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THE USE OF THE GEOSYNTHETIC MATERIALS FOR THE ANTIEROSIONAL PROTECTION OF THE METALLURGICAL TAILING DUMPS

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The anti-erosion geosynthetic is a three-dimensional element formed of tangled extruded filaments that form a labyrinth structure. It is used for the protection against erosion of the plants and of the riverbanks. It has the capacity to protect the soil against being washed away and allows the rapid growth of the roots of the plants.

Key words: geosynthetic materials, erosion, protection, metallurgical tailing

Primjena geosintetskih materijala za antierozivnu zaštitu odlagališta metalurške jalovine. Antierozivni geosintetik je trodimenzionalan element načinjen od spletenih ekstrudiranih vlakana koja formiraju strukturu labirinta. Koristi se za zaštitu biljaka i riječnih obala od erozije. Ima sposobnost zaštite tla od ispiranja i omogućava brzi rast korijena biljaka.

Ključne riječi: geosintetski materijali, erozija, zaštita, metalurška jalovina

INTRODUCTION

In metallurgy, as in other fields, engineering has to find optimal solutions to the relation between the efficiency of plants and technologies, on the one hand, and the level of the impact upon the environment, on the other hand. By combining (technical and technological) engineering knowledge and data with ecological data new analytic technologies are developed by utilizing the concept of technical & ecological complex and opportunities of developing new technical and ecological strategies arise [1].

The tailings deposits generated by the mining and metallurgical industries cover large areas on agricultural lands, both in our country and in other countries (this problem has remained unaddressed worldwide) and degrades the vegetation in such areas, giving it a desolated aspect. The poor vegetation on small surfaces and the lack of soil determine the action of the erosion phenomena that in time move the tailings and destroy the vegetation. Our goal is to implement the ecological rehabilitation technologies that use geosynthetic and natural materials for the ecological rehabilitation of the tailings dumps.

In order to choose the best measures of biological rehabilitations of the acid dumps and settling ponds and in order to reduce the pollution with the acid waters and heavy metals dissolved from the mining tailings generated by the exploitation of the nonferrous ores [2,3] the results of the ecological technologies applied to the mining and industrial deposits have been analyzed as well as the evolution of the mechanical, physical, chemical and biological phenomena that develop in time.

By analyzing the types of pollution and pressure put by the pollutant agents from the tailings dumps to the environment we will be able to take the best measures for their removal.

Adoption of several ecological restoration technologies for the mining and metallurgical dumps is of great scientific importance and it is very much required because on the large surfaces occupied by these deposits obvious phenomena of soil erosion and degradation of the vegetation take place. The situation is highly hazardous as regarding the stability of the pits, the pluvial water dissolve and carries the chemical elements and solid particles forming effluents, the wind engages the fine dust transporting them to remote locations determining the pollution of air and soil. Intense research works on the tailing dumps and pits have been performed in the countries with highly developed extraction and manufacturing industries; the first research works being focused on the stabilisation of the tailing dumps. For example the Mining Bureau of the U.S. has experimented and applied several methods: -stabilisation through physical methods: coverings with tree bark, straw mixture (ANACONDA company), wind shields, spraying a mixture of limestone and sodium silicate; -stabilisation through chemical methods, with different reactive

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agents than form a coat on the tailing's surface; -stabilisation of the tailing dumps by planting vegetation; -stabilisation through a combined chemical; -vegetative method [4].

Methods consisting basically of chemical dissolution associated with implantation of vegetation have been applied in Germany.

The Technical University of Dresda tested the fertilisation of the tailing dumps with the city's slimes. In the Netherlands different decontamination procedures have been applied to polluted soils.

The Norsk Institutt for Vannforskning (NIVA) developed methods for quantification and prediction of metal solubility into sediments. In Sweden at Grangesberg exploitation the immersed storage of the tailings was done till 1986 when the exploitation was closed. The main reason for applying this solution was to avoid the engagement of the dust by the wind. In some cases the marine immersion was also practised. Two of these cases can be mentioned: Titania in Norway and Greenex in Greenland. Titania, having deposited inert titanium ore, was forced by the authorities to move the deposit from the fjord to a location situated above the sea level. The Greenex exploitation closed in 1990 utilised a fjord to limit the negative effects upon aquatic life. After the close the concentration of metals measured at aquatic beings decreased to levels registered before opening. A recent issue studied at Kristineberg NIVA was the influence of the deposit of natural sediments on the immersed tailings. An intermediary solution for water saturation of the tailings without making the protection pond is the rising of the phreatic level. This method was experimented at two pits at Kristineberg, both containing highly altered materials. The selective deposit of the tailings in dumps as well as the control of natural leaching phenomena is subject studied in the last decade, but it is highly necessary to study how the vegetation interacts with the geosynthetic materials. It is estimated that in Canada exist 351 ML tons of tailings deposited in dumps, 510 Ml tons tailings deposited in settling pits as well as 55 Ml tons other mining rejects. The environment restoration of the pollutant exploitations requires important funds [5].

Also, the neutralisation of the acid mining effluents represents an issue. The surfaces of the tailing dumps in our country are mainly arid, without vegetation or limited areas of spontaneous vegetation consisting mainly of some species of trees, bushes or grass that grow in clusters. The low density of the spontaneous vegetation (especially of trees and bushes) and abrupt slopes that goes above 40-450 causes the wash of the organic residues by the water torrents [6].

The reduced green areas and lack of soil layer determine strong erosion effects that engage and transport the tailings and destroy the young vegetation. In these conditions it is necessary to use the geosynthetic material do avoid the negative effect upon environment.

Figure 1. Acacia trees planted directly on the tailings.

At a tailings dump where acacia trees were plated without providing the required soil layers, the trees did not develop properly (pond T, figure 1) and on certain areas they died.

WORKS OF ECOLOGICAL REHABILITATION OF THE DEPOSIT SURFACES

The rehabilitation technology of a deposit with the use of geosynthetic materials provided initially a drainage system. The drainage systems consume a large percentage of the total investment that leads to the necessity to have them designed correctly and cost effective.

The closing of the mining deposits, making them impermeable, assumes the acceptance of the minimal and compulsory stipulations imposed by the European Union (2 waterproofing layers, a synthetic layer and a mineral layer).

One of the solutions proposed by our team and applied to a deposit comprises the followings:

1. Rehabilitation of the horizontal surfaces (platforms): -bentonite geocomposite; -200g/m^2 geotextile for separation and filtration; -30 cm of gravel or quarry rejected material with layer of natural drainage; -200g/m^2 geotextile for protection; -30 cm of vegetal soil;

The bentonite geocomposite reduces the permeability with 1x10^{-14} m/s; the geotextile realizes a separation and protection between gravel and vegetal soil layers or between fine granular material of the deposit and the bentonite geocomposite.

2. Rehabilitation of the slopes. Due to the inclination of the slopes the water infiltration will be very much reduced the most of the water will drain at the surface. Thus mounting the bentonite geocomposite with a permeability of K=5x10^{-11} m/s will be sufficient. The structure of the covering comprises the followings: -bentonite geocomposite; -synthetic drainage material (geo-

dren); -30 cm of gravel or quarry rejected material with the role of natural drainage; -200 g/m^2 geotextile for separation; -40 cm layer of vegetal soil.

RESULTS AND DISCUSSIONS

In order to prevent the driving of the fine particles by the air currents and to allow vegetation to grow on the surface of the pond a vegetal layer was set on the layers of bentonite geocomposite, geotextile and gravel. The thickness of the layer allows the vegetation to grow on the platform as well as on the slopes; this thickness is given by the European norms as minimal for the protection of the settling ponds. Then grass was seeded [7].

After seeding the surfaces with endemic flora (3.96 kg/100 m^2) chemical fertilizers have been spread on the entire surface as follows:

- ammonium nitrate: 80 kg/ha
- potassium salt: 50 kg/ha
- calcium superphosphate; 50 kg/ha.

The seeding was made in March and April. The seeds and fertilizers have been lightly raked into the soil [8].

An organic pre-seeded mattress was laid on the vegetal layer at the edges of the slopes to control the erosion. The organic mattresses are stitched mattresses with a thickness of 10 to 15 mm, made of straws and/or coconut fibers in which the protection materials and selected seeds are incorporated during manufacturing.

This mattress was especially designed to control the erosion on the slopes where works have been done recently. The mattress improves the conditions of the poor soils by incorporating fertilizers and dried microorganisms. The strong and flexible mattress with the dense structure makes a barrier against the elements. The natural components of the mattresses degrade biologically without affecting the environment. The polymer structure remains intact for a long period of time protected by the vegetation against ultraviolet radiations and reinforcing the plant roots [9].

Then the seedlings are planted with the following purposes:

Deep fixing of the soil and evacuation of the exceeding humidity through evaporation;

Protection of the pond surfaces against erosion caused by wind and torrential rains.

It was assessed that out of all species of leaf trees the birch tree developed the best on the rehabilitated areas. It is recommended to plant leaf trees like: birch tree, black poplar hybrid, and acacia tree. Resinous trees should not be planted. The acicular leaves of the resinous trees biodegrade very slowly and thus the vegetal layer develops with much difficulty; it practically does not develop.

In some cases the bentonite geocomposite may be replaced by a geomembrane [10]. One tailings dump with scraps generated by a tire factory was ecologically rehabilitated by using a geomembrane as shown in figure 2. The drainage system collects the rain waters and directs them to the collecting tanks.

Figure 2. The ecological rehabilitation of a deposit with the use of geomembrane

CONCLUSIONS

The tailings deposits are subject to the destructive action of the elements like: rain, snow, wind, freezing-thawing that uncover the deposits, spreads the solid particles, unbalance the ponds respectively dislocating large volumes of tailings and contaminating the rivers. The heavy metals, once reaching the soil, may be transported, incorporated or absorbed by microorganisms, or the microorganisms may be absorbed by the plant roots (in ionic shape).

The best solutions of rehabilitation with the use of natural and geosynthetic materials are chosen by taking into consideration the stability of the tailings deposit, climate, position and the degree of ecological rehabilitation at the certain point in time. The team of nine researchers formed during a period of two years had preoccupations regarding the technologies of ecological rehabilitation of the mining and metallurgical deposits and the evolution of the mechanical, physical, chemical and biological phenomena that take place in time. Soil and water analyses, including the pH measurements, have been done to establish the factors with negative influence upon installing and growing of the vegetation. Tightening layers capable to undertake tearing efforts have been mounted on an insulating multilayer with the scope of preventing the oxygen diffusion and percolation of the rain waters. The performance of the geosynthetic material as protection against soil erosion and the plants growth are monitored thoroughly. New experimental methods have been produces by this research work on reducing the pollution with acid waters and heavy metals dissolved from the mining tailings dumps generated by the exploitation of the nonferrous ores. These new methods increase the safety of the ponds generated by mining and metallurgical industries; diminish the effects of the pollution with powders and effluent waters and reintegrate the areas into the environment.

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Note: The responsible translator for English is R. Pop