Innovative water absorbing geocomposite for anti-erosion protection

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Environmental Connections, Portland (OR), 2015

Introduction

- Superabsorbents (SAPs) or hydrogels are loosely cross-linked polymers
- 1g of SAP can absorb up to 1000g of water
- SAPs are used in medicine, hygienic industry and in agriculture
- In the soil they perform the function of a moisture buffer

Superabsorbent (SAP), dry

and

after water absorbtion

Introduction

- Mostly used potasium salt of poly(acrylic acid)
- Acrylic acid polymers are not harmful for plants, humans and animals
- Polymers based on acrylic acid do not contain acrylamide monomers

SAP overgrown by roots

Introduction

- SAPCs - composite polymers with the addition of clayey minerals
- Polymer with clayey molecules increase the absorption capacity and decrease the sensitivity to the activity of ions
- Recent research concern synthesis and properties of biodegradable hydrogels derived e.g. from cellulose
- Many research on superporous hydrogels (SPHs)

SAPCs - SAP with bentonite

Introduction

So far, superabsorbents were applied into the soil with use of the following methods:

- mixing with soil,
- spraying in form of a solution,
- injecting the polymer into the soil,
- hydrosowing with a diluted emulsion with seeds,

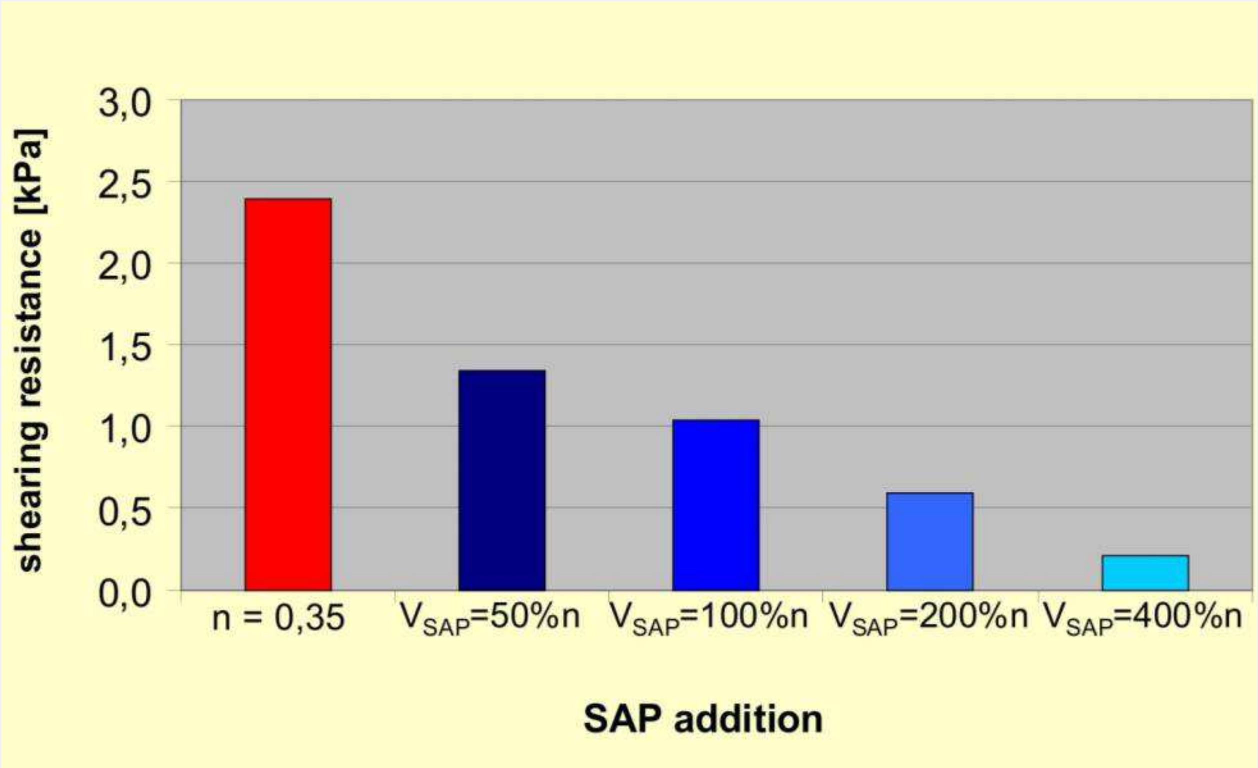
SAP mixed with soil

Introduction

- ✓ Problem with using SAP's on slopes
- ✓ Filling of soil pores
- ✓ Decreasing of internal friction
- ✓ Possible shallow landslide

Example of shallow landslide

Introduction



Shearing resistance of medium sand with different dose of swollen SAP

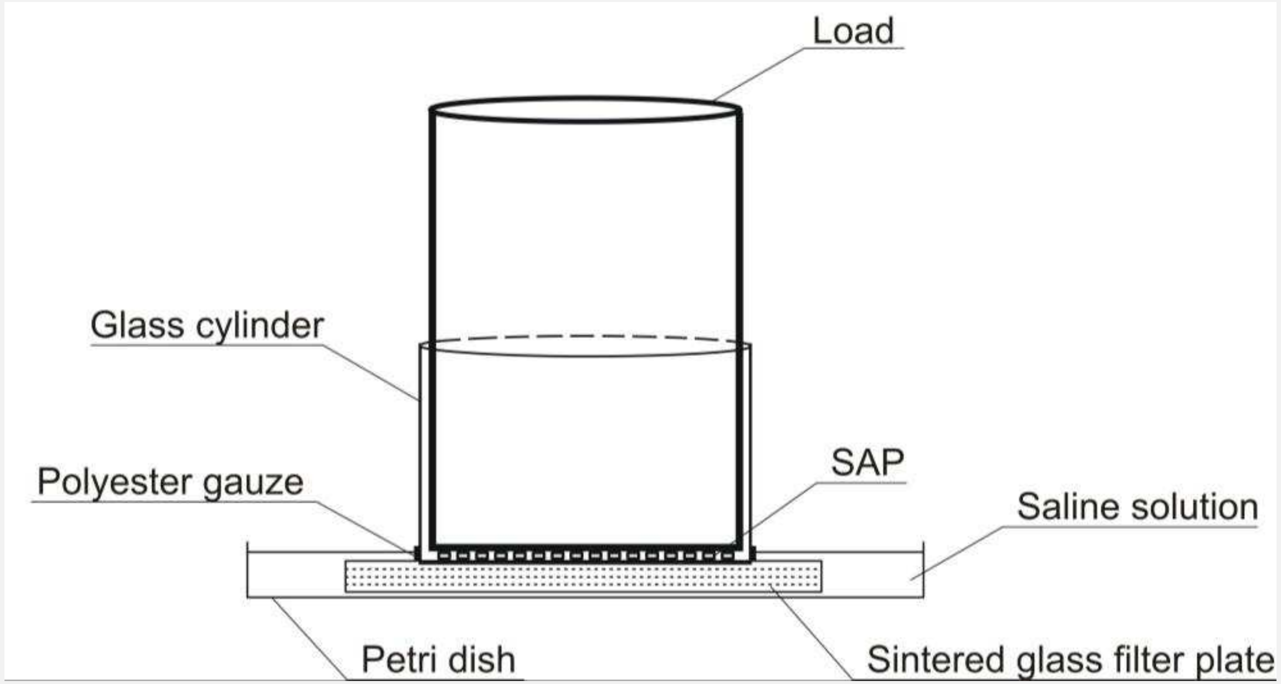
A. Pawlowski, K. Lejcus et al. Geocomposite with Superabsorbent as an Element Improving Water Availability for Plants on Slopes. Geophysical Research Abstracts, Vol. 11, EGU2009-9997-2, 2009

First idea

- ✓ New geocomposite in form of a tube/pipe
- ✓ It consists of dry superabsorbent particles placed between 2 layers of geotextiles

Prototype in form of a geocomposite tape, (photo: J. Dąbrowska)

Previous apparatus



M.J. Ramazani-Harandi, M.J. Zohuriaan-Mehr ey al. Rheological determination of the swollen gel strength of superabsorbent polymer hydrogels. Polymer Testing 25 (2006) 470–474

Materials and methods

Test apparatus

1) **superabsorbent,**

2) **load,**

3) **porous rock,**

4) **cylinder with water,**

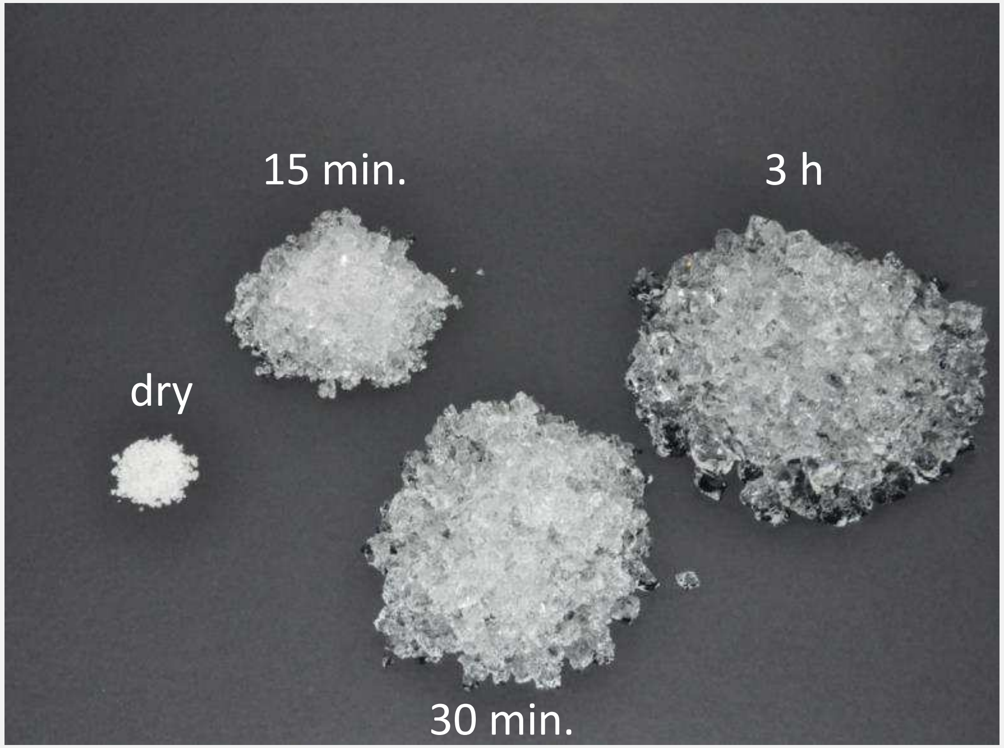
5) **inner cylinder with superabsorbent,**

6) **force sensor.**

Materials and methods

- SAP's absorbency under load (AUL) was tested.
- Mecmesin Multitest 2.5-xt was used,
- 2 g sample of SAP was placed in the measurement cylinder and loaded with a weight corresponding to 10 cm, 20 cm and 30 cm layer of soil
- dry density of soil was 1.3 g x cm^3,
- The increase in sample height in time was measured,
- Available on the market cross-linked copolymer of acrylamide and potassium acrylate
- D.I. water was used in the experiment

Volume of swollen SAP



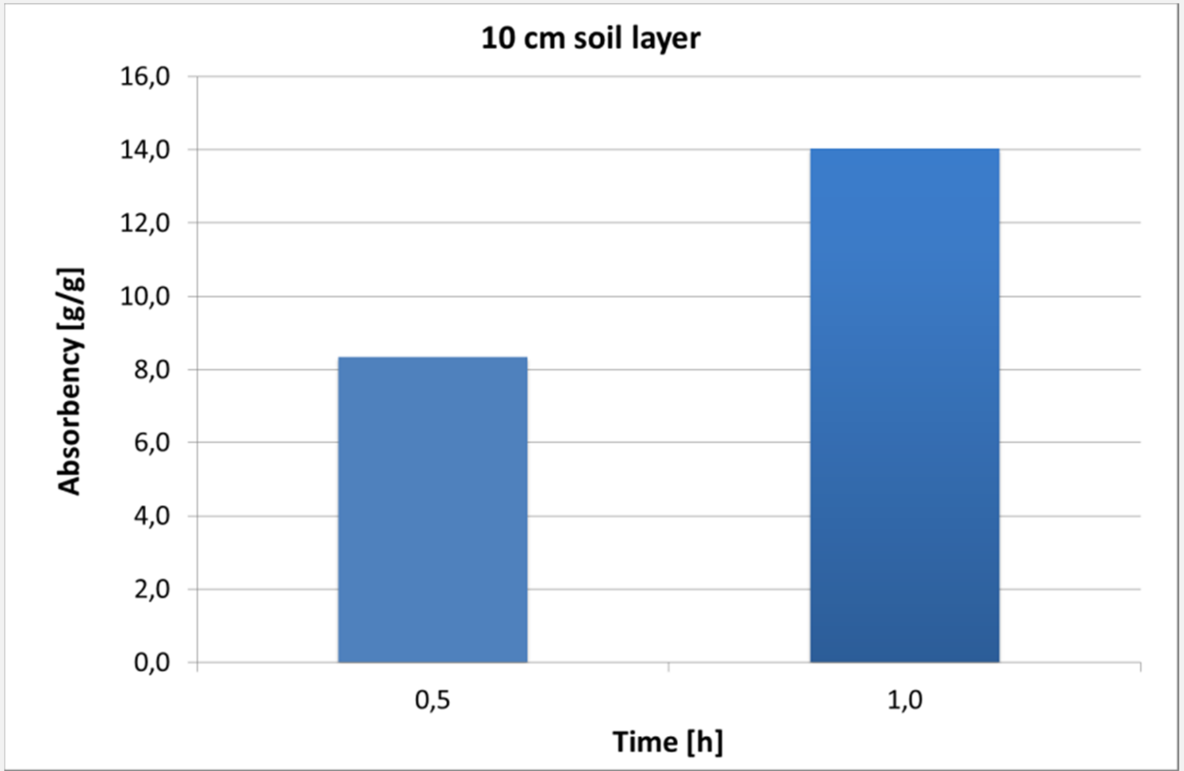
Simple experiment

On the left SAP absorbing water (coloured blue) with no load, on the right thin blue layer of SAP compresed by equivalent of 30 cm layer of soil

Results

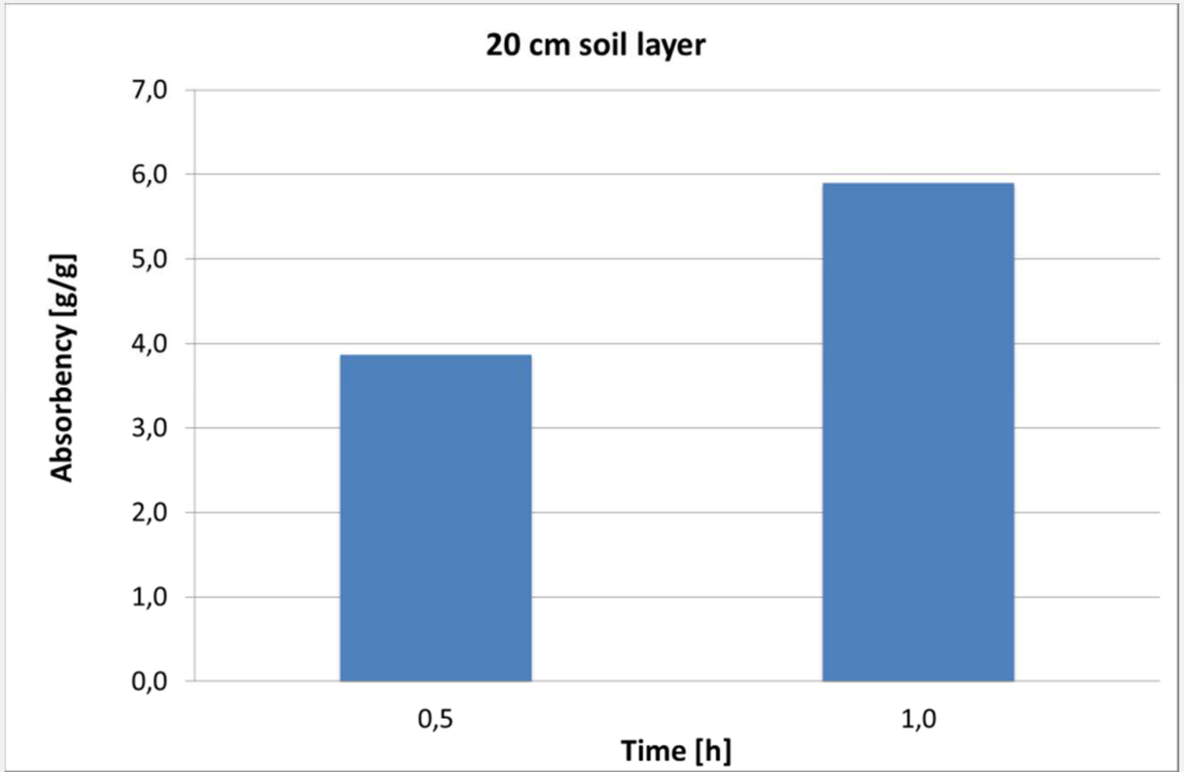
- Studies on the swelling of superabsorbent are not published very often.
- The presented results refer mainly to the description of basic properties of superabsorbents [Buchholz, Graham 1998] or are discussed in the context of the application of superabsorbent in baby diapers [Ramazani-Harandi et al. 2006].
- Literature rather does not mention the influence of load on water absorption and thus their functioning in the soil.

Results – absorbency under load



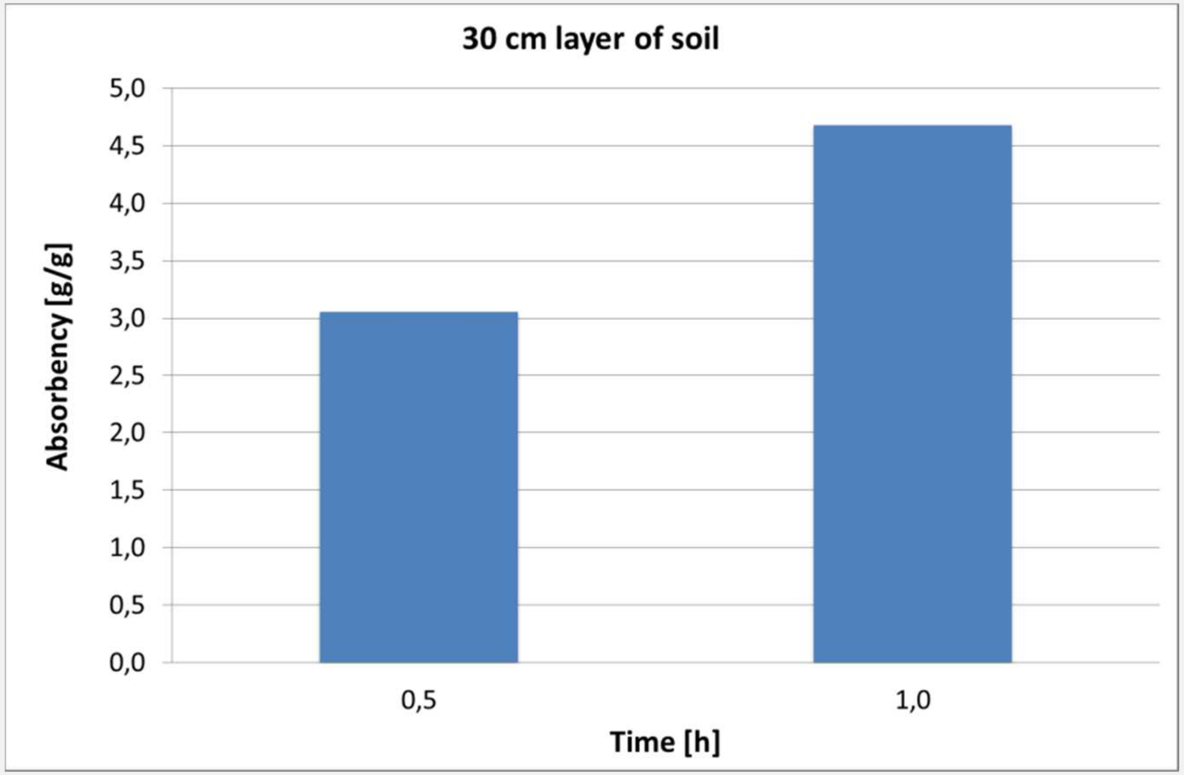
Absorbency under load with 10 cm of soil load

Results – absorbency under load



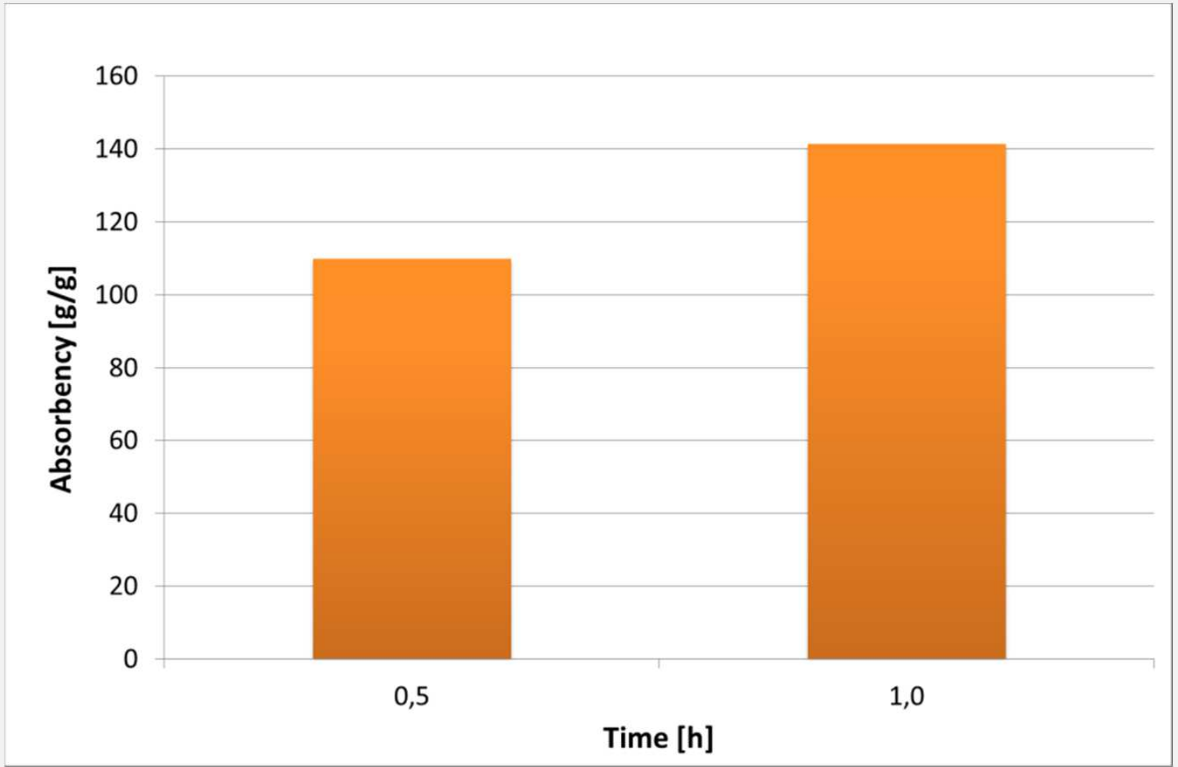
Absorbency under load with 30 cm of soil load

Results – absorbency under load



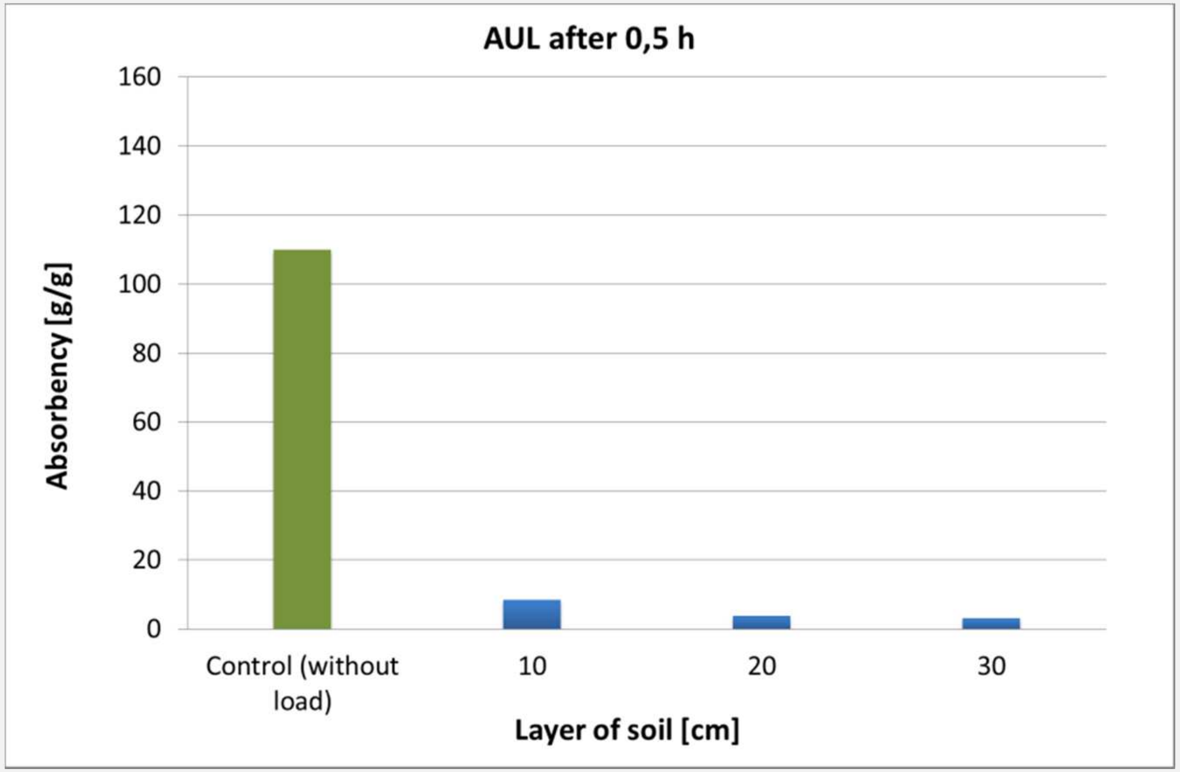
Absorbency under load with 20 cm of soil load

Results – absorbency under load



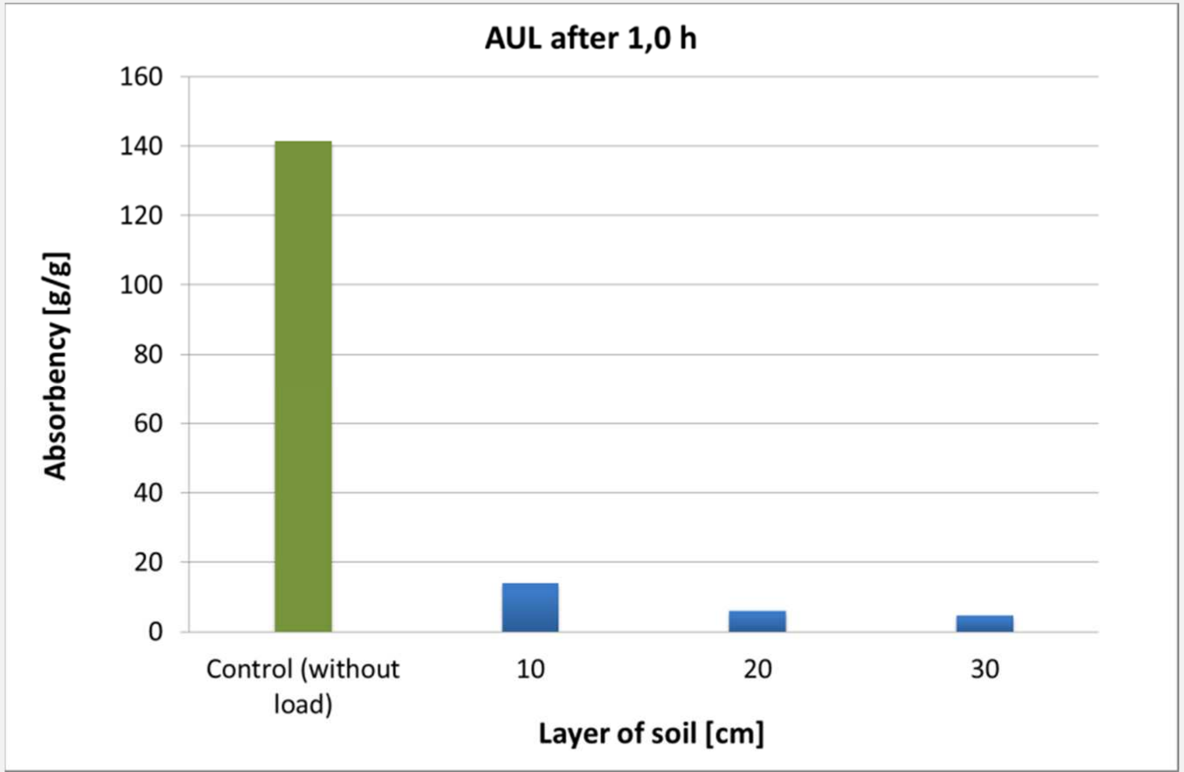
Absorbency under load without load (control)

Results – absorbency under load



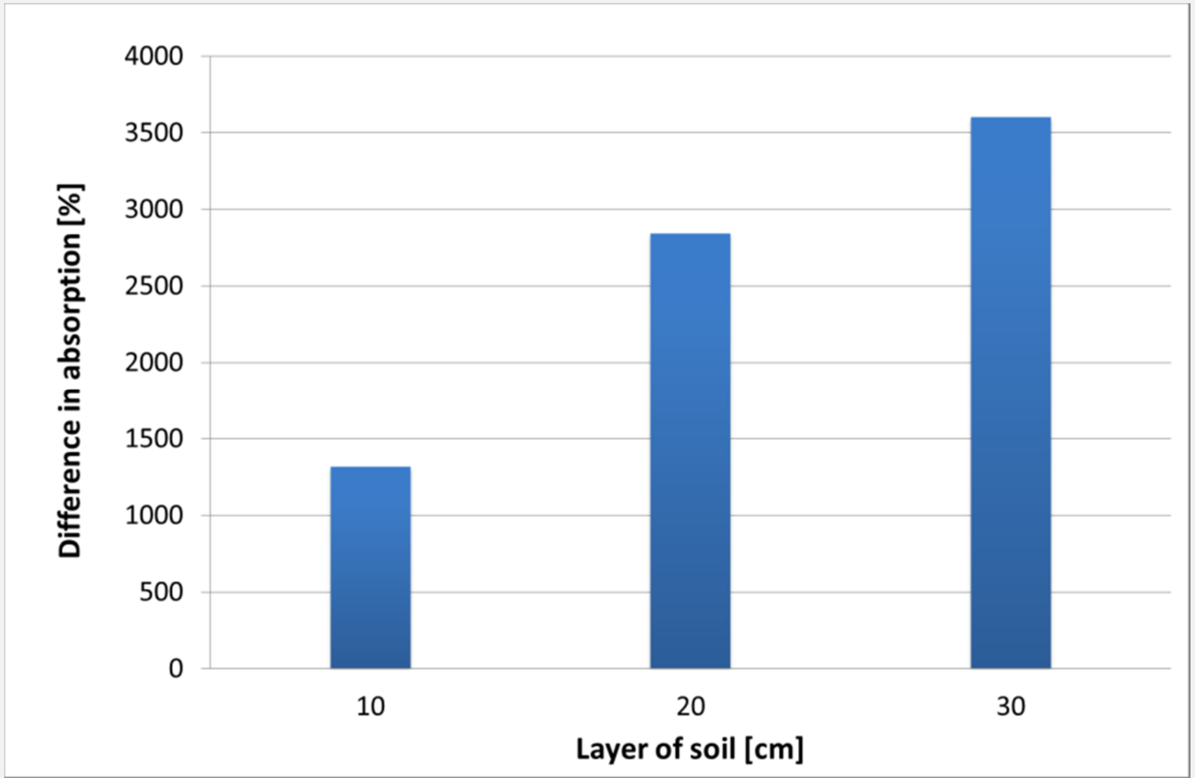
Comparison of absorbency under load with and without load after 0.5 h

Results – absorbency under load



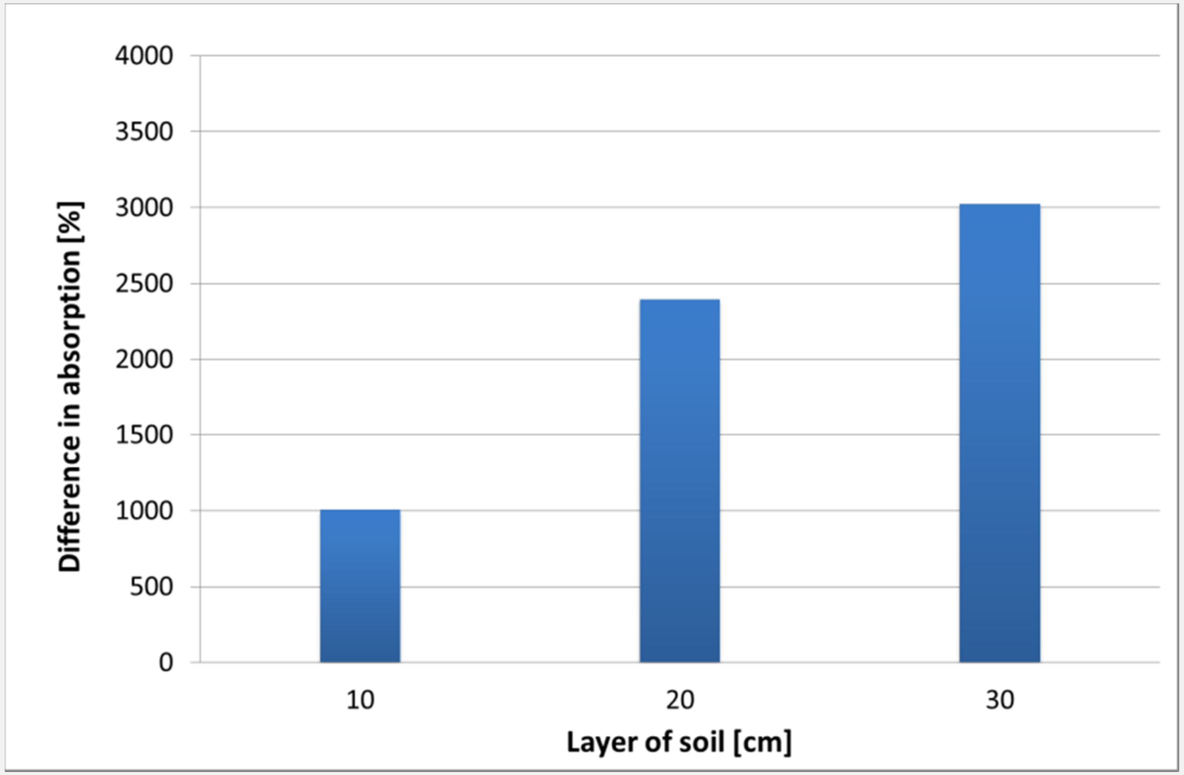
Comparison of absorbency under load with and without load after 1.0 h

Results – absorbency under load



Percentage difference in water absorption after 0.5 h

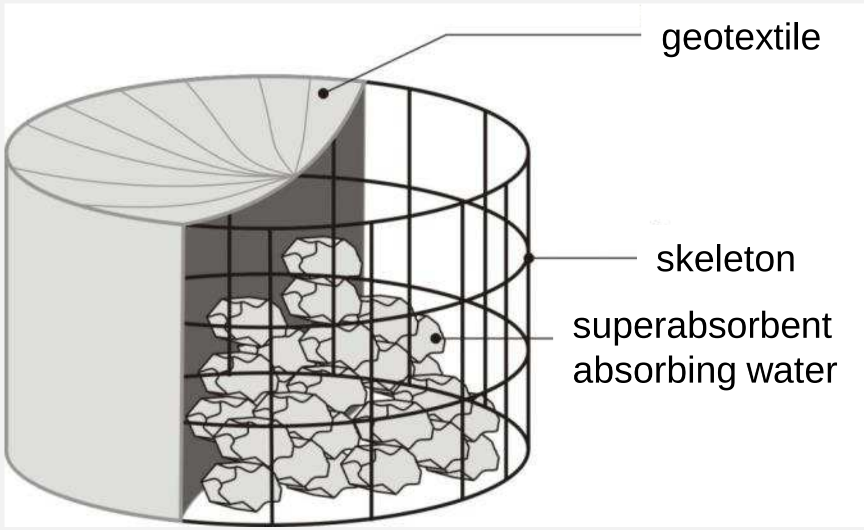
Results – absorbency under load



Percentage difference in water absorption after 1.0 h

The invention

Water absorbing geocomposite is a technology used to retain water in the soil, which is then available for the plants. Geocomposite is built of a skeleton creating space to be filled with superabsorbent and mounted on the outside of the geotextile, which acts as a separator and filter. It can be produced in long lasting and also fully biodegradable version.



The patent

Patent „Geocomposite element, particularly for enhancing plant growth",

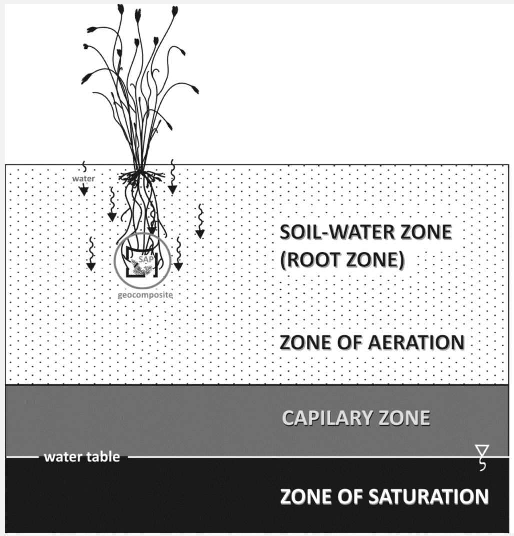
PL 211198, application PCT/PL2011/050008.

The patent has been commercialized. Products based on the invention are available on the market

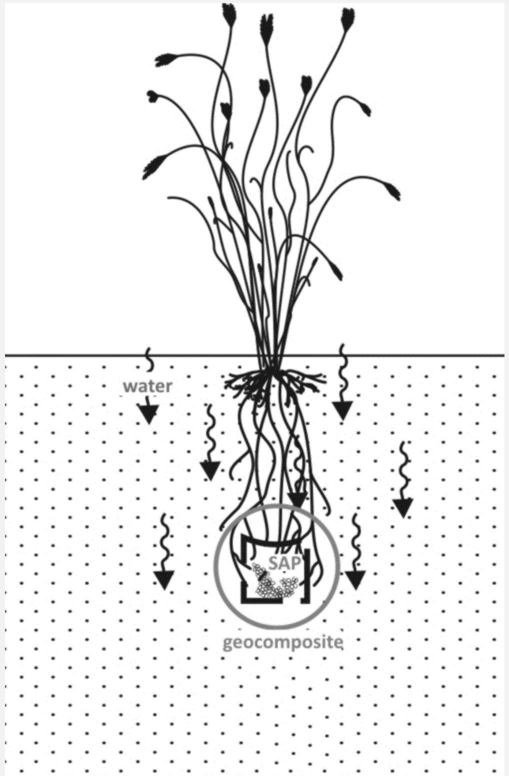
Examples of comercially done projects with water absorbing geocomposites

Geocoposite and water

Geocomposite retains water which is gradually absorbed by plants.
It ensures optimum growth of plants due to continuous watering.



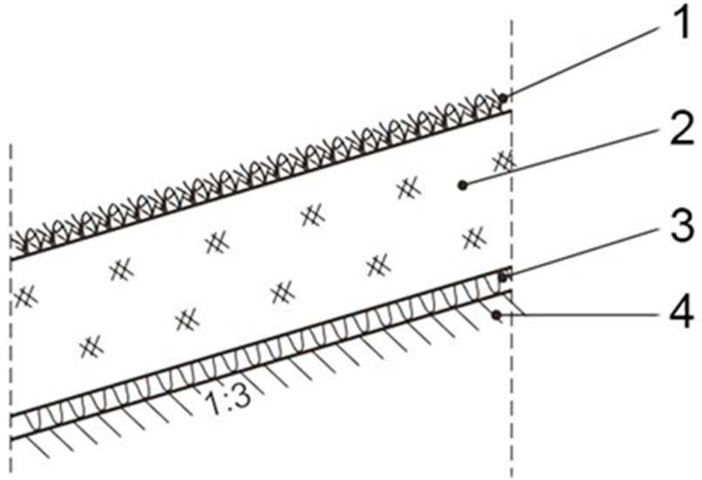
Water in the soil



Water absorbing geocomposite - possible arrangements

Water absorbing geocomposites during installation on the Odra River embankment

Water absorbing geocomposite on slopes



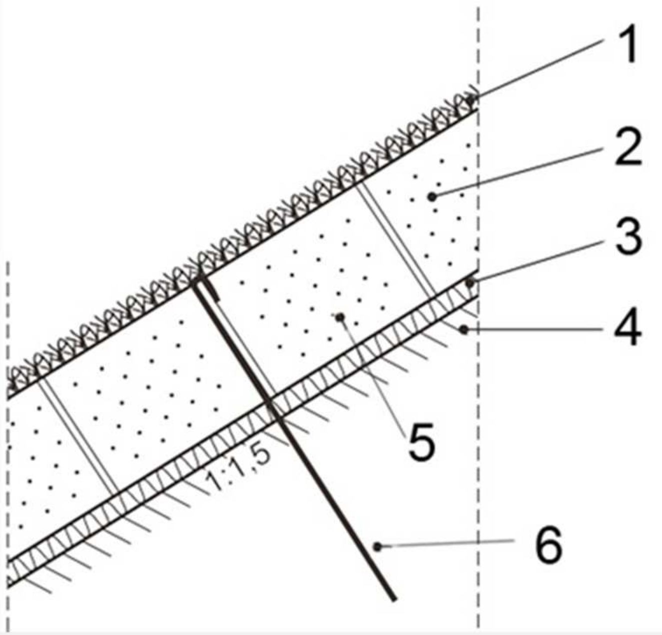
1 - grass cover

2 - soil (humus)

2 - water absorbing geocomposite

4 - soil (humus)

Water absorbing geocomposite on slopes



1 - grass cover

2 - soil (humus)

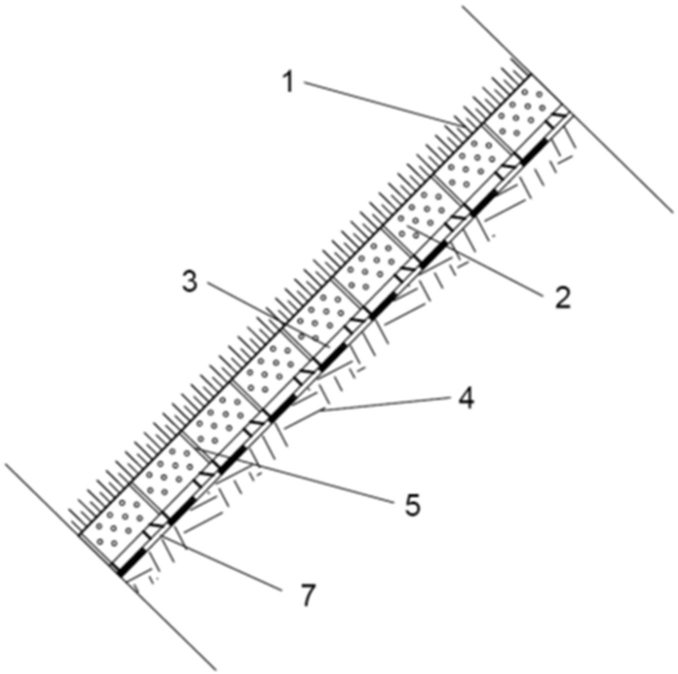
3 - water absorbing geocomposite

4 - subsoil

5 - geogrid (dimensional cellular system)

6 - anchor

Water absorbing geocomposite on slopes



1 - grass cover

2 - soil (humus)

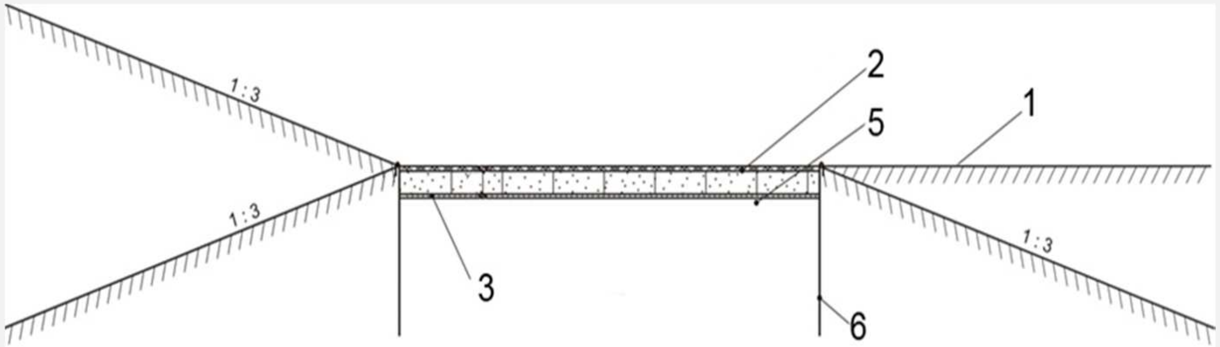
3 - water absorbing geocomposite

4 - subsoil

5 - geogrid (dimensional cellular system)

7 - geomembrane

Water absorbing geocomposite on slopes



1 - grass cover
2 - soil (humus)
3 - water absorbing geocomposite
5 - geogrid (dimensional cellular system)
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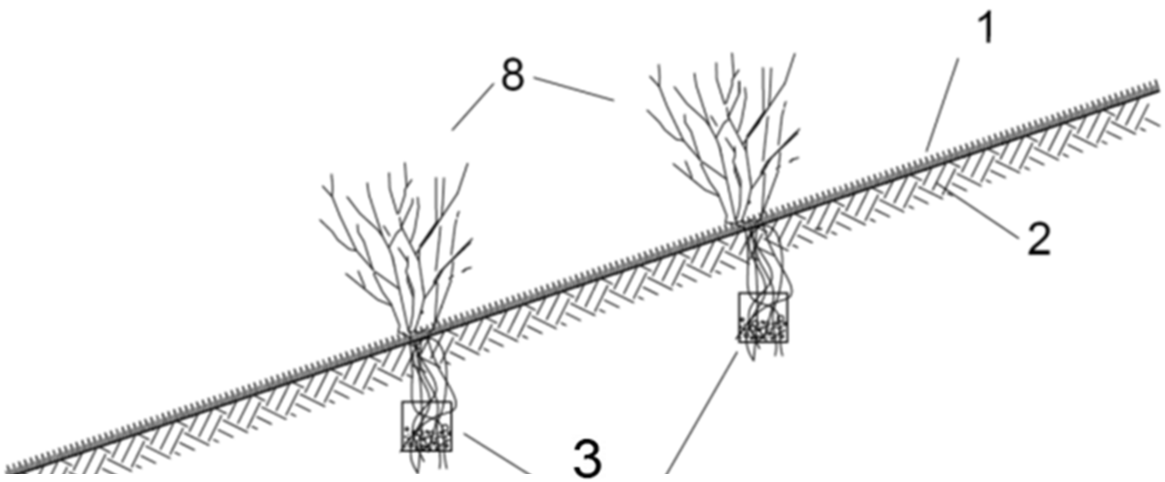
Water absorbing geocomposite on slopes



1 - grass cover
2 - soil
3 - water absorbing geocomposite
8 - shrubs

Water absorbing geocomposite on slopes

Water absorbing geocomposites during installation on steep slope – inclination 1 : 0,7

The experimental embankment

Slope with inclination 1 : 1.5

Experiment with erosion of the slope

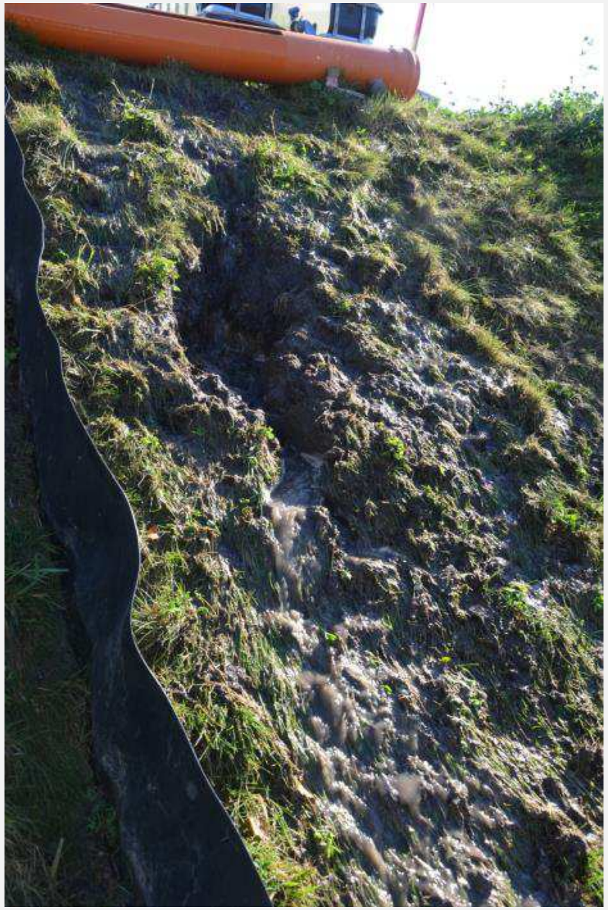
Slope inclination 1 : 1.5

- water flow 5 l/s
- field dimentials 1.5 m x 3.0 m

After 20 m^3 of water

with geocomposite

without geocomposite



On the left field with water absorbing geocompoiste (3 years before), on the right field without geocomposite

The monolith

Wash out the soil

Roots inside the geocomposite

The experimental embankment

Slope with inclination 1 : 3

Roots of the shrubs

with geocomposite without geocomposite

The experiment in old sand mine

Geocomposite installed on the geomembrane

The experiment with impermeable base

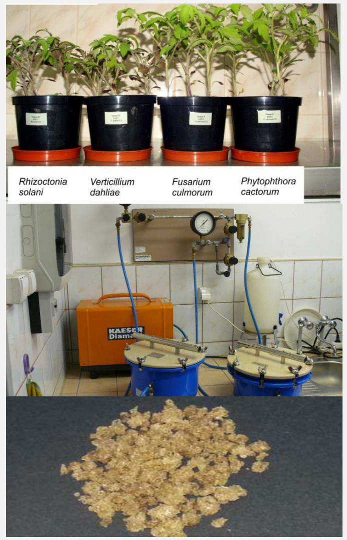
geocomposite

Roots development on geomembrane and geocomposite installed in sandy subsoil

The experiment with impermeable base

geocomposite

Other researches



The effects

Major effects:

- increasing biomass of cultivating plants
- limiting the amount of water used in plant cultivation
- increase in the resistance, density of roots of grass and shrubs

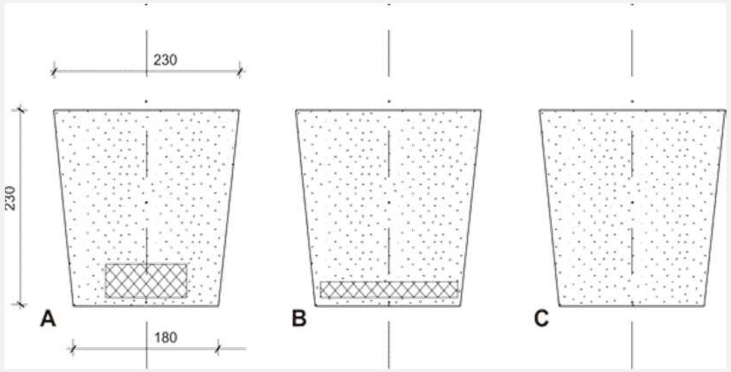
Condition of Papyrus after 7 days of experiment. Plants in the white flowerpots are with installed geocomposite. Plants were not watered during the experiment.

What it gives?

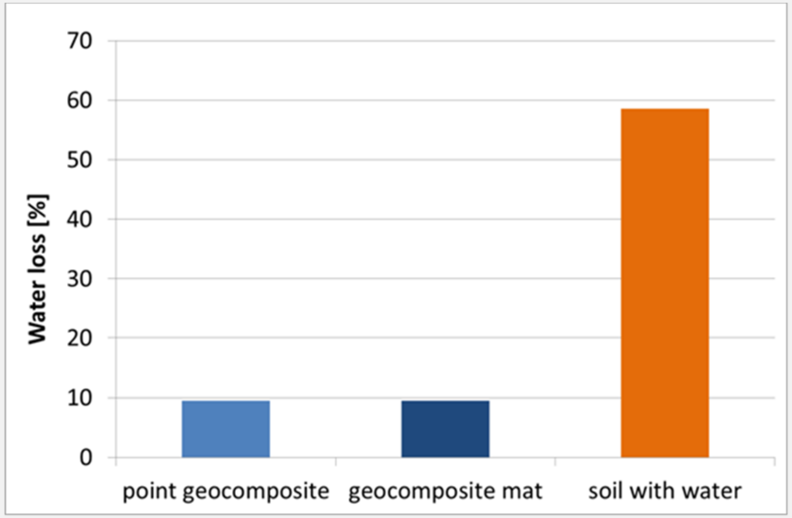
Can we save some water with water absorbing geocomposites?

The aim: to check evaporation from soil and from geocomposites

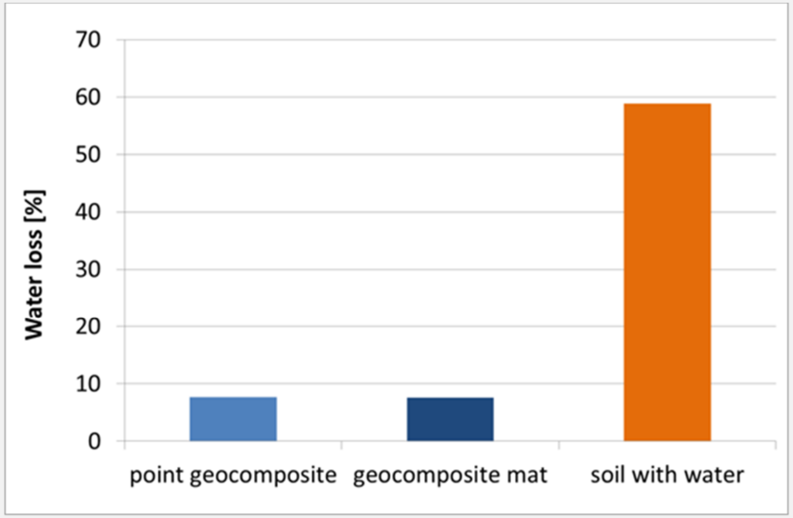
Conditions: T = **36-40 °C** (97-104 °F - day) and **20-25 °C** (68-77 °F - night)
Types of soil: **sandy soil** and **loamy soil**
Types of geocomposite: point geocomposite (A), geocomposite mat (B)
Duration time: **10 days**
Amount of water: **500 g/flowerpot**



How to save water with water absorbing geocomposite ?



A) sandy soil



B) loamy soil

Krzysztof Lejcuś et al. Water loss from soil and water absorbing geocomposite. 2014 International Conference on Natural Science and Environment (ICNSE 2014), Dubai. Soon on APCBEE Procedia.

Conculsions

- Absorption under load is an important parameter determining the possibility to effectively apply superabsorbents in environmental engineering and agriculture.
- Differences in the amount of water retained (absorbed) by the superabsorbent with and without load may even exceed 3500%.
- Water absorbing geocomposites may become a solution to the problem of insufficient functioning of superabsorbents under load. They are used in anti-erosion protection of slopes and in selected branches of agriculture.

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Project
Water absorbing geocomposites

innovative technologies supporting plants vegetation

INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

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project co-financed by the European Union
under the European Regional Development Fund

W A T E R   A B S O R B I N G   G E O C O M P O S I T E S – innovative technologies supporting plants vegetation

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