APPLICATION OF HUMIC SUBSTANCES THROUGH THE CONTROLLED RELEASE SYSTEMS

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Abstract

Humic substances are inherent part of soil. They are responsible for plants nutrition as well as soil structure and composition. Their content in the land continues to decline in the past several decades. There is an effort to artificial replacement. It was found that dusting and spraying of plants are not very effective. The most of conventionally applied fertilizers are very often washed away by rainfall or blown by wind. The solution of these problems can be found in the use of humic substances as a part of the controlled release systems. There are countless possibilities how to prepare product which would be able to release humic substances to the land continuously with limited losses only. This work is focused on use of superabsorbent polymer as a vehicle of humic substances or conventional fertilizers or both together. Incorporation of humic substances into the hydrogel matrix of superabsorbent polymer is very effective for growing plants. This system facilitates the soil's water management which is caused by structure of polymer network as well as humic substances specific properties. Nutrients are dosed to the structure of the hydrogel in an amount and combination to meet the particular needs of the certain plant. It is important to design the ideal composition of engineered products. They should contain sufficient nutrients, minimum or rather no pollutants where possible. They should undoubtedly be biocompatible and biodegradable and have enough durable mechanical properties.

Keywords: Humic substances, superabsorbent polymers, fertilizers

1. INTRODUCTION

A soil in region of central Europe is continuously losing its natural property to retain water in its structure. Most of the water which comes from rains just goes through the soil into the groundwater and agricultural lands suffer by the lack of humidity. One of the reasons of this strange soil behaviour is caused by decreasing amount of organic soil matter. Solution of this problem can be found in application of superabsorbent polymers enriched by addition of active substance based on humic acids. This system of controlled released preparation is able to retain more water in the ground together with sustainable supply of humic acids which are important part of organic soil matter

Superabsorbent polymers are loosely crosslinked, three dimensional networks of flexible polymer chains that carry dissociated, ionic groups which cause their ability to absorb large quantities of water and other aqueous solutions without dissolving by solvation of water molecules via hydrogel bonds.

Superabsorbent polymers have a wide range of usage. In the field of agriculture and environmental protection they are very often used as a water hanger during a dry season nowadays. In contrary they avoid to decay of plants' root system in the time of heavy rains. There is a new trend in a field of superabsorbent polymers and it is an incorporation of fertilizers into the gel structure. This can be consider as a functional system which allows controlled release of substances that support growing and maturing of plants. Such mechanism solves the problem with flushing of fertilizers into deep underground water and avoids to over fertilize of ground as well [1].

2. EXPERIMENTAL

2.1. Materials

Four different samples of superabsorbent polymers based on acrylic acid were used in this work. All of them have a certain addition of NPK fertilizer. Some of them have also an addition of humic substance in a form of commercial lignohumate. Furthermore the samples also differ in a content of acrylamide in the structure. We are trying to eliminate presence of acrylamide in the structure of superabsorbent because of its toxicity. Accurate representation of these selected substances can be found in the **Table 1**.

Table 1 Composition of Superabsorbent Samples

Sample	SAP 1	SAP 2	SAP 3	SAP 4
NPK (wt %)	1	10	1	1
lignohumate	no	no	yes	yes
acrylamide	yes	yes	no	yes

These samples were prepared in cooperation with the company Amagro, s.r.o. and their composition will not be specified in more details because of the intellectual property protection.

Artificial soil was used in this work to ensure precise condition. Its composition is shown in **Table 2**.

Table 2 Composition of Artificial Soil

	Peat	Kaolin	Quartz sand	$CaCO_3$
(wt %)	10	6	83	1

2.2. Swelling measurements

Monitoring of swelling behavior was carried out by very simple method, sometimes referred to as “tea bag” method. 0.5 g of each sample was immersed in excess distilled water of volume 200 mL at room temperature for 24 hours to reach the swelling equilibrium. Swollen samples were then separated from unabsorbed water. Water absorbency in distilled water of the superabsorbent composite Q, was calculated using the following equation:

$$Q = \frac{m - m_0}{m_0}, \; [\mathrm{g/g}] \qquad (1)$$

where m_0 and m are the weights of the dry sample and swollen sample, respectively. Q is calculated as grams of water per gram of dry sample. On the **Figure 1a** is displayed xerogel of superabsorbent polymer before immersion to the excess of distilled water. On the **Figure 1b** there is a swollen gel after 24 hours in the water [3].

Figure 1 a) Xerogel of superabsorbent polymer b) Swollen suberabsorbent polymer

2.3. Water retention test

One g of superabsorbent sample was mixed with 100 g of dry artificial soil and kept in a beaker. 100 mL of tap water was added into the beaker and weighed; excess of unabsorbed water was decanted next day. A controlled experiment without addition of superabsorbent was carried out as well. The beakers were maintained at room temperature and were weighed every day if possible for 18 days. The water retention ratio (WR %) of soil enhanced by superabsorbent was calculated using the following equation:

$$WR\ \% = \frac{W_i - W_S}{W_1 - W_S} \times 100\ \%, \tag{2}$$

where W_1 is a weight of soil with SAP sample immediately after adding of water, W_i is a weight of soil with SAP sample and with water after certain time, W_S is a weight of soil with SAP sample.

3. RESULTS AND DISCUSSION

Swelling behaviour of all superabsorbent samples were determined by the measurement of water absorbency. The results show that all samples exhibit very good swelling properties, as it is displayed in the **Figure 2**, moreover revealed some interesting findings. The samples differed from each other by special composition that is shown in the **Table 1**. There is a significant negative effect on superabsorbent swelling properties caused by the higher content of NPK in the structure of sample. This sample SAP 2 reflects much lower ability to absorb surrounding water. Samples with an addition of lignohumate swelled significantly better than samples without lignohumate. That is caused by hydrophilic character of lignohumate [3].

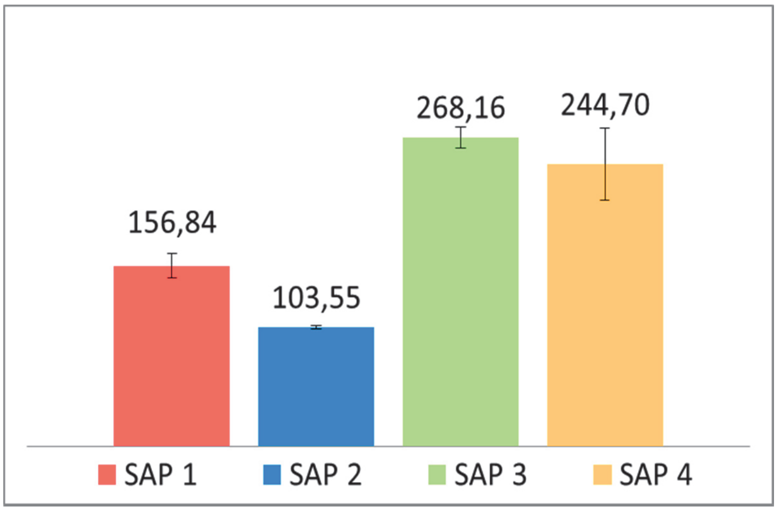

Figure 2 Swelling behavior of superabsorbent samples

Water retention behaviors of the soil with and without SAP were investigated in this work by very easy method. The **Figure 3** shows water retention ability of the soil with all SAP samples and of the pure artificial soil. It was found that the addition of SAP to soil obviously increase the water retention in case of all used samples of SAP. Results show that soil without any addition of SAP was able to retain water only for a period of seven days. After this period the soil was completely dry.

Four various samples of SAP were investigated and there are significant differences among them. The best water retention abilities exhibit samples SAP 1 and 4. They both have small addition of NPK fertilizer and acrylamide as well in their structure.

There is a big effort to prepare a SAP with an addition of lignohumate in the structure. It was done in case of SAP 4 where is lignohumate incorporate to the structure of SAP together with NPK and this combination make wider possibility of its application.

There was also a focus of a preparation SAP sample without acrylamide in a composition. This kind of sample was prepared as SAP 3. This product didn´t show as good water retention results as other products.

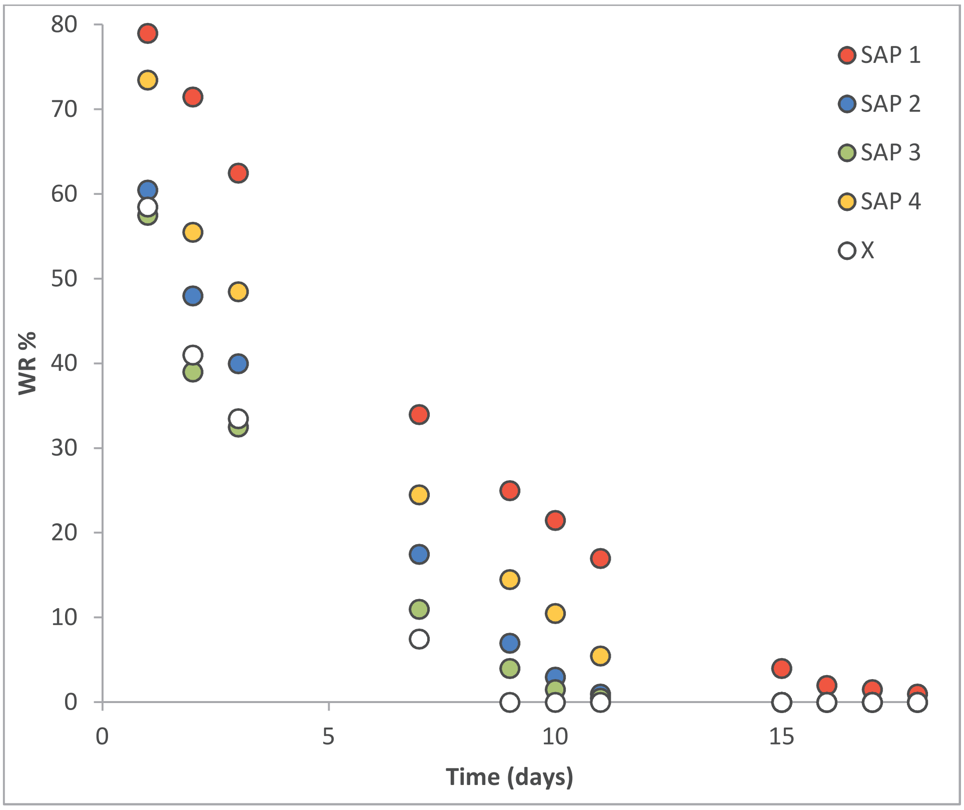

Figure 3 Water retention behaviour with SAP samples 1 - 4 and without SAP X

4. CONCLUSION

Superabsorbent polymers were investigated for their possible application in agriculture and horticulture, especially for saving water in dry and desert region. All samples were enriched by active compounds, especially by NPK and by lignohumate. The results of this investigation show that addition of superabsorbent polymers into soil could improve the water holding ability and water retention property of the soil. Presence of nutrients inside the structure of superabsorbents shows possible usage as a controlled releasing fertilizer.

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