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Soil Science

Restoration-Recultivation Method of Eroded Areas

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ABSTRACT. The objective of this article is to describe the new bioengineering technology for stabilization and revegetation of slopes in different settings. The method is ecologically absolutely safe due to the use of natural binding materials. As shown by preliminary field experiments carried out at several sites, as well as by laboratory studies at the Georgian Technical University, the results, if implemented on a large scale, will be promising not only in terms of saving the land, but also in terms of preventing heavy metals and other hazardous pollutants from washing out and spreading around. The slopes develop a topsoil and grass cover of controllable thickness quite quickly after treatment, gaining not only stability but aesthetical value as well. Grass cover is formed starting from 2-3 weeks to 2-3 months depending on climate conditions. Filling the free space singled out for recultivation by ground up to the earth surface in the depth of 35-45 cm, the surface will be covered by waterproof mixture with thickness of 3.5-5 cm, produced from ecologically safe materials excluding infiltration of irrigative water to the depth. After the waterproof layer will be covered by ground mass with the seed of necessary grass the surface will be smoothed out till the earth surface. The neogenic surface should be covered by 2 cm thickness mixture reducing the evaporation to minimum. *© 2018 Bull. Georg. Natl. Acad. Sci.*

Key words: eroded slope, bioengineering technology, stabilization, revegetation, binding materials, grass cover, clayey soil, water accumulation

Natural and man-made slopes of different origin (mining, road construction, etc.) are highly vulnerable to soil erosion, leading to losses of land and to spreading of heavy metals and other harmful substances from open pits and quarries. This is a particularly important environmental problem for Georgia, which is mostly mountainous country where slopes of various geological composition, as well as ore mines, are abundant, and disintegration of slopes is causing considerable damage to the environment. Georgia is notorious for landslides of various scale that have long been an object of scientific research and engineering solutions.

Small-scale slides of surface material that are triggered by weathering, atmospheric precipitation and erosion, especially those that occur on man-made slopes related to quarry mining, are of double hazard. On the one hand, they cause loss of agricultural land, which is highly precious in the country, disrupt traffic on auto- and railroads, etc. On the other hand, they lead to the spreading of

pollutants (heavy metals, etc.) dangerous to the environment.

One example of such hazardous situation is the area around the copper ore quarry near Kazreti in the Bolnisi District. Surface waters around its tailings contain, as compared with the average composition of the world waters, more copper by the order of magnitude 10^5 , and more cadmium, manganese, cobalt and other metals by the order of magnitude 10^4.

Another example is the area around Chiatura, a large industrial center, where tailings of the manganese quarries formed a specific hill/mound terrain. Surface waters around these tailings flow into the Quirila River that for many kilometers downstream preserve a specific grayish color caused by the concentration of manganese. This concentration in the river just outside the city is about 600 mg per liter, which is over 50,000 times higher than the average concentration of manganese in the rivers [1].

Besides manganese, the tailings, and consequently the waters around them, contain significant amounts of other toxic metals, leading to contamination of soils, vegetation and groundwater. The contamination is facilitated by the topography of the city and by the fact that metals can be easily washed out from the disperse tailings either in the ionic form (dissolved) or in suspensions.

The concentrations of toxic metals considerably exceeding their maximum permissible concentration in the soils and groundwater, the latter being used for water supply from individual wells, cause various contagious diseases.

In order to stabilize such slopes, expensive measures or structures for landslide control would be inexpedient. The ideal solution would be to find a cheap binding substance that would not only stop the superficial slides, but also favour the growth of vegetation on such slopes, which would further stabilize the slopes and bring evident ecological equilibrium.

This idea has been exploited for quite some time. However, all technologies developed so far are based on the use of either artificial synthetic binders, which are ecologically unsafe, or expensive biotextile materials like jute or coconut palm fiber; sometimes they use composites including sugar, nitrogen and phosphorus. These materials and technologies are quite expensive.

Also, such binding materials can be mentioned as Airspray, Soil-Sil, XB-2391, Peneprite, Nerosin, Nerosin-M. The first four are manufactured in the U.S., Nerosin in Estonia, and its modified version (Nerosin-M) in Georgia. However, all these materials are effective in case of sandy soils only, while on clayey or silty soils a grass cover has to be created first. At the same time, grass grow is essentially hindered by the fact that all the materials mentioned are manufactured on the basis of gasoline or acetone, which makes them not only toxic but also flammable. It has been proven that, when restoring the eroded slopes using these materials, 2-2.5 years are needed for the grass cover to form [2].

Recent publications describe studies on stabilizing eroded slopes and mining dumps in different countries. However, the solutions they are dealing with are mainly engineering structures like gabions, riprap, drainage systems, piles slope grading, lining, etc., which again are expensive and hard to accomplish. Bioremediation is regarded as an auxiliary method, supplementing to the engineering ones.

As opposed to this, the team of researchers at the Georgian Technical University has recently developed and tested natural blinding composites that seem promising. Two powdered natural components have been chosen. One of them is local montmorillonite clay that has strong binding properties, and the other is local zeolite-containing tuff that has ideal properties for aeration and grass seeds growing. Both materials are rather inexpensive: 1-1.5 % of ecologically harmless polymer is added to the water-saturated mixture of

the powdered materials, almost instantly forming a uniform mixture, and at the same time enhancing the mixture's blinding and fertilizing properties. Per 1 sq. meter of the surface to be stabilized we need no more than 2.5 kg of the soil-polymer mixture plus certain grass seeds. The composition of the mixture, including the type of grass used, should vary depending on the slope steepness and some other factors.

The first field experiment was conducted in the fall of 1997 in the high-mountain (1.700 m above the sea level) part of the Kazbegi District, where over 25% of the area of pastures and meadowlands belong to the category of highly eroded terrain. The experimental site, with the area of 12 sq. m, was selected in the lower part of a natural slope (70 m high, 50^0-70^0 steep, with occasional grass cover) composed of black metamorphosed shale dipping almost vertically. In their weathered mantle, shale is essentially disintegrated, largely consisting of broken and loose fragments. There is no soil as such, only fragments of unstable, sliding sod. Several landslide scars, 30-40 cm high, are distinctly visible on the slope. Under one of them, the experimental site was chosen.

The site was divided into 4 sectors, each of which was treated differently. All of them were covered with a binding mixture of natural components mentioned above, but on two sectors, polymers (1%) were added, while on the other two what was added to the natural components was only water.

It is worth noticing that on the day of the experiment, as well as on the following days, the weather was very windy and rainy, which must have had adverse impact on the results. However, the first positive observation was made on the second day when, is spite of the bad weather, the cover appeared to get fixed to the steep slope, not washed away. And since the spring of 1998, for the seven years already, the experimental section has been covered with thick regenerating annually, even on the sectors no special additives were applied. No traces of erosion have been observed there since, while the adjoining areas have been intensely eroded.

A preliminary conclusion could be made that long-term stabilization of the section has been achieved. Since, in addition, grass cover developed there, downslope transfer of pollutants by surface runoff substantially reduced. When used for open-mining dump slopes, this would minimize the washout of toxic substances and the risk of environmental pollution in general.

The second (small-scale) experiment was conducted in the Tbilisi area. The site, 6 sq. m in area, was on the dump slope, up to 35 degrees steep, consisting of crushed brick. On the 5^{th} day after covering the slope with the binding mixture, grass appeared, and within a week a dense grass cover was observed.

The third (also mall-scale) experiment was conducted on three sections in Eastern Georgia, on a highly eroded natural slope. Here the percentage of the polymer added was different on each section in order to find the optimum; it appeared to be 1-1.5%. It is noteworthy that with no polymer added it is very hard, time-and labor-consuming to obtain a uniform water-saturated soil mixture, while with the polymer a uniform high-plasticity mass is formed in an instant, fully covering slopes of any configuration and composition.

The field experiment in Kazbegi, and the smaller-scale experiments conducted later, showed that the method is effective and also cheap, simple to use, not labor – or time-consuming, and ecologically harmless. It can be used to stabilize numerous man-made slopes, resulted from road construction, open mining, etc. It can also be instrumental in securing stability of the areas around the new oil pipeline Baku-Tbilisi-Ceyhan. This pipeline goes through the predominantly mountainous areas. However, due to maintenance requirements, no deep-rooted trees or other plants will be allowed around it. In these conditions, the proposed method will help create, within a short

term, a stable grass cover preventing weathering and erosion on the slopes above and below the pipeline. Moreover, an alternative modification of the binding composition may create a subsurface protective layer above the pipeline, which would minimize infiltration of aggressive water and its contact with the pipeline.

Summarizing the above discussion the main advantages of suggested method are:

It is cheap, fast and simple to employ;

It is absolutely safe ecologically;

It does not need additional materials or biotextiles due to our grouting mixture consisting of natural sorbents binding capacity;

Grass does not have to be sewn into the ground; seeds of local species are mixed with the binding solution that is applied to the slope (if necessary, by pumping);

The topsoil does not have to be planted onto the slope; instead, it is being created as a result of chemical/biological processes;

A wide range of geological settings and slope inclinations is fit for this method;

It brings results fast: when applied late in the fall, the grass of a controlled thickness will grow the following spring.

As shown by our preliminary studies, the composition of binding solutions should be adjusted for the specific climate and elevation conditions, as well as to the soils, which are quite variable in Georgia. In the subtropical Western Georgia, red earth-podzolic soils prevail. In the steppes of Eastern Georgia, chernozem-chestnut soils are predominant. In mountainous areas of Southern Georgia, brown and alpine meadow soils occur. This adjustment will be one of the objectives of the researchers.

For restoration-recultivation of naked slopes damaged by erosion, restoration of natural life conditions on the washed slopes and preservation-growing of biodiversity it was necessary to create a composition from ecologically safe natural materials such which is tenacious and is characterized by attaching property on the slopes of any configuration and composition [1]. Also it was necessary to form the suitable conditions for growing the grass seeds; the method should be cheap, accessible and less laborious. Composition “Vita” created by us completely meets the above mentioned requirements. Therefore the Project was awarded by third place and special prize. On the second hand, in parallel with positive properties, the slope developed by “Vita” during the summer session needs irrigation no matter we deal with arid climatic or other zone. In view of the fact that the certain part of 1000 quarries subjected to “Heidelberg Cement” is located within the arid climatic zone, the question takes on particular importance as after the recultivation-restoration of washed lifeless slopes it is urgently necessary to irrigate them during the summer. This process is connected with excessive material and financial expenditures and, besides, it causes such an undesirable processes as swamping and salinization of soils. In these cases the overhead irrigation or trickle irrigation methods should be applied, but creation of this irrigation system demands additional expenditures.

In the air high temperature conditions, when the evaporation of ground water is intensive, the soil salinization processes develop.

Avoiding the above mentioned and other undesirable processes restoration of eroded and naked slopes is possible by new original approach. Substance of question is to use the accumulation method of irrigation water described below for restoration of prepared soil and ground layers.

The following procedure is implied in the method suggested by us. Before filling the free space prepared for restoration of slope its surface should be covered by impermeable alternative composition of “Vita”, about 3.5-5 cm in thickness located at a depth of 35-45 cm from earth surface. This composition excludes

infiltration of irrigation water to the depth. To avoid side infiltration the borders of quarry should be covered by the same composition. Then impermeable cover will be covered by ground in which the grass seeds are distributed. On the smooth surface of ground "Vita" modification composition will be spread about 2 cm in thickness, which significantly decreases evaporation and does not hinder aeration conditions. It is necessary for seed's maturing and creation of normal vegetation conditions.

After realization of Project there does not occur dehydration of seed containing life layer, caused by infiltration, there will be preserved the necessary value of aeration and by this way it will be created favorable conditions for growing of grass [2].

As a result of Project's realization a new original method will be developed for the dense grass cover creation on lifeless naked slopes in a short time. Accumulation of irrigation water decreases to minimum water consumption, which is precondition for reduction the price of work and for making it significantly less laborious. After detailed study of the suggested method equipped in the Project, students will be able to select directly subjected to development areas and necessary materials, preparing of substance and to study its properties in laboratory conditions and then to develop selected area in situ. Carrying out the above mentioned works gives the students the team labor experience and capability to realize such works by oneself on other areas.

ნიადაგმცოდნეობა

ეროზირებული ფართობების რესტავრაცია-რეკულტივაციის მეთოდი

თ. ჯიქია

საქართველოს ტექნიკური უნივერსიტეტი, გამოყენებითი გეოლოგიის დეპარტამენტი, თბილისი, საქართველო

(წარმოდგენილია აკადემიის წევრის თ. ურუშაძის მიერ)

სტატიაში წარმოდგენილია მეთოდი, რომელიც გულისხმობს რეკულტივაციისთვის განკუთვნილი ფერდობის თავისუფალი სივრცის გრუნტით მიწის ზედაპირამდე ამოვსებას, ზედაპირიდან 35-45 სმ სიღრმეზე ფართობის ზედაპირი უნდა დაიფაროს 3,5-3 სმ სისქის ეკოლოგიურად უსაფრთხო მასალებისგან დამზადებული ნაერთით, რომელიც სარწყავი წყლის სიღრმეში ინფილტრაციას გამორიცხავს. ამის შემდეგ, წყალგაუმტარ საფენს ზემოდან დაეყრება გრუნტის მასა, რომლის ზედაპირი ფართობის ზედაპირს გაუსწორდება. გრუნტის მასაში განაწილებული იქნება აღმოსაცენებელი ბალახეულის თესლი. გრუნტის მიწის პირამდე მოსწორებულ ზედაპირს დავფარავთ დაახლოებით 2 სმ სისქის ისეთი ნაერთით, რომელიც მნიშვნელოვნად ამცირებს აორთქლების ინტენსიურობას.

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