бурения, такие как буровой шлам, буровые сточные воды, отработанный буровой раствор и места их размещения – шламовые амбары.

Общее число ежегодно образующегося нефтешлама на предприятиях нефтяной отрасли Казахстана составляет около 100 тыс. тонн, а ресурсы этих отходов оцениваются более чем в 40 млн тонн. Размещаются отходы в специальных шламовых амбарах, оснащенных противofильтрационным экраном. Однако, несмотря на имеющиеся современные технологии для устройства гидроизоляции объектов размещения отходов бурения, по-прежнему наблюдается высокий уровень загрязнения почв. Как правило, эти загрязнения связаны с нарушением требований стандартов при строительстве, а также при эксплуатации шламовых амбаров, продуктопроводов, хвостохранилищ, шламонакопителей и временных хранилищ. Поэтому для временного размещения образующихся отходов до передачи их на переработку либо утилизацию необходимо строить надежные хранилища, при эксплуатации которых не будет процесса миграции загрязняющих веществ в окружающую среду.

Таким образом, в качестве противofильтрационного экрана для гидроизоляции таких объектов при строительстве и эксплуатации предлагается использовать бентонитовые маты, являющиеся инновационным по свойствам, многофункциональным композиционным материалом, представляющим собой комбинацию текстильных материалов с прослойкой природного самовосстанавливающегося минерального компонента – бентонита. Также в настоящее время остро стоит проблема ужесточения требований к проектированию и эксплуатации шламонакопителей и амбаров, с применением современных технологий и материалов, которые дают возможность долгосрочного хранения. Поэтому необходим обязательный пересмотр нормативных требований в РК с разработкой Национальных стандартов и специализированных Рекомендаций по применению бентонитовых матов для проектных, строительных и других профильных организаций, который мог бы способствовать скорейшему развитию локального производства отечественных материалов на базе бентонитовых месторождений Казахстана.

Ключевые слова: нефтешлам, отходы бурения, бентонитовые маты, нефтезагрязненные земли, охрана окружающей среды.

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www.nauka-nanrk.kz

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

<http://www.geolog-technical.kz/index.php/en/>

Редакторы *Д. С. Аленов, М. С. Ахметова, Р. Ж. Мрзабаева*
Верстка *Д. А. Абдрахимовой*

Подписано в печать 15.04.2021.

Формат 70x881/8. Бумага офсетная. Печать – ризограф.
13,0 п.л. Тираж 300. Заказ 2.