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Implementation of hydroseeding methods as bioengineering techniques for soil stabilization and reclamation projects

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Abstract

The protection of soil from erosion is an essential element for projects where we have to deal with steep slopes terrains. Those could be construction of roads, quarry and open-pit mines. The soil stabilization occurs with the implementation of technical works such as the installation of synthetic and metallic textiles or with bioengineering methods. The mine closure and the rehabilitation of mine sites and waste dumps are popular projects under sustainable policies. A bioengineering stabilization method is hydroseeding which can be used for mine rehabilitation. Hydroseeding is considered one of the most appropriate methods for fast installation of vegetation. It is used for planting seeds of grass species, even shrubs and trees. This paper aims to highlight the advantages of hydroseeding as a sustainable bioengineering method for soil stabilization. The contributing factors for successful installation of hydroseeding were examined and analyzed. Those are time the: time and climatic conditions, different methods, selection and quality of the materials and the selection of the proper mix of species which are used. A review of applied projects in Greece is taking place with focusing in the growth of the plants and the results of this method compared with others.

Keywords: hydroseeding, erosion, soil stabilization, reclamation, bioengineering, steep terrain

1. Introduction

The slopes created during the construction of roads and other technical works are sensitive to erosion with significant environmental consequences (pollution and reduction of the clarity of streams) as well as in the technical works themselves (Parsakhoo et al. 2000). Soil stabilization and disturbance restoration is achieved by various methods which can be classified into purely technical and plant-technically (Albaladejo, 2000; Stergiadou et al., 2008). Technical works are retaining walls, installation of metal or synthetic textiles, construction of wire boxes and covering with concrete (Stergiadis, 1982). Plant-technically works are mainly planting and reforestation with trees, shrubs or seeds (Karagiannis et al. 2000; Stergiadis, 2005). The main advantages of the plant works are (Kotoulas, 1987; Goulas,2000): a) the adaptation with the natural environment b) their superiority from an aesthetic point of view, c) they are not decomposed or destroyed over time and d) their implementation is more economical with better environmental results. Lammeranner, Raych and Laaha wrote that soil bioengineering is an approach to deal with erosion problems and shallow seated landslides (2005).

Hydroseeding is considered a slope stabilization technique which addresses surface erosion in areas where vegetation has been destroyed and the soil has lost some of its functions and especially the ability to be able to support the natural regeneration of vegetation (Valladares et al. 2008; Alifragis et all, 2016). The types of hydroseeding based on the standards of the Hellenic Standardization Organization (ELOT) are the simple hydroseeding and the hydroseeding with mulch materials which is distinguished in a) hydraulic hydroseeding, b) in hydraulic hydroseeding and straw cover and c) in hydroseeding with simultaneous use of geo-textiles. From the mentioned methods, in the present work, the hydraulic hydroseeding and the hydroseeding with simultaneously use of geotextiles are examined.

Hydraulic hydroseeding uses a mixture of seeds, fertilizer, soil stabilizer and organic mulch materials which are sprayed with water and the required mechanical equipment from a suitably shaped vehicle on the soil surface (Galatsianou, 2017). The proportions of the materials vary and depend on the type and degree of soil disturbance. Important factors that are taken into account when choosing the appropriate seed mixture are a) the vegetation zone, b) the altitude of the area, c) the climatic conditions, d) the exposure of the slope d) the existing flora of the area. For the selection of auxiliary materials important factors are a) the type of slope (earthen, semi-rocky or rocky), b) the slope of the soil, c) the percentage of organic matter and nutrients in the soil.

The timing of hydroseeding plays an important role in its success. The appropriate time is determined by the type of seeds to be used (Eskioglou et al., 2012). Hydroseedings usually take place between the months of October to November and February to March. The main goal is the rapid germination of the seeds to prevent surface erosion.

2. Methodology

In the present paper, three cases of hydraulic hydroseeding applications, which were applied by technical companies operating in Greece during the years 2016-2018, are examined. All the factors that contribute both during the implementation phase and during the maintenance phase are analyzed. The aim was to select different areas in order to extract conclusions about whether each factor affects the success rate.

The projects that were examined are: 1) Implementation of hydroseeding for the restoration of soil that was deforested and disturbed by the construction of a natural gas pipeline in R.D. of Florina. During the stage of the specific project, care was taken for the storage of the upper soil horizon (10cm), which after the completion of the works was spread over the entire surface. 2) Implementation of hydroseeding for the stabilization of forest road slopes in the area of central Chalkidiki. In this case, in the slopes had previously placed an organic geotextile (jute). 3) Implementation of hydroseeding in slopes of internal road construction site in which there were placed synthetic geotextiles. In all cases, the hydroseedings were carried out in the months of late February to early March.

3. Results

Table 1 shows the data collected from each case, while Figures 1 to 4 show the slopes at different times. Moreover, tables 2 and 3 show plants species which used in each case.

Table 1. Data of the hydraulic hydroseeding case under study

	Case 1	**Case 2**	**Case 3**
Location	Florina	Chalkidiki	Chalkidiki
Vegetation zone	Quercetalia pubscentis	Fagetalia	Fagetalia
Type of soil	Earthen	Earthen	Semi-rocky
Aspect	NE	E	SE
Incline	4:1	2:1	3:1
Geotextile	No	Organic	Synthetic
Amount of seeds per 1000m²	20kg	25kg	25kg
Amount of organic mulch per 1000m²	200kg	125kg	25kg
Fertilizer	Organic 15kg/ Synthetic 15kg	Synthetic 20kg	Synthetic 20kg
Soil stabilizer	1 kg per 1000m²	1 kg per 1000m²	1 kg per 1000m²
Maintenance works	None	Synthetic fertilizer after 6 months	Synthetic fertilizer after 6 months

Table 2. Plant species used in the implementation of hydroseeding in case 1

Agropyron cristatum	*Lotus corniculatus*
Agropyron elongatum	*Medicago sativa*
Agrostis capillaris	*Melilotus officinalis*
Cynodon dactylon	*Anacampsis lupinella*
Dactylis glomerata	*Phacelia tanacetifolia*
Festuca arundinacea	*Poa pratense*
Festuca ovina	*Sanguisorba minor*
Festuca rubra	*Trifolium pratense*
Lolium rigidum	*Trifolium subterraneo*

Table 3. Plant species used in the implementation of hydroseeding in cases 2 and 3

Festuca rubra	*Poa pratensis*
Lolium perenne	*Medicago sativa*
Festuca stolonifera	*Agrostis stolinofera*
Bromus cathartcticus	*Trifolium repens*

The reported cases showed that each of the key factors contributes significantly to the success rate of hydroseeding. From the hydroseeding, as a plant-based project, the germination of the seeds is required after one week from its application. The growth of the plants should be within a month at such a point that the protection against surface erosion due to rainfall is sufficient. Point failures can lead to deviation from the goal of hydroseeding which is the non-detachment of parts of the soil.

Figure 1. Implementation of hydroseeding in RD. of. Florina, LC of Variko

Figure 2. Implementation of hydroseeding in RD. of. Florina, LC of Variko

Figure 3. Hydroseeding results earthen slope with organic geotextile after 3 months in R.D. of Chalkidiki. Earthen slope with organic geotextile and in the right image a semi-rocky slope with synthetic geotextile

Figure 4. Hydroseeding results earthen slope with synthetic geotextile and in after 3 months in R.D. of Chalkidiki. Semi-rocky slope with synthetic geotextile

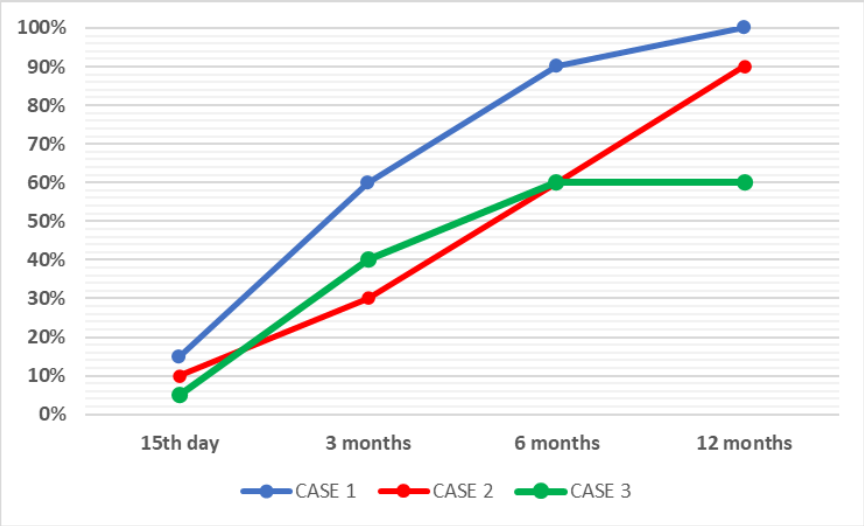

Chart 1. Comparison of the percentage of surface coverage after the implementation of hydroseeding in the examined cases

4. Conclusions

The analysis of the results showed that hydroseedings, in order to have high success rate, require soil preparation during the construction phase of the technical project. Especially in Case 1 where there was a layer with a higher soil horizon the results were better. In none of the cases, repeated hydroseedings carried out the following planting season in order to cover the failures. With the exception of case 1 where hydroseeding reached full soil cover, the repetition of hydroseeding could lead to improvement of the coverage rate. In addition, the maintenance of the hydroseedings has an important role. Fertilization and irrigation during the dry season can greatly improve the final result. It was also observed that when hydroseeding is applied with the simultaneous use of geotextiles, the use of a large amount of coating materials blocks sunlight and there is no breakdown of seed dormancy. For this reason, the use of coating materials was less in cases 2 and 3. As a general conclusion we can add that hydroseeding can significantly reduce the surface erosion of the sloping soils of forest roads. However, in case of slips or falls, then construction of support engineering works is required. These can be reinforced concrete retaining walls or any other kind of technical stabilization work. In case of ecologically sensitive areas, the retaining walls could be lined with stones from area. In some cases of small slips or falls it is even possible to use walls made of wire boxes.

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