Environmental Technology & Innovation 6 (2016) 123–131

Contents lists available at ScienceDirect

Environmental Technology & Innovation

journal homepage: www.elsevier.com/locate/eti

The immobilization of heavy metals during drilling sludge utilization

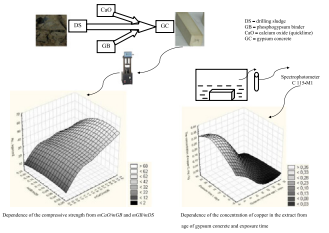
Ablieieva Iryna *, Plyatsuk Leonid

Department of Applied Ecology, Sumy State University, Sumy 40007, Ukraine

HIGHLIGHTS

- Drilling sludge utilization with obtaining a building material is proposed.
- The obtained gypsum concrete has a satisfactory environmental properties.
- Gypsum concrete strength is interconnected with the gypsum mixture content.
- The leaching of heavy metals depends on the gypsum concrete age and exposure time.
- The gypsum concrete with the age above 20 days is environmentally safe materials.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 14 December 2015
Received in revised form 12 August 2016
Accepted 23 August 2016
Available online 30 August 2016

Keywords:
Drilling waste
Binding
Gypsum concrete
Leaching of pollutants
Compressive strength

ABSTRACT

Drilling sludge is formed by the drilling of oil wells. This waste adversely affects the environment due to the content of heavy metals in its composition. So far, its burial was carried out in sludge pits made without walls and bottom isolation, which promotes migration of pollutants into the environment. The idea of the author is recycling of drilling sludge in building material such as gypsum concrete using phosphogypsum binder. Thus binding of heavy metals in the lattice sites of the obtained material occurs. Building material was prepared using phosphogypsum binder. The efficiency of this process is unknown.

The purpose of the article is to determine the influence of the chemical composition of gypsum concrete mixture on the migration of heavy metals into the environment.

The study was conducted by the experimental determination of the concentration of heavy metals in the extract at a different composition of the mixture, gypsum concrete age and exposure time. All factors have approximately equal influence. The binding of heavy metals increases when gypsum concrete age grows. The leaching of heavy metals from the gypsum concrete complies with the environmental regulations. There is a correlation between the composition of a mixture of gypsum concrete and compressive strength of

* Corresponding author.
E-mail address: i.ableyeva@ecolog.sumdu.edu.ua (A. Iryna).

http://dx.doi.org/10.1016/j.eti.2016.08.004

gypsum concrete. The weight content of calcium oxide in the mixture, which increases the strength of gypsum concrete, was determined.

Contents

1. Introduction

The current stage of development of oil production technology is characterized by the formation of a significant amount of different types of waste in the oilfields reclamation. Industrial and technological drilling wastes are serious hazard to the natural environment objects due to the fact that they are collected and stored directly on the territory of the drill site. Most of them, for example drilling sludge, are currently located in sludge pits and not always exposed to recycling. Particular danger for the environment is the consequences of non-compliance with the measures of technical organization of these objects. After all, its walls and bottom should have sufficient waterproofing to prevent the infiltration of wastewater into groundwater and waste pollution of soil.

Drilling sludge is a mixture of drill cuttings and drilling fluid removed from the drill circulation system with various cleaning equipment. Drilling fluids (also known as muds) are used to aid the drilling process. The fluid phase can be water, synthetic or natural oils, air, gas, or a mixture of these components. The pollution potential of drilling fluid depends on the quantity and toxicological characteristics of chemicals used for its preparation. The reagents and compounds of 3 and 4 class of hazard differing in chemical nature, physical and chemical properties and functional purpose are used in borehole drilling. Core components of the drilling fluid are the following substances of II–IV class of hazard: bentonite gel powder, CSAB-MT (condensed sulfite-alcohol bard), CMC (carboxymethylcellulose), caustic soda, oil, LAR (lignin–alkaline reagent), potassium chloride, technical lignosulfonates, sulphonol, phenols and others (Balaba, 2004; Barakhnina et al., 2000).

Ecological danger of drilling sludge is caused by adsorption of chemicals listed above by slices of rock which in itself is safe. Thus, drill cuttings consist of heavy metals, a small amount of oil, detergents, CMC, synthetic organic compounds, etc. (Ogechi Opete et al., 2010a,b). Drilling fluids typically contain heavy metals like chromium, ferrum, nickel, copper, zinc. These metals can enter the system from materials added to the fluid or from naturally occurring minerals in the formations being drilled through (Bonsu, 2004). Drill cutting mixes which contain typical average concentrations of hydrocarbons (4.2% w/w) (Al-Ansary and Al-Tabbaa, 2006).

Mobile forms of chemical compounds that determine the degree of drilling sludge toxicity and hazard, have the highest risk to the environment. Therefore, sludge pits without proper waterproofing bottom and sides are a source of soil, surface water and groundwater chemical pollution. Drilling waste management is implemented in oil industry to prevent appearance of such consequences. The worldwide known techniques of drilling waste treatment are based on the following main processes:

- physical and chemical processes (removal of free phase, thermal desorption, excavation and disposal in landfill, deep injection in the wells, dehydration, incineration, neutralization, solidification and stabilization);
- biological processes (landfarming, biopiles, composting, phytoremediation and bioreactor) (Khodja et al., 2010).

The solution to existing problem provides a choice of an optimum method of implementing environmentally safe and cost-effective drilling sludge recycling technology. Choice of waste management options typically considers local regulations, environmental assessment, cost/benefit analysis and the composition of the drilling wastes (Adekunle et al., 2013).

Domestic and foreign experience shows one of the most prevalent methods of drilling waste utilization is solidification and stabilization (El-sayed and El-Naga, 2001; Khodja et al., 2005; Ogechi Opete et al., 2010a,b).