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The technology refinement of soil decontamination contaminated with petroleum products by the reagent capsulation method

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Abstract

The soil decontamination technology contaminated with oil products in emergency situations and due to the oil spill was examined. The decontamination technology is based on the oily waste encapsulation using alkaline reagent based on calcium or magnesium. The experimental studies results for determining the optimal reagent amount required for the efficient completion of the neutralization process of soils containing oil depending on the contamination degree and the contaminant type are presented in the article.

Keywords: oily waste; recycling; decontamination; reagent encapsulation

1. Introduction

Nowadays cases of pollution with oil products happen very often. The pollution sources can be different, contaminating all the environment components; and the pollution process cannot be fully excluded. Very often environmental pollution is the result of accidental oil spills into the soil.

One of the most promising methods for decontamination of soil containing oily waste and oily sludge is a chemical method based on oily materials encapsulation using alkaline reagent based on calcium or magnesium [1, 2, 3]. The most suitable reagent [4] is quick-slaking, air, powder, obtained by grinding lime. In Russia this lime is manufactured in accordance with GOST 9179-77 "Building lime" (first grade lime).
2. The study subject (Model, Process, Device, Synthesis, Experimental procedure, etc.)

The study subject is to determine the optimal reagent amount required for the efficient completion of the decontamination process with the reagent encapsulation method in soils containing oil; besides pH acidity of the encapsulated material obtained as a result of decontamination would be minimal.

Oily wastes decontamination technology with reagent encapsulation method traditionally involves several stages. Calcium oxide is added to the oily wastes in the first stage, and then homogenization process followed until homogeneous mixture, whereby calcium oxide encapsulates the contaminant.

The obtained mixture is added with water in the second step and chemical reaction occurs with heat generation:

\[
CaO + H_2O \rightarrow Ca(OH)_2 + Q
\]  

At the third stage there is reacting of calcium hydroxide resulting from chemical reaction (1) with carbon dioxide located in the ambient air. As the interaction result there is formation of calcium carbonate microcapsule shells on the oily material surface and the encapsulated material formation:

\[
Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O
\]

Microcapsule shells are hardened in further reacting process of the encapsulated material with carbon dioxide.

Carried out researches analysis in this area shows that the efficiency of oil-containing materials neutralization process by the reagent encapsulation method depends on many factors. According to various recommendations [1, 4, 5] decontamination of one ton of oily material depending on the pollutant type and the contamination degree requires as necessary minimum reagent amount of the first grade quick-slaking lime from 150 kg to 1200 kg.

If the reagent amount is insufficient, then neutralization process will not be completed, and the reagent addition with an excess promotes the encapsulated material formation having high pH acidity level (pH > 12.6) [4]. In this case, the number of encapsulated material waste directions obtained due to oily material decontamination is greatly reduced.

For this reason it is important to know the optimum reagent amount required for the efficient completion of the oily material decontamination when the pH acidity level of the encapsulated material obtained as a decontamination result will be minimal. Moreover, considering the lime market price and amounts of oil-containing materials formation the reagent encapsulation method application on industrial scale requires significant investment.

To determine the reagent optimal amount required for the efficient completion of the decontamination process, series of experiments were carried out to refine the decontamination technology with the method of reagent encapsulation soils containing petroleum products.

The decontamination process was carried out using the third grade quick-slaking lime, which is much cheaper than the first grade lime. As the oily material two soil samples batches containing oil were used. The first batch of soil samples contained engine oil, and the second batch contained diesel fuel. Each batch consisted of soil samples with different oil content degrees. This soil contamination nature is the most common for situations related to road transport accidents.

Each soil sample containing oil was subjected to the decontamination method by reagent encapsulation with the fixed addition amount of the third grade lime. Moreover, the decontamination process in a form of chemical reaction with the calcium hydroxide formation is not always carried out depending on the amount of the added lime. The main assessing criterion of the decontamination process was significant increase in temperature after water addition to form a homogeneous mixture of lime and soil containing petroleum products. If after water addition the mixture temperature did not change or changed only slightly, then the added lime amount for decontamination process was considered not enough, and this sample was not subjected to further investigation. Another criterion for assessing the decontamination process is the presence of oil traces in the oil film form on the water surface after diving for a day into water of the encapsulated material obtained as oily waste decontamination result. For the encapsulated
material samples where the chemical reaction resulted successfully, the pH acidity level was determined after seven
days of the decontamination process.

In the course of experimental studies the optimal amount of the reagent required for the efficient completion of
the decontamination process by the method of reagent soil encapsulation containing petroleum products was
determined. Also, studies have shown that expensive powdered lime of the first grade may be replaced with a
cheaper lime of the third grade [6].

3. Results and discussion

The research results are presented in diagrams showing acidity level dependences of neutralized soils containing
oil products from the contamination and lime degree (Fig. 1, Fig. 2). The diagram (Fig. 1, Fig. 2) dotted line shows
the encapsulating boundary separating the area where the neutralization process was completed and the area where
the soil samples decontamination with content in various oil products concentration (diesel fuel, engine oil) was not
implemented.

![Acidity level dependences diagram of soil decontamination containing diesel fuel from the degree of contamination and lime.](image)

Fig. 1. Acidity level dependences diagram of soil decontamination containing diesel fuel from the degree of contamination and lime.
Using acidity level dependences diagrams of decontaminated soils containing oil products, the degree of contamination and lime (Fig. 1, Fig. 2) the curves would quickly determine the optimum amount of the reagent required for the efficient completion of the soil decontamination process containing oil products depending on the contamination degree and the contaminant type (Fig. 3).

For example, to complete effectively the decontamination process with soil reagent encapsulating method containing 35% of oil from the soil weight we need different reagent amount depending on the pollutant type (motor
oil, diesel fuel). The diagram provided (Fig. 3) shows that the soil contamination with diesel fuel needs 68% of the reagent for the effective completion of the decontamination process, and if the contaminated soil is with engine oil it needs 79% of the reagent from the oily material weight.

4. Conclusion

- The optimum reagent quantity required for the effective decontamination process of soils containing oily waste was determined, the same time pH acidity level of the encapsulated material obtained as a decontamination result was minimal.
- The obtained results allow determining the optimum reagent quantity required for effective decontamination process of soils containing oily waste depending on the contamination degree and the contaminant type.

References


