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Bioecological materials for soil and water protection

Биоеколошки материјали за заштиту земљишта и вода

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Abstract

The priority of bioecological materials is their efficiency, price, ready production, application, as well as the aesthetics and the rate of matching in the natural environment. The necessity of their wider application in our country, because of the cost efficiency and supporting the world trends and achievements.

The increased concern for ecology and environmental protection brought about the development in the application of natural vegetation materials, as well as their residues in the form of prefabricated elements (bands, mats) in slope protection against erosion especially in civil regions.

Keywords: erosion control materials, bioengineering, biofixators, erosion, ecology, erosion control

Извод

Живе материјале за биоинжењерску заштиту земљишта и вода, чине траве, жбуње и дрвеће које је својим биолошким својствима као и испитиваном применом, у нашим условима, показало задовољавајућу трајност, отпорност и успешност. То је, током времена, испитивано у овом раду и са неким врстама које овде немају већу примену у биоинжењерингу. Као што се из података и резултата рада може видети, клеке имају боље карактеристике и већу могућност примене, него хамеципариси, који су, опет декоративнији и погоднији за урбане средине. Клеке се боље примају и показују интензивнији раст у почетној, најважнијој, фази биоинжењерске заштите замљишта и вода.

Ова област екологије захтева још шира и бројнија истраживања, како би још већи дрој биљних врста и њихових живих грађевина био примењен у овој значајној делатности. Биоинжењерске грађевине имају предност над конструкцијским јер су: еластичне, отпорније, трајније, флексибилније, лакше се постављају, одржавају, јевтиније су и много природније. У случају потребе могу се комбиновати са конструкцијским материјалима, што се и препоручује.

Introduction

Bioengineering erosion control materials are employed in the sanation of eroded regions along railways, motorways, river banks, lagoons, on sand dunes and in deforested urban zones. They are often made of different natural materials, i.e. plant fibers and residues formed into strips of different dimensions and joined with geosynthetic base and joining materials. Sometimes they are grass sown. They are primarily applied in the protection against erosion, but they easily blend with the surrounding landscape and have a high level of applicability.

They are easy to install and move, which make them suitable for the establishment of green areas, sports grounds, parks and other similar places. When they have a reinforced structure, they can be used for frequently trodden areas.

Materials and methods

Green fixtures can be made of straw, grass, bast, twigs, reed, cornstalks and other plant fibers, joined with synthetic (for instance polypropiletic) threads. They can also contain grass or shrub seed or we can expect indigenous, autochthonous vegetation to spread through the loose structure of these *"bioplasters"*.

Biomaterials are being increasingly used in ecological engineering nowadays. Plants spread through and assimilate *"green fixators"* which are primarily used in the initial phase of surface soil protection. Pushing their way through their loose structure, plants begin to anchor the imperilled soil.

«Biofixators» are composed of various plant materials and they have a wide range of application in the protection against erosion, particularly in urban areas.

In order to prevent surface erosion of urban zones, public building operations require the installation of plant surface structures (covers), which enable a quick and easy development of indigenous or sown vegetation. The tree root systems anchor the surface soil layer, while the above-ground parts protect it from the influence of atmospheric water, thus making the surface soil firm. Phytocovers are used in the protection of bound and sand soil, river or lake banks, coastlines, as well as loose soil (Matic,V., 1998).

The experience of some foreign countries (Spain, South America) tells us that these green fixators last twelve to eighteen months, which is enough for indigenous or sown vegetation to develop in erosion affected areas. After that they are no longer needed. The most common dimensions of the *"Biofixators"* are 1.20 x 60m and 2.40 x 42m, with both surface and inner reinforcement with polymeric threads.

We use wedges, 4 mm in diameter and 200m deep to firm *"phytofixators"* to the base. They are packed in trunks or rolls of different weight, which depends on where and how they are going to be used. (Begemanin/Schiechtl, 1986).

Another kind of protection against erosion is the use of shrub and tree seedlings. They are placed at contour lines at certain intervals, with the aim of reinforcing soil by covering its surface and enriching it with plant residue. This kind of control is most frequently used in inhabited areas because it is both economical and aesthetically pleasing.

Plant selection should be governed by the site conditions: climate, soil, exposition, moisture and other environmental factors. There is a great number of domestic and allochton forest and decorative species that can find use in such protection in our region. The selection process is a responsible task, in which the purpose of the protected area must also be considered so that the selected species can be decorative, medicinal or melliferous. Therefore we have examined performance of certain decorative species at the slope of 45^0, exposed to the west in the part of Belgrade called Košutnjak.

We used three different decorative shrub species, which were well adapted to the conditions of the locality and had well developed underground and above-ground parts with the aim of prevention surface and gully erosion of the slope.

Five year old seedlings, balled and burlapped to prevent evaporation and mechanical injury, were placed on the slope in horizontal rows at 1.5 x 1.5 intervals. They were placed on the sample plot at the beginning of March in 2011.

The following empirical formula was used to define the depth of soil binding (Begemanin/ Schiechtl, 1986):

$d = m \times 2$

$d = 2.28\ m$,

from the site conditions:

- angle of inner friction β 250;
- slope angle β 450;
- slope length l = 12.00 m;
- distance between biological shelterbelts 1.5 m;
- m = 0.205

Research results, discussion

This research was performed with available decorative species. We used the following five year old seedlings:

- Chamaecyparis thyoides (L.);
- Chamaecyparis nootkatensis (D.Don);
- Juniperus communis (L.)

They belong to Cupressaceae Bart family, Chamaecyparis Spach genus (which means a small cypress).

Chameciparis thyoides (L.) and nootkatensis(D. Don) is known as cypress. It is native to the coast of the Pacific and northwest California, occurring up to 1,500 m (4,900 ft) altitude and as far as 70 km inland. It attains a height of 30-40 m, with a diameter from 1.5 to 3 m. When young, it grows slowly, then faster. It is frost resistant and tolerates temperatures as low as –22 or – 25^0C. It is a shade species, adapted to a wide range of soils. It grows both in base and salty soils. When there is enough moisture, it can grow in loamy soils as well. The best growth occurs in deep, fresh clay soils. In humid climates, it has a mighty root system which makes it wind-resistant. It is also tolerant of smoke and air pollution, although it is susceptible to dry air and dry soil. It is disease resistant. It is a valuable hard, aromatic tree species, which makes it suitable for furniture manufacture. It can be propagated by seeds, cuttings, grafting (green cuttings) or stump sprouts. There are hundreds of cultivated forms which are common in parks. In our country short forms are most common. It can appear in alpinums, be planted in groups and used as a hedge.

Family: Cupressaceae Bartl.

Genus: Juniperus L.- juniper

Its name originates from the word junior which means young, meaning that it produces seed and fruit when young. It is an evergreen, monoecious tree or shrub, propagated by seeds, ground layering or grafting. It is often decorative. There are about 50 different species in the temperate region of the north hemisphere. They are all phytoncidic species. They can grow in almost any kind of soil and they are frost resistant. Many species and forms are very decorative. They have a wide spreading stem, more than a meter high. Only male specimens can attain a height of 3m and the same width. There are a lot of mutations, since they are widespread and widely used.

The soil of the sample plot belongs to smonitza soil. It has a fairly deep solum and regarding its texture it belongs to loamy clay, which cause low permeability. It has a neutral chemical reaction on the surface horizon, while its pH factor slightly increases with the depth of solum. It is non-carbonated. Because of its heavy texture, it has a high level of absorption, as well as of absorbed cations and base saturation. There is only a small amount of humus, which makes it deficient in nitrogen. Phosphor is in short supply throughout the whole depth. Potassium, which plants need for their growth, occurs only in humus accumulative layer, while there is much.

The seedlings were not cared for, but they grew well at the beginning of the vegetation period in 2008. At the end of August, some of the Chamaecyparis seedlings showed signs of drying, which became more obvious at the end of September. By the beginning of November 52% of seedlings had dried, most of which were

Discussion

Chamaecyparis, while junipers showed better resistance to drought, which is shown in next diagram 1:

Although planting productivity was not so good its effects are very significant. Root systems reinforced the soil of the slope and considerably prevented the process of washing and carrying away the soil. The aboveground plant parts protected the slope from pluvial erosion and from raindrops bombarding the surface. Planting contributed to the aesthetic quality of the locality and the improvement of the local microclimate.

The percentage of dried Chameciparis thyoides (L.) reached 92 %, which was a significant value and it caused a new erosion threat.

Unfavorable climate conditions – temperatures above 40 oC with little precipitation, i.e. drought – caused significant drying of Chameciparis seedling. Mighty beech trees in the vicinity of the sample slope also had a bad influence on the growth of the seedlings. Beech trees fill in underground aquifers, taking in a great amount of water at the same time, especially when the temperatures are high and they are exposed to direct sun. This caused a lack of water in the area surrounding the slope, which was intensified by the clay type of soil.

All in all, such conditions reduced the amount of moisture that these young plants with relatively shallow root systems needed for their growth (0.5 – 1.0 m) and brought about partial drying of newly planted seedling. This didn't refer to junipers, which survived despite the unfavorable climate conditions and the lack of care and maintenance. They served their erosion control purpose since the angle of inner friction increased to β 460, as shown in the results of geomechanic testing.

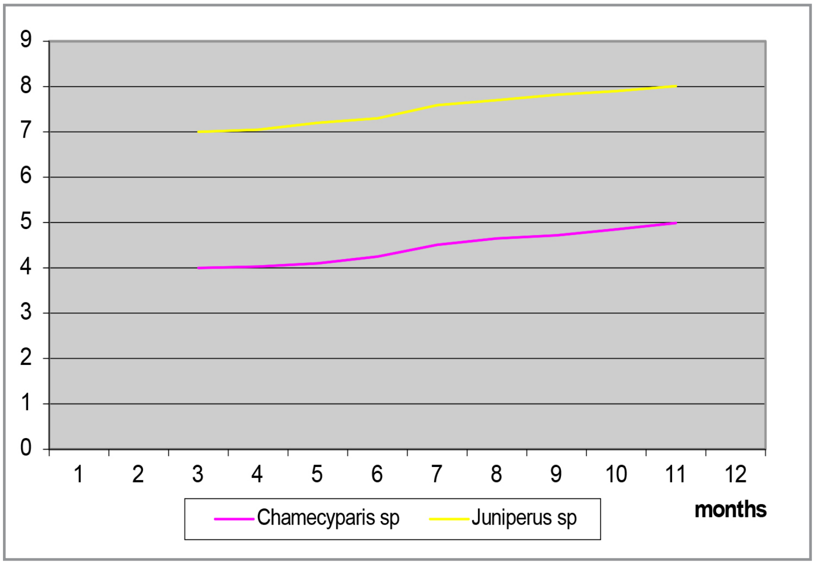

Diagram 1 Seedling growth

Conclusions

"Fitofixators", both as elements made of plant parts and as live phytomaterials, can be greatly used in the erosion control of slopes, watercourses or erosion affected river basins.

This research shows that, unlike construction materials, bioengineering materials require at least minimal maintenance in the initial stage, but as soon as they begin to function as erosion control agents, further maintenance is not necessary. On the other hand, construction materials need constant maintenance.

We can conclude this kind of protection is not suitable for sizeable areas, because they are directly affected by climatic factors (measures of initial maintenance cannot be applied in the most critical period), which means that erosion control works are strongly exposed to climate risks.

In all other respects, vegetation, as the only natural protection against erosion, is by all means the most suitable and ecologically approved way of protection, which is proved by the increase in the angle of inner fraction of the examined slope soil.

Vegetation protection of slopes against erosion increases soil depth and enriches it with humus and other elements that plants need. It also improves the soil composition and enriches the underground water resources. It has a favorable influence on the microclimate of the site.

This research shows that the application of erosion control engineering in the protection of slopes is effective in many ways, which calls for new researches into ways of using different species of grass, trees and shrubs in the local site conditions.

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