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Abstract. The paper considers the technologies of the drilling sludge industrial utilization. Deep-well drilling for oil and gas extraction results in wastes in the form of sludge that is hazardous for the environment. The research aim is to study the existing technologies for working the drilling wastes into salvage that can be used in construction and road building at the oil and gas fields.

1. Introduction

Deep-well drilling in oil and gas fields results in wastes in the form of the sludge stored in special waste pits. As the sludge contain toxic substances and petroleum products, it has a complex negative impact on the environment [1], the human being and ecosystem being mostly affected. The hazardous influence of the sludge is revealed in the water pollution and the negative impact on the organisms in the nearby water bodies. The soils and vegetation cover are also affected: the soil structure changes and as a result, the crop-producing power of the agricultural lands is reduced.

The sludge pits are built to prevent the ingress of the polluted water in the soil. This is realized with water-proofing the pit bottom, which leads to the pits' high watering (Figure 1). Another feature of the pits is their increasing size which is connected with drilling inclined wells in clusters - when fewer waste pits are used, but the pit's volume increases.

Figure 1. A waste pit for storing the drilling sludge.

The aim of the study has been to analyze the technologies and approaches to utilizing the drilling sludge in order to obtain industrial products for the construction and road-building purposes. As the latter are logistically connected to the oil and gas fields, this would reduce the environmental load on the given territory. Obtaining industrial products makes it possible to decrease the amount of the wastes connected with the oil and gas fields' exploration and exploitation.

The main tasks have been:

• To develop a technology of separating the polluting organic compounds (oil, POL, polymer compounds, etc.) or a technology of producing building materials with the hazardous wastes' neutralization.

• To develop technologies of separating the liquid and solid phases of the wastes.

• To standardize the chemical and disperse composition of the materials and industrial products.

• To create algorithms for developing recommendations on utilization and storage of the industrial products.

• To analyze the methods of the second-stage treatment of the service water using wild-growing plants, algae and microorganisms typical of the given area.

The researchers traditionally distinguish a few ways of utilizing or neutralizing the drilling waste [8]. Thermic methods based on the incineration of the drilling sludge in open waste pits or in different-capacity thermal furnaces. Physical methods include waste disposal in burial facilities, separation in centrifugal machines, vacuum and pressure filtration. Chemical methods include extraction with the use of various solvents, hardening with calcium sulfate, cement, clay loam, and other additives, both organic and non-organic. Physical-chemical methods use sorbents and additions that change the physical-chemical properties, hazard class and other characteristics of the drilling waste. In biological methods, microbiological agents and organisms are added in the waste to enhance the decomposition of the latter in the soil [8].

2. Materials and methods

The study uses the results of the analysis of the drilling sludge samples taken from different fields. The composition of the *Kogalymneftegaz'* production waste and the parameters of the materials stored in the sludge pits of *Irkutsk Oil Company*, Ltd, have been analyzed.

3. Research results and analysis

Oil-and-gas companies face the problem of utilizing the well-drilling wastes. There are millions of tons of the drilling wastes accumulated in the sludge pits of the Eastern Siberia and Yakutia oil and gas fields. The wastes' hazard class is 3 to 5, which leads to the annual increase of the pollution tax, surcharges and environmental payments. The waste processing is hindered by the climatic, environmental, geographical and economic conditions of the fields.

The main approach to solving the problem is separation of the materials when advancing the wells as well as separate utilization of the hazardous and non-hazardous drilling products. However, this technology cannot be used for utilizing the sludge pits because of the waste's high watering and stratification as a result of the long-term storage.

Defining the technologies for the utilization of the accumulated drilling wastes is an important task in cost-effectiveness terms [2].

The suggested utilization technology includes the following stages:

• Mechanical separation (floatation)

• Sorbent usage

• Treatment with the use of biotechnologies

• Obtaining agloporite rubble (fly ash aggregate)

The technology is as follows.

The wastes' liquid and solid phases are separated. The solid phase' components are blended in terms of their chemical and granulometric composition, and the material is then stored as salvage for further usage in road building as well as in industrial and civil engineering of the objects logistically

connected to the oil field. The specification of the salvage contains the salvage's characteristics and guidelines on its further usage. The liquid phase (i.e. service water) is collected in the artificial basin where it goes through second-stage treatment with the help of the aquatic cultures (i.e. the wild-growing plants, algae and microorganisms typical of the area). It is intended to not only follow the general guidelines, but also to consider the specifics of every oil field, as well as to implement the project supervision and support.

The most cost-saving utilization method (on condition that there is charge-free fuel available) is obtaining agloporite rubble. The raw material for the rubble production can contain any mineral material and certain amount of clay. The substantiation is as follows.

1. The drilling sludge originally contains a big amount of water, thus it is unsuitable for any technological operations. The clay that is in quantity around the pits makes it possible to bind the excess water and turn the sludge in a conveniently-stacked product. Besides, the oilmen and road workers have soil-mixing equipment.
2. The obtained kneaded mixture of sludge and clay can be baked in calcining furnaces, with the associated gas as fuel. The furnaces are industrially manufactured. All the organic substances contained in the sludge are utilized in the burning process.
3. The agloporite rubble' density, mechanical durability and water resistance can vary significantly depending on the clay content. The light rubble can be used in thermal insulation concrete production for the purposes of housing construction; the more durable and hard rubble can be used in road building. If there is no demand on the side of the construction companies, the rubble can be used to backfill the pits.
4. Transportation in the off-the-road conditions makes practically all the products too expensive. The rubble production eliminates the necessity of transportation: all the materials are taken on-site and utilized nearby.

Thus, the suggested technology makes is possible to work the drilling sludge in the salvage that can be used in the road building and construction works in close proximity to the oil fields.

4. Discussion

Processing the drilling sludge is an important task as the accumulated wastes pollute the environment (especially, in the northern territories) and lead to the increase of the pollution tax. Therefore, there are many researchers dealing with the problem and suggesting different solutions, the most common one being the usage of the drilling sludge in agriculture. Adding the sludge in the soil increases the soil mineralization and the content of the chemical substances necessary for the agricultural crop yield enhancement [3]. The drilling sludge can be used for the reclamation of the technogenic soils as the sludge enhances the vegetation cover restoration and the vegetation growth rate [4]. This makes it possible to use the drilling sludge in the oil fields' territories, the consumption of the material being not so high though. Ecologists pose processing the sludge with filtering membranes [1], the output material being dehydrated and compacted.

The usage of the sludge components as building materials has been considered by a few researchers [5,6,7,8,9,10]. The most commonly mentioned way is to use the processed or utilized drilling sludge as a portland cement component [5, 6, 8, 9].

Some researchers suggest using the drilling sludge as salvage for building materials that in turn can be used for road and cluster berm landfilling [8]. The authors suggest sludge solidification with further burying under the mineralized soil layer, or using the sludge in the hosting industry. The clay-like solidified mixture serves as a building material or, being grinded, as a fertilizer. In order to solidify the sludge, it is processed with activating components. The solidifiers include such binding materials as polymer additives, carbamide resin, gypsum, cement, liquid glass, etc. To shorten the binding time, the above additives' content is increased or +polyelectrolytes are added (sodium salt, calcium chloride and soda ash) [8]. However, the approach is not suitable for the Eastern Siberia oil fields because of the high costs of the binding additives transportation.

5. Conclusion

The study of the composition of the drilling sludge stored in the waste pits of the oil and gas fields has shown that the sludge can be used as a basic salvage component; and provided there is associated gas that can be used as fuel, a valuable product in the form of agloporite rubble can be obtained. On the whole, the suggested technologies make it possible to work the drilling wastes in building materials.

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