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Water Loss from Soil and Water Absorbing Geocomposite

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Abstract. Evaporation can be one of the main reasons of water loss from soil. Usually the second, excluding evapotranspiration, is infiltration due to which water becomes unavailable to plants. Water absorbing geocomposite was designed to minimize water loss from soil and to provide water for plants during vegetation. It is built of a skeleton creating space for water absorbing superabsorbent (SAP). On the outside it is covered with geotextile, which acts as a separator and filter. It can be manufactured in a fully biodegradable version. It is a technology used to retain water in the soil, which is then available for plants. The paper presents the results of a simple experiment concerning water loss from two types of soils. The experiment was conducted in a thermal chamber with electronically controlled temperature. Two types of soils – sandy soil and loamy soil and two types of geocomposite were used. In the chamber flowerpots with and without geocomposite filled with sandy soil or with loamy soil were watered with 0.5 l of water. During the following 10 days water loss was observed two times a day. The results show high efficiency of geocomposite in water saving. Water loss from soil with installed geocomposite was nearly 7 times lower than from soil without the device. The idea was patented - Geocomposite element, particularly for enhancing plant growth, PL 211198, application PCT/PL2011/050008. The patent was commercialized in Poland. Products based on the license of Wroclaw University of Environmental and Life Sciences are available under the trade name HYDROBox. They are used in the cultivation of strawberries, raspberries, and the cultivation of ornamental plants for urban green areas in order to increase production and improve the condition of the plants. On slopes they are used as a means for the protection of turf and other plants from the harmful effects of drought and erosion.

Keywords: Water absorbing geocomposite, water scarcity, drought, evaporation.

1. Introduction

Droughts are a consequence of climate changes that have been observed for years. The problem of droughts concerns the whole world and affects food security more than other types of natural disasters [1], [2].

According to the data provided by FAO Aquastat [3] the amount of precipitation falling on land is approx. 110 000 km^3 per year. Over 60% of this amount evaporates from the ground or transpires from vegetation. 40 000 km^3 per year are converted to surface runoff, or supply surface waters and aquifers. Part of this water is being removed from these rivers or aquifers by installing infrastructure as a water withdrawal. Agriculture is the largest user of freshwater resources, using at global level 70% of water withdrawal (industrial use 19%, domestic use 11%) up to more than 90% in some developing countries. According to the FAO estimation, water withdrawal for agricultural irrigation will increase by 11% until 2050 [4], [5].

The results of tests of the intensity and the forecasting of the course and consequences of droughts show that in the present century, a significant decrease in soil moisture can be expected in most regions of the

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world. The most significant decreases in soil moisture – even up to 25%, are forecasted in the subtropics and the Mediterranean region [6], [7].

Water deficits significantly affect the crops of plants, not only directly through the lack of water, but also through their influence on the deterioration of soils.- microbial activity in soil, nutrient availability, impact on biogeochemical processes, gaseous and leaching losses, N and C cycle [1], [6], [7].

Soil moisture in the root zone is essential in agricultural drought. Water retained in this zone is available for plants, but it can also be transported to the atmosphere in the process of evapotranspiration [2]. Increasing the amount of water available for plants in the soil and limiting the transfer of water to the atmosphere by means of the application of water absorbing geocomposites can significantly contribute to the reduction of the effects of drought in agriculture.

1.1. Water Absorbing Geocomposites

Water absorbing geocomposite was designed to minimize water loss from soil and to provide water for plants during vegetation. It is built of a skeleton creating space for water absorbing superabsorbent (SAP). On the outside it is covered with geotextile, which acts as a separator and filter. It can be manufactured in a fully biodegradable version. It is a technology used to retain water in the soil, which is then available for plants. Superabsorbents are loosely cross-linked hydrophilic polymers. Usually they are made of lightly cross-linked poly (acrylic acid) in form of potassium salt. They can absorb a large amount of water, even up to 1g SAP/1000g of water [8]. In recent decades they have also been used in hygienic products, horticulture and medicine.

2. Materials and Methods

To test evaporation from soil and from geocomposite a simple experiment was carried out. The experiment was conducted in a thermal chamber with electronically controlled temperature. The temperature during the day was 36-40 ℃ and 20-25 ℃ during the night. Two types of soils – sandy soil and loamy soil and two types of geocomposite (point geocomposite and geocomposite mat – Fig. 1) were used. In the chamber flowerpots with and without geocomposite were used. They were filled with sandy soil or with loamy soil. Soils were watered with 0.5 l of water and the geocomposites were soaked with water (0.5 l) before the experiment and installed on the bottom of the flowerpots. Then, 7 kg of sandy or loamy soil were added to the flowerpots. Five flowerpots were used for each repetition. The basic data obtained in the experiment was the mass of the flowerpots including content. Variability indicators: standard deviation and coefficient of variation were also calculated for the obtained data. Following the statistical analysis, the data from 5 series of measurements were averaged. Water loss was calculated basing on the difference between the mean mass measured at the given time and the mean initial mass. During the following 10 days water loss was observed two times a day. Dry soil density (ρ_d) was 1.406 g·cm^{-3} for sandy soil and 1.414 g·cm^{-3} for loamy soil. The initial soil moisture (w) was 1.73 % and 2.75 %, respectively. Soils were clear from plants. No outflow from the flowerpots was noticed.

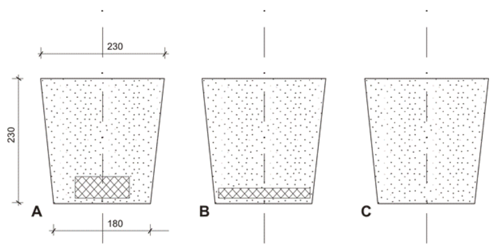

Fig. 1: Outline of the experiment: (a) point geocomposite, (b) geocomposite mat, (c) soil with water

3. Results and Discussion

The process of water loss from soil resulting from evaporation was different in the case of soil mixed with water and soil with installed geocomposite, although the course of the process for both versions of the geocomposite was very similar. The statistical analysis of basic data (mass of pots with content in grams) showed that the standard deviation and coefficient of variation are characterised by very low values. The spread of data is quite low; they are grouped in the proximity of the mean. For sandy soil, the highest variability was characteristic for the results obtained for samples of soil with water, and the lowest – for point geocomposite. Significantly lower variability was obtained in the case of the results of tests carried out in loamy soil than for sandy soils. No differences in the variability of results for specific solutions were observed (Table 1).

On the average, the largest amounts of water evaporated from the containers in which soil was mixed with water (400 g). The lowest amount of water evaporated from the geocomposite in form of a mat, placed on the bottom of flowerpots filled with loamy soil (52 g). The course of the evaporation process in time is shown in Fig. 2.

The lowest loss of water, in comparison to the loss of water from flowerpots containing only soil, was noted in the case of loamy soil both for point geocomposite and for geocomposite mat – only 13% of the amount that evaporated from flowerpots containing only soil. Similar results were obtained for flowerpots filled with sandy soil, where geocomposites were installed – in both instances 15% of the amount that evaporated from flowerpots containing only soil. However, there are no significant differences in water loss in time between the two types of soil applied. Taking into account only the water that was added (0.5 l to each of the pots) it turns out that in the experiment with point geocomposite only 10% and in the case of geocomposite mat only 8% of the total amount of water contained in the soil and in the geocomposite evaporated. That means water loss from soil with installed geocomposite was nearly 7 times lower than from soil without the device. Total water losses are shown in Fig. 3.

There are no reports from similar experiments in literature, which can easily be explained by the fact that water absorbing geocomposites are a new solution that has not become commonly known yet. The tests conducted by Li *et al*. in 2012 [9] prove that water loss resulting from the evaporation from soil can be significantly reduced through the application of plastic sheet mulch or wheat straw mulch. Similar results were obtained with use of tephra mulch [10]. In this context, the results obtained for water absorbing geocomposites seem very promising. Also the possibility to apply both technologies at the same time, e.g. geocomposites in the soil under the root mass of the plants and the mulch on the surface of the soil seems noteworthy.

Table 1: Statistical analysis of data (mass of pots with content in grams, N=5) obtained from the experiment

Samples	Standard deviation (σ)	Coefficient of variation [%]
Sandy soil		
Geocomposite mat	11,40-15,57	0.136-0.186
Point geocomposite	7,42-10,61	0.089-0.126
Soil with water	6,52-47,75	0.080-0.571
Loamy soil		
Geocomposite mat	5,70-9,08	0.068-0.109
Point geocomposite	4,18-8,37	0.050-0.100
Soil with water	4,18-8,66	0.050-0.107

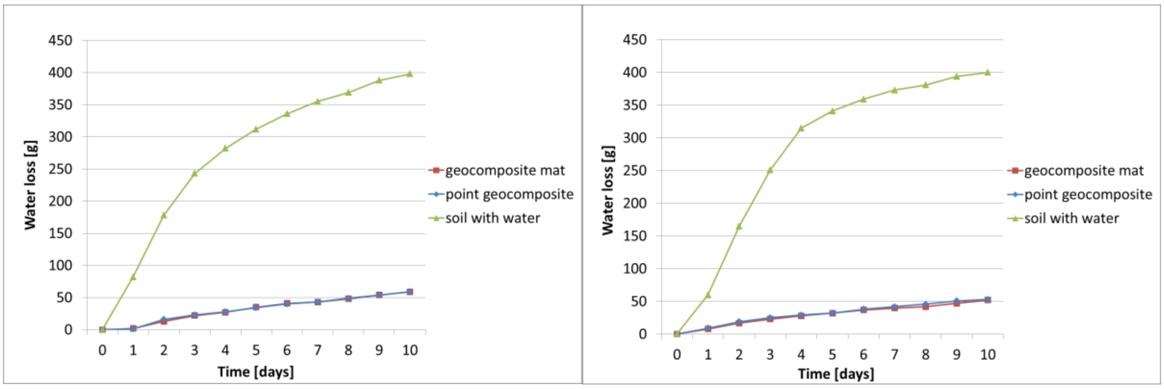

Fig. 2: Water loss with and without geocomposites (a) from sandy soil, (b) from loamy soil

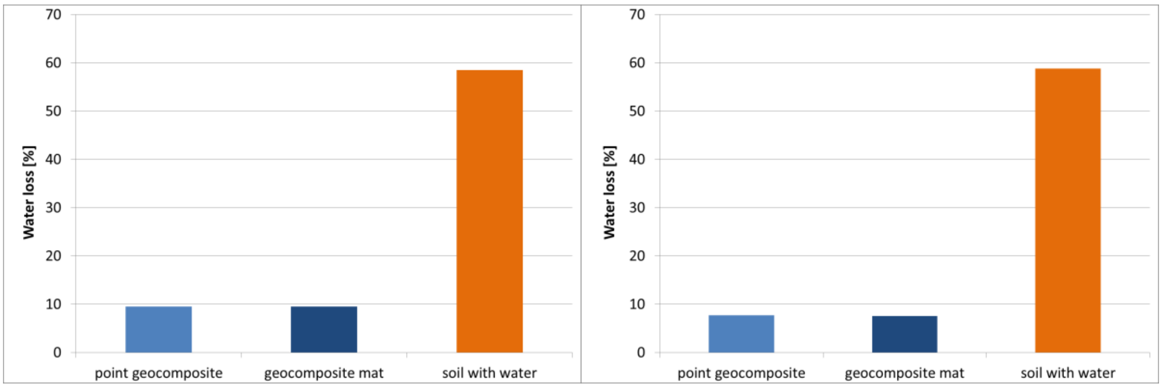

Fig. 3: Water loss percentage with and without geocomposite (a) sandy soil, (b) loamy soil

4. Conclusions

The results show high efficiency of geocomposite in water saving. Water loss from soil with installed geocomposite was nearly 7 times lower than from soil without the device.

The application of water absorbing geocomposites significantly reduced the evaporation of water from soil. In the case of sandy soil only 10% of the water evaporated, while in the case of loamy soil – only 8%. For soil without geocomposites the loss amounted to 59%, both for sandy and loamy soils.

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