Analysis of the environmental status and measures for safety and environmental protection in oil and gas producing areas

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Abstract. Environmental pollution in the areas of drilling and field development is one of the main priority environmental problems. At the same time, as observations show, the main objects of pollution are groundwater, hydro-and lithosphere (open water bodies, the bottom of water areas, soil and vegetation cover). Sources of pollution are the results of the process itself. The greatest danger posed to environmental objects is technological drilling waste, which is accumulated and stored directly on the drilling site. Drilling waste includes drilling cuttings, waste drilling fluids and drilling wastewater. They are formed in the process of washing the well. In the process of deepening a well at the bottomhole, a drill is formed. Hydrotransport that drills mud from the bottom of the well to the surface of the rock under the influence of man-made factors turns into drill cuttings. Therefore, in the cleaning system of the circulating system of a drilling rig, the cuttings are not separated from the drilling fluid. But drill cuttings differ in volume and, most important from an environmental point of view, in physicochemical properties. The volume of cuttings is equal to the volume of the wellbore. When designing, the volume of drill cuttings is approximately taken by 20% more than the volume of cuttings.

1. Introduction

Environmental pollution in the areas of drilling and field development is one of the main priority environmental problems. At the same time, as observations show, the main objects of pollution are groundwater, hydro-and lithosphere (open water bodies, the bottom of water areas, soil and vegetation cover). Sources of pollution are the results of the process itself. Researchers divide them into two groups: permanent and temporary (Figure 1). The first is the filtration and leakage of liquid waste from sludge pits. The second includes temporary action sources - complications arising from the drilling of wells, in particular, the absorption of drilling mud, the release of drilling mud to the surface, the tightness of the annulus, leading to inter-layer flow and behind-the-column manifestations, etc.

Technological drilling waste poses the greatest danger to environmental objects. This waste is accumulated and stored directly on the drilling site. Drilling waste includes drilling cuttings, waste drilling fluids and drilling wastewater. They are formed in the process of washing the well.
2. Purpose of the study
The purpose of the paper is to assess the negative environmental impact on the environment during drilling and the effects of drilling waste (drill cuttings) produced directly on the soil.

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![Diagram of environmental pollution sources](image)

**Figure 1.** Classification of sources of environmental pollution during drilling.

In the process of deepening a well at the bottomhole, a drill is formed. When hydrotransport drills mud from the bottom of the well to the surface of the rock under the influence of man-made factors, it turns into drill cuttings. The volume of cuttings is equal to the volume of the wellbore. When designing, the volume of drill cuttings is approximately taken more than the volume of cuttings by 20%.

The increase in the volume of drill cuttings compared to drilling cuttings is associated with the following factors:
- decompression of sludge particles as a result of a decrease in the effect of external pressure on them;
- the formation and expansion of cracks;
- swelling of clay particles composing the sludge;
- adhesive sticking to the surface of the sludge particles of colloidal size of the washing liquid [1-3].

As is known, the majority of wells are drilled in sediments, in which clayey rocks are the most common. Their share is about 65-80%. Drilled particles of clay or rocks bonded with clay cement in the process of hydrotransport from the bottom of the well to the surface are impregnated with washing fluid filtrate and swell. The duration of the formation of rock particles in the drilling fluid varies in a relatively wide range with the depth of the well. The longer they are in the mud, the greater their swelling. When this occurs, there is adherence of solid particles of predominantly colloidal dimensions from the washing liquid to it.

3. Materials and research methods

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The dispersion medium of the drilling fluid has a significant effect on the change in the physicochemical properties of the particles of the drill cuttings. The pores and cracks of the rock particles are filled with the dispersion medium of the drilling mud. Substances from the dispersion medium of the drilling mud are adsorbed on the surface of the drill cutting particles. The mineralogical composition of the drill cuttings is determined by the lithological composition of the drilled rocks and may change significantly as the well deepens. The chemical composition of the drill cuttings depends on both its mineral composition and the properties of the drilling fluid. The granulometric composition of the sludge, as is known, is determined by the type and diameter of the rock cutting tool, the mechanical properties of the rock, the drilling mode, the properties of the drilling fluid and the efficiency of its cleaning. When using cutting-type bits, the volume of sludge is significantly larger than when drilling with roller bits, and when using cutting-type bits, the volume of sludge is much smaller and amounts to 10-15% of the total drill cuttings [1]. With the rotary drilling method, the amount of sludge is reduced compared to the turbine due to the dispersion of drill cuttings caused by the rotation of the drill string. This circumstance worsens the rheological parameters of the drilling fluid, necessitates their treatment with aqueous solutions of chemical reagents, which accordingly increases the volume of excess flushing fluid. Sludge volumes and excess flushing fluid depend on the effectiveness of the cleaning devices.

The environmental hazard of drill cuttings is determined by:
- the toxic effects of chemical elements and compounds in its composition;
- increased turbidity of water, which disrupts the vital activity of marine fauna;
- physical effects on bottom organisms.

Toxic effects on organisms are one of the serious aspects of the problem. Currently, in assessing the environmental friendliness of drill cuttings, the focus is on the gross content of mineral components. However, it is important to know in which chemical form the mineral components are present in the sludge. Numerous studies have shown that the most dangerous are mobile forms of chemicals that determine the degree of toxicity and hazard of drill cuttings [4].

The most common way to eliminate sludge pits is as follows. The barns are freed from the liquid phase, which is sent to the system for collecting and treating oil and then using it in the system for maintaining reservoir pressure. The remaining sludge is covered with mineral soil [5,6]. The described
method of eliminating sludge pits has a number of serious drawbacks, one of which is the content in the drilling sludge of fairly high concentrations of hydrocarbons, heavy metals in mobile form, and other toxic substances. Therefore, the need to eliminate sludge pits with subsequent disposal and disposal of drill cuttings is obvious.

The measures noted in [7,8] also provide for: complete abandonment of the use of earth barns and their replacement with metal tanks of large capacity; the use of a circulation system of an improved design with reliable closed pipelines for the bypass of drilling mud; putting into practice the transportation of drilling fluid from the well to the well for its multiple use (first of all, this refers to oil-based and emulsion solutions); processing and disposal of drilling mud residues and dumping them in specially designated areas. For those cases when, due to large distances, the transportation of drilling fluids from the well to the well is unprofitable, other methods are being developed. For example, in BashNIPIneft, a spray drying method has been developed for chemical solutions of clay solutions to obtain secondary clay powders.

In general, in various countries, methods are being developed for treating the remaining mud in the settling tanks with special activating additives that accelerate the process of solidification of drilling waste.

As is known, the process of well construction covers several stages: preparatory work, drilling, fixing, development, final work, including the elimination of sludge pits and recultivation of land disturbed by drilling. Each stage is characterized by its own complex of works, the implementation of which must necessarily be carried out in strict accordance with current legislation and environmental regulations. The process of liquidation of the barn in [5,6,8-10] is proposed to be divided into the following technological stages:
- collection of oil film from the surface of the barn;
- cleaning of a liquid phase from emulsified oil;
- additional treatment of the liquid phase (the degree of purification depends on the further use of purified water);
- dewatering and disposal of drill cuttings;
- disposal of drill cuttings;
- cleaning of oil contaminated soil.

Thus, the whole noted technological process of liquidation of a sludge barn can be presented in the form of two stages:
1) cleaning and disposal of the contents of the barn;
2) the actual disposal of drill cuttings.

The first stage should be carried out taking into account the particular composition of the waste in the sludge barn.

Preliminary collection of the film from the surface of barn liquid is carried out using installations such as USN-2, USN-300, SM-5, in which the productivity of oil products is 0.2-5 m³/h, the minimum allowable thickness of the oil product layer is 0.01-1 mm. The efficiency of oil product collection is 99.5-90%, the water content in the collected oil products is 2-10%, respectively [3,4,11-13].

4. Research results
In general, as the analysis shows, the changes occurring under the influence of drilling waste are as follows:
- toxic effects on organs and tissues of benthic organisms due to the accumulation in them of various harmful substances present in the composition of drilling waste;
- reduced life expectancy in most populations;
- complete extinction of some species;
- death from suffocation of sedentary forms of benthos due to discharge of materials to the bottom and prolonged turbidity of the bottom water.
When organizing a system for controlling waste dumping into the sea, determining the dumping areas and determining the dynamics of pollution of sea water and bottom sediments are of crucial importance.

5. Conclusion

Thus, to identify possible volumes of discharge into the sea, as well as storage on land, it is necessary to analyze drilling waste and compare the concentrations of all pollutants with their maximum allowable amount taking into account hazard classes. The changes of the drilling waste are identified. Determination of dumping areas and pollution dynamics of sea water is of special relevance.

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