ENVIRONMENTAL JUSTIFICATION OF THE USE OF DRILL CUTTINGS IN THE SOIL

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SUMMARY

The results of the study of the chemical composition of drill cuttings of the Bovanenkovskoe oil and gas condensate field on the following indicators are presented: calcium, magnesium, chloride-sulfate and phosphate ions, total amount of heavy metals and their mobile forms, amount of oil products, chemical consumption of oxygen in aqueous extract. Drill sludges hazard class is defined, also data on biotesting of soil samples derived from the brown sludge of the Bovanenkovskoe oil and gas condensate field with the addition of crushed silica clay, peat grass-roots sieved and calcined diatomite of Iznenskoe field is presented.

Key words: drill cuttings, biotesting, soils.

INTRODUCTION

Currently, the problem of disposal of drilling waste is becoming more severe, as this type of waste is formed in large quantities and causes great damage to the environment. Natural ecosystems in the territories of drilling waste storage are exposed to the greatest anthropogenic impact, which is a consequence of the imperfection of drilling and disposal of drill cuttings (DC) technologies. In this regard, drilling fluids, as well as drill cuttings, formed mainly by drilled rocks, are hazardous waste for the biosphere, accumulated in the territories of drilling in specially equipped earthen storage barns. The greatest danger for the objects of the natural environment are industrial and technological drilling waste, which accumulate and are stored directly on the territory of the drilling rig. In its composition, they contain a wide range of pollutants of mineral and organic nature, represented by materials and chemicals used for the preparation and processing of drilling fluids (e.g., polyacrylamide (PAA), condensed sulfite alcohol bard (CSAB), carboxymethylcellulose (CMC) etc. Up to 68 kg of polluting organic matter per 1 m^3 of waste, excluding oil and oil products and mineral pollutants is accounted [1]. The impact of drill cuttings on the soil, flora and fauna mainly consists of oil pollution. When soil is contaminated with oil products, there is a violation of the air regime and water properties of the soil. As a result of oil products impact on the soil cover, there is a change in living microorganisms inhabiting the soil: the number of cellulose-decomposing microorganisms and bacteria that absorb nitrogen compounds decreases. There is an inhibition of redox enzymatic processes, which ultimately reduces the biological activity and fertility of soil [2]. Drill cuttings in most cases have an alkaline reaction, which contributes to the formation of easily soluble humates, which are washed out of the surface layer of the soil, reducing the total content of humus [3]. In order to reduce damage to the environment, an effective method of disposal is required, which would make it possible to obtain safe products from waste, which will then be involved in further production.

There are many ways of DC processing, which are very effective in solving this problem. However, when implementing them in practice, there are significant technical and economic shortcomings. Today, the most common technology of sludge disposal (in addition to burial, which does not solve the environmental problem) is incineration. This method is universal: sludge does not require preliminary preparation, that is, the separation of plants, stones, debris, petroleum products. The volume of the processed product (ash) is ten times less than the volume of the initial sludge. But when burning a large number of harmful gases that require cleaning are released into the atmosphere. In addition, as a rule, the moisture content of the sludge is very high, so they need a large amount of energy to burn, ie burning is a very expensive process. There are biological methods in which bacteria, cultures of fungi, plants are introduced into the contaminated soil,

allowing to provide the most complete cleaning of sludge from oil products, but this process is long and requires certain conditions: temperature, humidity and others [4].

It should be noted that the most successfully solved are the problems of utilization or processing of DC with a low content of water-soluble salts and petroleum products. Of the known methods for this kind of DC the applicable are:

- thermal – firing DC to obtain expanded clay, brick and other building ceramic materials, and its essence lies in the fact that organic substances are completely burned at high temperature;
- physico-chemical - solidification of DC with cement, liquid glass, quicklime, other additives and their combinations to obtain sand and gravel-sand soils for road construction or lithification with subsequent disposal;
- biological – mixing with peat, humus and other biomaterials, followed by the addition of the product into the soil[5].

In this paper we consider the possibility of obtaining soils using drill cuttings.

RESEARCH METHODS AND RESULTS

Samples of spelled drill cuttings of the oil and gas condensate field "Bovanenkovskoye" (6 samples from various wells) were taken for research.

Bovanenkovskoye oil and gas condensate field is a giant gas field on the Yamal Peninsula in Russia, located 40 kilometers from the coast of the Kara sea, in the lower reaches of the rivers Se-Yakha, Mordyakha and Naduy-Yakha.

In order to assess the use of drill cuttings for the preparation of soils, the chemical composition of drill cuttings samples was studied according to the following parameters:

- the presence of calcium and magnesium ions (hardness salts);
- the presence of chloride ions;
- the presence of sulfate ions;
- the presence of phosphate ions;
- the presence (total and soluble forms) of heavy metal ions (lead, copper, cadmium);
- the presence of oil products;
- COD (chemical oxygen demand) — the presence of organic and inorganic substances oxidized by strong oxidizers integral index.

Analysis of the results of the chemical composition of the sludge showed that its soluble components are mainly calcium and magnesium sulfate, the presence of chlorides and phosphates is minor; in addition, there are soluble salts of copper and insoluble compounds of lead and cadmium.

At the same time, the presence of petroleum products and other organic and easily oxidized inorganic substances in quantities not exceeding $TLV_{subsoil}$ was noted.

To assess the possibility of using sludge for soil preparation, the class of waste hazard was calculated in accordance with the order of the Ministry of natural resources of the Russian Federation "On approval of criteria for classifying hazardous waste as a hazard class for the environment" dated June 15, 2001 № 511 for each of the 6 sludge samples. According to the results of the calculation, all six samples have the index of the degree of danger of waste of $K_{gen} \leq 10$ (K_{med}=0.103), that is, they belong to the class V of danger (practically non-hazardous waste), but since it is not experimentally proved, they were assigned the class IV of danger.

To clarify the hazard class of the waste obtained in accordance with the calculation method, biotesting of soil samples prepared on the basis of drill cuttings obtained by mixing sludge from different drilling horizons was carried out.

Soils with different ratios of components, which are shown in table 1, were prepared from a mixture of sludge samples with the use of structuring and sorbing additives.

Used as additives were: ZTO-7 (powdered silica), peat grass-roots sieved and calcined diatomite from Iznenskoe field.

Silica clay, diatomite are loose materials, good sorbents (tend to absorb petroleum products).

Peat is a fertilizer used as a source of humus substances and nitrogen assimilated by plants.

Table 1. Data on prepared soil samples

Sample №	DC, % mass	Silica clay, % mass	Peat, % mass	Diatomite, % mass
1	80 %	-	20%	-
2	60%	20%	20%	-
3	60%	-	20%	20 %
4	60%	10%	20%	10%
5	60%	10%	30%	-

Prepared soil samples based on sludge were tested for toxicity by biotesting.

Biotesting is usually understood as the procedure for determining the toxicity of the environment with the help of test objects that signal the danger regardless of what substances and in what combination cause changes in the vital functions of the test objects. Due to it's simplicity, efficiency and accessibility biotesting is widely accepted around the world and is increasingly used alongside methods of analytical chemistry.

According to the results of the calculation presented earlier, the drill cuttings belong to class V of waste danger. To check its safety and for the selection of the most suitable soil for growing

plants with the use of sludge, biotesting of soil samples was carried out according to the following procedure.

The substrate was put into cups, moistened with the same amount of water. 5 seeds of test plants were planted in each cup of test substrate. Watering was made by standing tap water [6].

After 2 weeks measurement of the height of the shoots, length of roots and weight of biomass of the test plants were made. Garden cress was used as test plant.

5 soil samples and 1 control sample were tested (the soil from the Tomilinsky forest park adjacent to the territory of Dzerzhinsky of the Moscow region was used as a control sample). 2 parallel studies were performed for each sample.

The results of biotesting of soil samples showed that the presence of drill cuttings in the soil does not have a negative impact on the development of the test plant. The best results for biomass of grown test plants were shown by soil samples №4 and 5, containing respectively 60% mass drill cuttings, 10% mass silica clay, 20% mass peat, 10 % mass diatomite, and 60 % mass drill cuttings, 10% mass silica clay and 30% mass peat; the remaining samples, with contents of drill cuttings from 60 to 80 % mass gave approximately the same results for plant biomass. The best indicators of samples №5 can be explained by the increased content of peat, which is an organic fertilizer, in comparison with other soil samples.

It should be noted that the indicators for the control samples (soil of the Tomilinsky forest park) showed the worst results of biotesting among all soil samples. The latter can be explained by the exhaustion of the soil of the urban forest park and the low content of humus substances in it.

Analysis of the results of soil biotesting shows that the soils obtained on the basis of drill cuttings are suitable for cultivation and even contribute to the better development of plants.

COCNCLUSION

1. On the basis of the analysis of the literature data it is shown that the problem of development of methods of utilization of the drill cuttings formed at the oil and gas producing enterprises is relevant now.

2. The composition of drill cuttings of the Bovanenkovskoe oil and gas condensate field is studied and it is established that they belong to the wastes of the class IV of danger, the content of all the studied components does not exceed $TLV_{subsoil}$.

3. Samples of soils based on Bovanenkovskoe oil and gas condensate field sludge were obtained and their biotesting was carried out. It is established that soils on the basis of drill cuttings do not have a negative impact on the development of plants and can be used for utilization in soil mixtures.

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