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Soil Reinforcement And Detoxication By Means Of Mineral Binder Systems

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Abstract

In the paper the problem of pollution of the railway ballast by heavy metals is considered. Heavy metals migrate into the soil under the action of precipitation and acid rain. Environmental pollution caused by heavy metal ions is particularly hazardous. Unlike other pollutants in soils the heavy metal ions reserve for a long time even after removal of the pollution source. The ability of heavy metal ions to migrate to soil, into the underground, ground and surface water, to accumulate in food leads to the need of consideration of their impact on human health. Heavy metals are carcinogenic. To solve this ecological problem we offer to reinforce contaminated ballast by means of binder systems having geoecoprotective properties against heavy metal ions.

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Keywords: heavy metals ions, railway track, ballast, binder systems, geoecoprotective properties.

1. Introduction

Railway track is an integral part of the process of passenger and freight traffic, but also it is a natural and technogenic system that contributes to environmental pollution. The main part of contaminants get into the soil, and consequently, to ground and surface water by transportation cargoes by railways and, especially, during their rash or leakage. Oil products and heavy metals are the most dangerous for the environment. As opposed to other pollutants

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heavy metal ions are kept in soils for a long time even when a pollution source is eliminated. Periods removal of heavy metals from soils are several thousand years [1]. Heavy metals have the ability to migrate to the plant, into the lakes and rivers, groundwater and underground water and also they can accumulate in the food chain. Disorder of the cardiovascular system and the occurrence of severe allergies are the result of contact human with the pollutant. Most of the heavy metals have embryotropic and carcinogenic properties. They are genetic poisons that are accumulated in human body with a long-term effect.

It was determined the patterns of distribution of heavy metals in the side from the railway track in the works of some researchers [2]. According to this pattern the most polluted soil is in the interval 0-20 m and the concentration of heavy metals decreases with perpendicular movement away from the top of rail. Influence of train traffic intensity have shown that the degree of soil contamination at a distance from the railway track varies from category «hazardous » at a distance of 3 meters, to «moderately hazardous» (50 m) and the «allowable» (100 and 200 m). This is confirmed by a decrease of integrated index of soil pollution (Zc). At the same time the accumulation of heavy metals content in soils is confirmed for many years of observations period from 2004 to 2012. Integrated index of soil pollution (Zc) (3 meters from the centre of first track) increased by 16.3 % in the place of the most braking effect [3].

According to the research [4], the samples of crushed ballast contain copper at a concentration that exceeds the maximum allowable concentration (MAC) 30-190 times and 2-6 times for lead. Possible sources of ballast contamination by copper are: line electric locomotives, railroad cars. Contamination occurs due to abrasion of the aerial contact wire during their operation forming metal dust. As a source of ballast contamination by cobalt, nickel, manganese and iron may be metal dust resulting from the abrasion of rails and wheels. Possible sources of ballast contamination by nickel, cadmium and lead are nickel-cadmium and lead-acid accumulators.

The priority task of «Ecological strategy» of Russian Railways [5] is to reduce the negative impact on the environment by 70% by 2030, including through the introduction of resource saving environmental technologies. In this connection the purpose of the work was to develop a geoecoprotective construction structure in the railway substructure by soil reinforcement and detoxication by means of mineral binders systems. The main task of the work was to study the detoxication properties of the binder systems of different nature against heavy metal ions.

2. Experimental studies on the detoxification properties determination of the binder systems of different nature

Cementation is one of the easiest and safest ways of soil reinforcement. But this issue has not been considered in terms of soil cleanup processes before and during the curing period [6-10].

It was found [11-15] that some binder systems and finished materials consisting of calcium silicate and magnesium hydrosilicate have neutralizing ability against heavy metal ions (HMI). In this connection the purpose of the experiments was to study the processes of detoxication of soils contaminated by HMI through the use of binder systems of different nature.

The sand has been studied as a soil that has been subjected to artificial pollution. Portland cement, self-stressing and expanding cements are binder systems, which have been considered for the detoxication polluted sand.

Initial investigations were aimed at identifying of the optimal conditions for the process of soil detoxification (neutralization from pollutants). For this it was necessary to establish:

- the maximum concentration of HMI in the sand, which binder system can neutralize;
- optimum values of binder system content towards contaminated sand and sand fraction for most efficiently of neutralization process.

Four fractions of sand were selected for the research: 0.14-0.315 mm, 0.315-0.63 mm, 0.63-1.25 mm, 1.25-2.5 mm. For artificial sand pollution contact 3 solution containing cadmium ions concentration were prepared (II) exceeding approximately permissible concentration (ODC) in soil (0.5 mg / kg) in 100, 1000, 5000 times.

We were prepared three solutions containing a cadmium ions concentration, which exceeds of approximate permissible concentration (APC) in the soil (0.5 mg / kg) 100, 1000 and 5000 times. We confirmed the presence in the data solutions the cadmium ions using qualitative analysis. To this we added to each sample of sodium sulfide. Cadmium sulfide yellow precipitate indicates the presence of cadmium ions. Experimentally we have found that the volume of the solution to moisten or artificially to pollute the soil is 20 ml per 100 g of sand.