Sustainable Development in Transport Construction Through the Use of the Geoecoprotective Technologies

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Abstract
In this article the authors examine the building wastes on the example of autoclave foam concrete, silicate brick and so artificial obtained mineral substance as cement clinker as facilities of environmental protection. Studies have shown that these materials in the dispersion form have geoecoprotective properties and can neutralize the heavy metal ions. The authors were suggested to use this materials in geoecoprotective technologies in transport construction for reduce pollution of the environment, that is consistent with the principles of sustainable development.

Keywords: sustainable development, environmental protection, building wastes, autoclave foam concrete, silicate brick, cement clinker, geoecoprotective properties, materials, geoecoprotective technologies.

1 Introduction

1.1 Purpose and Main Tasks of the Work

Sustainable development is development that maintains the balance of the relationship between people and environment. Sustainable development involves the development of society and the economy within the limits defined by the environment, its resources, the environment ability to heal itself and provides a better quality of life for present and future generations. The most important element of the human environment is such natural and man-made system as transport, for example, railway transport. Environmental pollution occurs in non-compliance with safety instructions for transit and transportation of dangerous loads. Heavy metal ions and petroleum products are the most dangerous pollutants for rail transport. Therefore, the purpose of the work is to develop of geoecoprotective technology solutions in transport construction for the preservation of a productive environment for present and future generations. Achieving the goal can be achieved through the use of building wastes on the example of autoclave foam concrete and silicate brick, and so artificial obtained

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mineral substance as cement clinker as facilities of environmental protection in the geocoprotecive technologies.

The main tasks of the work is to determine the geocoprotecive properties of the selected materials and the use of these materials in the dispersion form in transport construction technologies to protect the environment from the harmful effects of heavy metal ions.

1.2 Negative Impact of Heavy Metals Ions on Environment

Heavy metal ions are carcinogenic. Environmental pollution caused by heavy metal ions is particularly hazardous. Unlike other pollutants in soils the heavy metal ions have been reserved for a long time even after removal of the pollution source. The ability of heavy metal ions to migrate to soil, into lakes and rivers, to accumulate in food leads to the need of consideration their impact on human health. Entrance of pollutants into the human body leads to disruption of the cardiovascular system, severe allergies. Heavy metal ions are carcinogenic. They are genetic poisons that accumulate in the human body with a long-term effect of the action (Davydova, 2002). Studies (Kazantsev, 2007) have shown that the railway transport is one of the sources of environmental pollution caused by heavy metals.

2 Determine the Avtoclave Foam Concrete, Silicate Brick and Cement Clinker Geoecoprotective Properties

2.1 Geoecoprotective Properties Study of Different Solid Materials in the Department Engineering Chemistry and Natural Science

Geoecoprotective properties of clinker and some technogenic wastes are considered as ad- and absorbents of heavy metals ions. Research of this kind for the past 20 years of the department Engineering Chemistry and Natural Science, led by Professor L.B. Svatovskaya. Department scientists have identified geoecoprotective properties of materials such as non-autoclaved foam concrete, granulated blast-furnace slag, phosphogypsum, rubble containing shungite etc (Svatovskaya L., 2010).

2.2 Laboratory Experiment Conditions

For studies 4 fractions of materials were selected: 0.14-0.315 mm, 0.315-0.63 mm, 0.63-1.25 mm, 1.25-2.5 mm. For this purpose, all the materials were pre-crushed in a mortar and sieved through a series of sieves with mesh size: 0.14 mm; 0.315 mm; 0.63 mm; 1.25 mm; 2.5 mm.

Researches on identification of geoecoprotective properties of artificially received and technogenic materials were carried out with solutions of heavy metals ions salts. Those solutions had concentration of $10^{-3}$, $10^{-4}$ and $10^{-3}$ mol/L that exceeded maximum permissible concentration (MPS) 200 times and more. For the solutions containing heavy metals ions the following salts were used: Cd(NO$_3$)$_2$, Pb(NO$_3$)$_2$ and Cu(NO$_3$)$_2$. Determination of the concentration of heavy metal ions in a solution was performed before and after the interaction of that solution with the test materials was performed on an electronic analyzer "Expert- 001" using a series of ion-selective electrodes ALICE (Cu (II), Cd (II), Pb (II)) (Fluid analyzer Expert–001., 2007). To this volumetric flasks filled with 100 ml of model solution containing heavy metal ions of different concentrations. Then the flasks were poured into these test materials 1 gram of various fractions. The suspension was stirred alternately every 5-10 minutes. The contact time was taken to 1 hour, based on the adsorption-desorption equilibrium establishment. After this time the materials separated from the test solutions on to filter paper, and the
determined final concentration of heavy metal ions in each sample. The reaction was spontaneous at an air temperature of 293 K.

2.3 Laboratory Experiment Results

The results of researches are presented on figure 1 and figure 2.

![Figure 1](image1.png)

**Figure 1:** The dependence of the efficiency of cleaning solutions from the initial concentration of Cd$^{2+}$ ions in solution (air temperature 293 K)

As Figure 1 shows, the most effective decontamination of water polluted by technological and artificial silicates and hydrosilicates are achieved when the initial content of polluting cation is to 0.1 mmol/L. This exceeds maximum permissible concentration (MPC) over 2000 times. It is significantly higher than the level of real cadmium pollution on railways.

![Figure 2](image2.png)

**Figure 2:** The dependence of the Cd$^{2+}$ ions residual concentration in a solution of the test materials fineness (initial concentration 1 mmol/L, air temperature 25 °C, contact time 1 hour)
Experimental data demonstrated the dependence of the residual concentration of Cd$^{2+}$ ions in a solution on the degree of dispersion test materials (Fig. 2). As the grains of the materials, the dimensions of which are ranging from 0.1 to 2.5 mm, are increased in size and volume, the residual concentration of cadmium after the interaction with the test materials at the initial ion concentration $10^{-3}$ mol/L is risen too. That is why we can draw a conclusion about the reducing their geoecoprotective properties (Svatovskaya L. B., 2012).

3 The Use of Building Wastes and Cement Clinker in the Geoecoprotective Technologies in the Field of Transport Construction

In this paper the questions of use of wastes of building production and artificial obtained mineral substance are considered as geoecoprotective materials at railroads construction.

Analysis of modern transport technologies showed that three technological ways can be considered when using the investigated geoecoprotective materials.

3.1 Geoecoprotective Technology With the Use of Geocontainer

In this study the problems of surface wastewater purification are considered within the limits of railroad precinct. The use of geoecoprotective drainage trays is offered with subsequent technology of their laying. The mechanism of use of investigated materials is to apply them as geoecoprotective materials in the hollows outside of tray walls. Thus polluted runoff is purified before it gets into a tray (Fig. 3).

![Figure 3: Drainage tray with geoecoprotective properties](image)

It is possible to use containers made of woven geotextile, in which can be placed geoecoprotective material (Fig. 4).

![Figure 4: Geocontainer with geoecoprotective material](image)
Technological operations schematic diagram on giving of geocoprotective properties for drainage tray is shown in Figure 5.

Figure 5: Technological operations schematic diagram on giving of geocoprotective properties for drainage tray

3.2 Geocoprotective Technology with the Use of Gabion Construction

Next geocoprotective technology involves the use of gabion structure, which is loaded by different stone placeholders in the process of construction and installation work.

It is proposed instead of the standard gabion loading used loading from investigated geocoprotective materials (Fig. 6a). Such structure is arranged to release surface runoff contaminated by heavy metal ions from the tray along the railway to the nearby river (Fig. 6b).

Gabion structure will consist of three sections. The two outer sections are filled by standard loading of stone. The inner section is filled by loading of investigated materials having geocoprotective properties towards heavy metal ions. The inner surface of gabion structure section is covered by nonwoven geotextile having high filtration properties and filled by geocoprotective materials. Technological operations schematic diagram on giving of geocoprotective properties for drainage facility is shown in Figure 7.
**Figure 6a:** Gabion construction with stone and geocoprotective

**Figure 6b:** Geocoprotective gabion structure on release of drainage facility for surface runoff

**Figure 7:** Technological operations schematic diagram on giving of geocoprotective properties for drainage facility
3.3 Geoecoprotective Technology With the Use of Geomembrane

The use of building wastes or clinker together with a geomembrane is offered with subsequent technology of their laying into a track. In order to give the protective properties for the railway line we suggest using one of the test materials placed under subgrade shoulders (Fig. 8). On the top of subgrade a geomembrane diverting polluted water from the surface towards a subgrade shoulder is laid where it purifies water from heavy metals ions (Svatovskaya L. B., 2012).

![Figure 8: Railway track with geoecoprotective properties](image)

Technological operations schematic diagram on giving of geoecoprotective properties for railway track is shown in Figure 9.

![Figure 9: Technological operations schematic diagram on giving of geoecoprotective properties for railway track](image)

These technologies are proactive. They improve transport structures in order to minimize negative environmental impacts.
4 Conclusion

Thus, these geoeconomic technologies are very relevant today because the accumulation of building wastes by quantities is a big environmental problem and freight transportation on railways will grow every year contaminating soil and water by heavy metal ions. The solving of these problems as a whole will allow bringing down the anthropogenic loading on the geosphere that will contribute.

References


