WATER RETENTION OF ORGANIC MATTER AND ITS INCREASE USING ORGANIC HYDROSORBENT

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Abstract
The article is focused on the evaluation of organic matter as one of the important parts for water retention in soil and on the demonstration of a modern practical sustainable way to increase it. Organic matter fractions> 3-10 mm dominate with 70 % of the total fraction volume, but do not retain enough water.
Granular organic hydrosorbent (GOH) with only half the amount (750 g) retained more water than the fraction > 3-10 mm after 8 days without water. The differences in water retention between the fraction < 3 mm and GOH decreased over time and GOH with half the amount retained the same amount of water as the fraction < 3 mm after 71 days. Alternative organic materials in an easy applicable form represent a quick method to improve soil quality and conditions.

Key words: *sustainability, fraction, soil quality, biowaste, digestate, planting*

INTRODUCTION

Soil ecosystem services provide mitigation of weather extremes. These functions depend on the supply of organic matter, that enhances biological, chemical and physical soil properties (*Essling, 2020*). Organic matter influences the water regime (*Rawls et al., 2003; Miháliková et al., 2025*) and is more variable in contrast to soil texture, which is a stable and unchanging part of the soil. Water retention is one of the physical soil properties and is influenced by the amount and quality of organic matter (*Kováříček et al., 2010)*. The amount of organic matter is accumulated mainly in the upper layer of the soil profile (10 cm) and decreases considerable with depth (*Zhang et al., 2021*). The decrease of organic matter in the upper layer occurs due to changes in weather conditions (*Yanai et al., 2003a*), but not at deeper depth, where the amount of organic matter is stable in the long time (*Zhang et al., 2021*). The aim of this article was to provide information on the water retention of the organic matter fraction and granular organic hydrosorbent (GOH) as a sustainable alternative organic matter for planting with ability to retain water. The first aim of this paper was to show how much organic matter affects water retention over time and how much water retention is influenced by the organic matter fractions. The second aim of this paper was to present a way of increase water retention in soil using an organic hydrosorbent. For this study, we investigated water retention in bucket trials.

MATERIALS AND METHODS

Samples were taken with field-shovel from the 0–10 cm upper soil layer in 2025 in the coniferous forest (*Picea abies*) near the town of Jihlava in the Vysočina region (49.3804614 N, 15.6487231 E). The samples were air-dried, homogenised and divided into variants by sieving through 2 mm, 3 mm, 5 mm a 10 mm sieve. Variants were samples with a diameter of over 10 mm, 5-10 mm, 3-5 mm, 2-3 mm and under 2 mm (Fig.1,2). Another variant was a granular organic hydrosorbent (GOH) produced in the form of pellets with 10 mm in diameter, 25 mm length and 9 % moisture. The composition of this organic hydrosorbent comprised 25 % dried separated digestate from a biogas plant, 50 % wheat straw and 25 % husks of postharvest residues from cereals, oilseeds and legumes (Fig.2). The last variant was control including only loam-sandy soil. All variants were tested for water retention in 3 replicates. The experiment was realized for each variant with amount of 500 g (one variant with amount 250 g GOH) in five-litre buckets (17 cm of diameter and 20 cm of height) with holes and

covered with a grid in the bottom. Buckets were weighed and then placed in a water bath for 60 minutes. Buckets were then placed on wooden grates, left to drain for 120 minutes and weighed. The second bucket trial was comparison of water retention in natural modelled forest soil profiles (2 500 g of weight) (Tab.1) with typical horizons (Soil Classification Working Group, 1998) and their mixed version and mixed version added by 250 g and 500 g of GOH. The initial water retention of all variants and trials was calculated from the weights before and after watering. Weighing was repeated after 4, 8, 25, 49, 71 and 97 days. Basic statistical analyses were performed using Statistica software version 13. Results are presented as mean values and standard deviation.

Tab.1 Natural modelled forest soil profile in the bucket trial

Fraction	Quantity in grams	Soil Horizon	Layer in cm
> 10 mm	150	L	5cm
5-10 mm	250	F	
3-5 mm	100	H	2cm
2-3 mm	100	H	
< 2 mm	500	Ah	4cm
Loam-sandy soil	1400	B	7cm

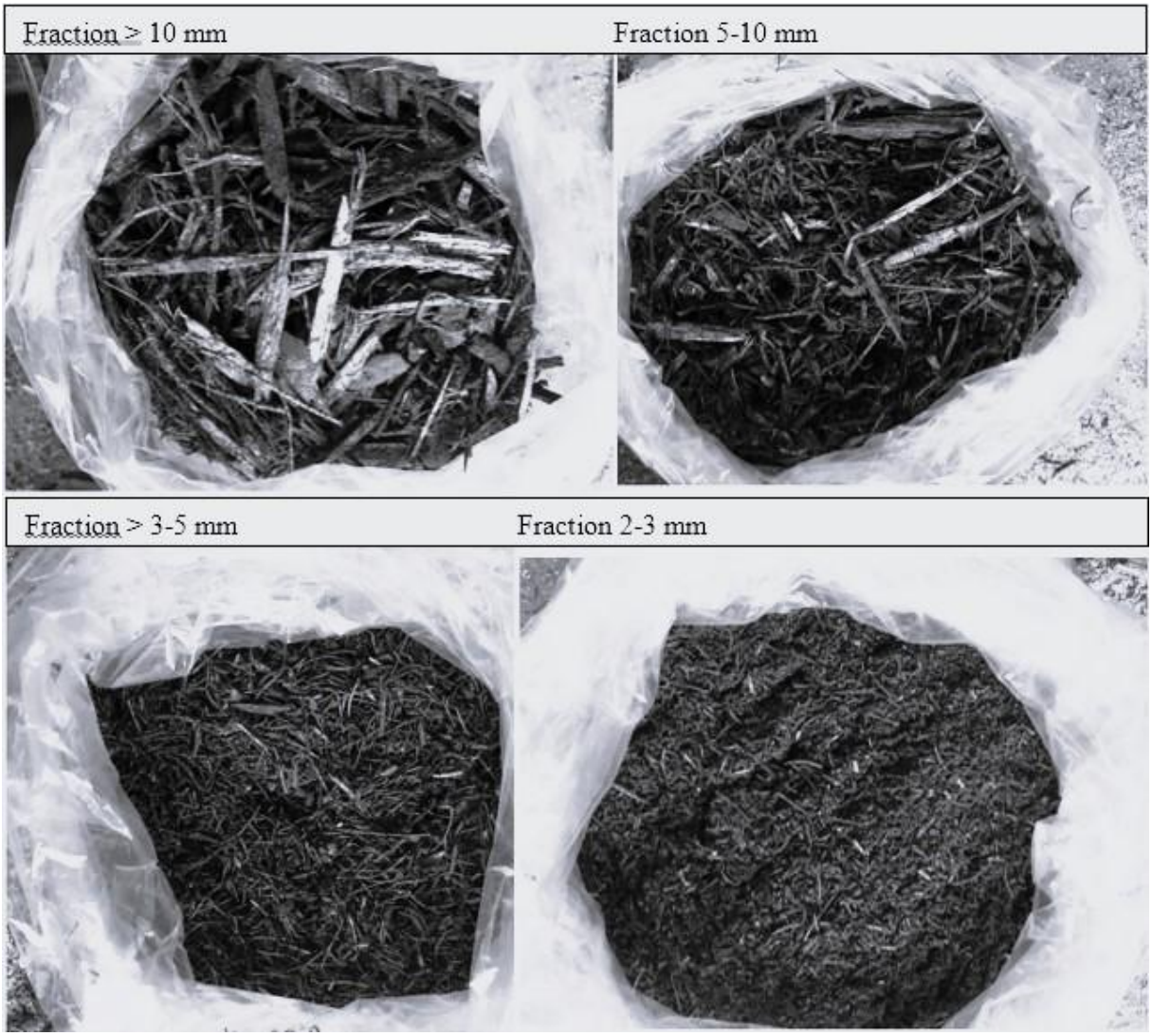

Fig. 1 Used organic fractions for trials

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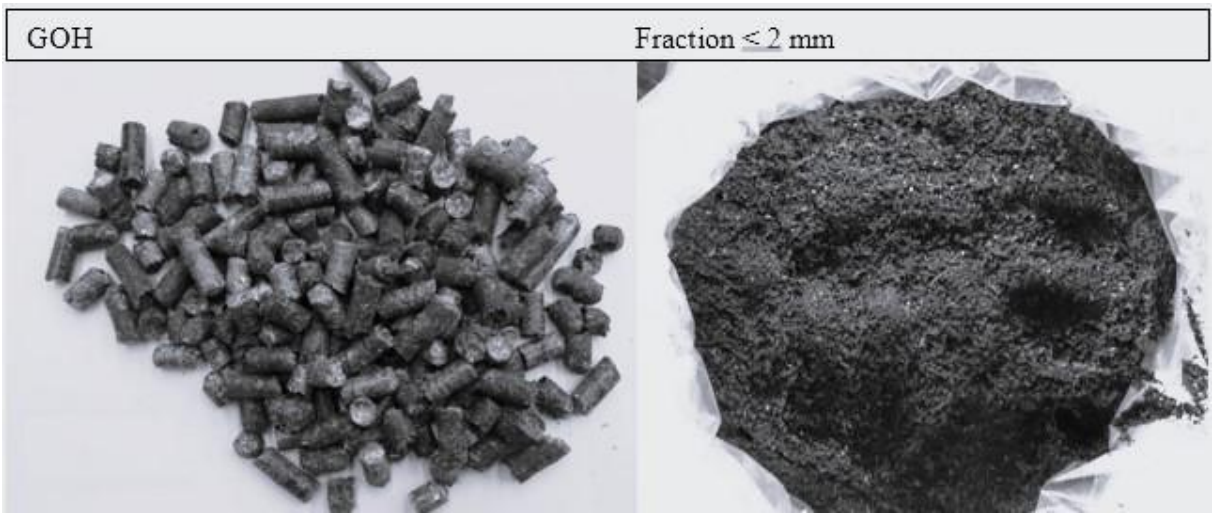

Fig 2. Used GOH and organic fractions for trials

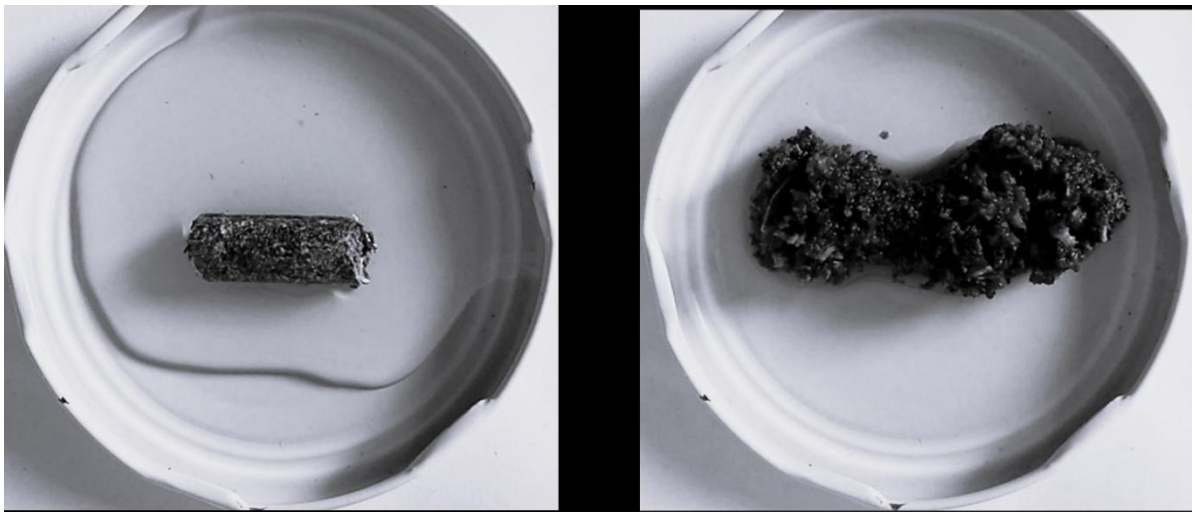

Fig. 3. Initial and saturated GOH fraction of 2.5 cm

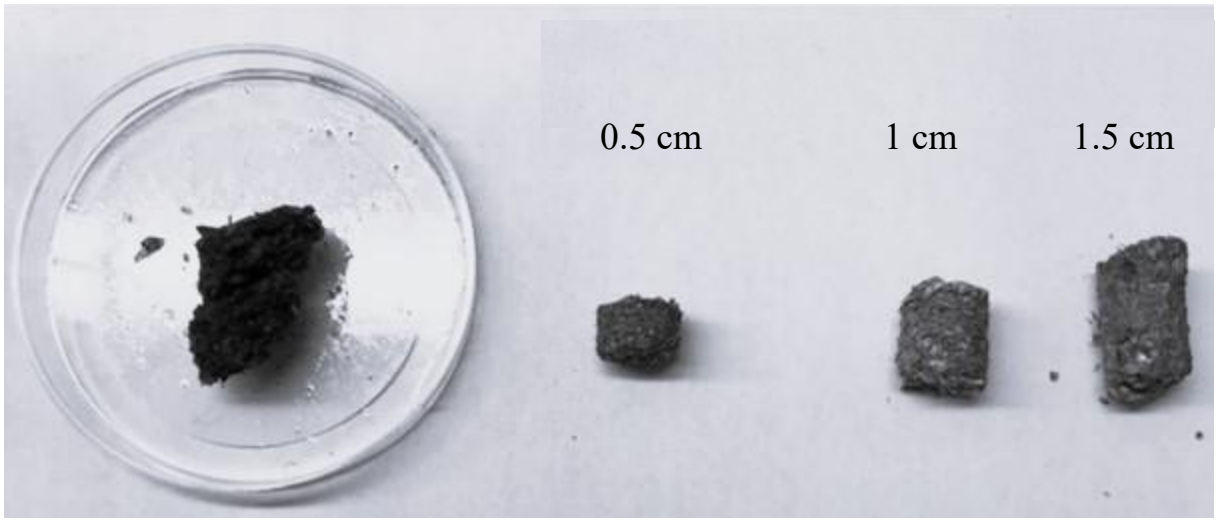

Fig. 4. Saturated GOH fraction of 0.5 cm after saturation of 2.5 ml water and comparison with initial condition

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RESULTS AND DISCUSSION

Enrichment of the soil profile with organic materials leads to better soil quality and physical properties *(Blanco-Canqui, 2017; Mayerová et al., 2023b; Vlčková et al., 2011)*. The addition of organic materials into the soil supports higher water retention (*Kováříček et al., 2010; Kovaříček et al., 2013; Kovaříček et al., 2014; Miháliková et al., 2025)*.

The water retention is influenced by size of the soil fraction and organic carbon content (*Rawls et al., 2003; Feifel et al., 2024*). Organic matter is a source of carbon and can persist for a long time until the transformation into the soil *(Hararuk et al., 2020*; *Jacob et al., 2010*). Although the natural transformation of organic matter is slow, the size of the fraction is crucial for water retention. Fraction of organic matter higher than 3 mm dominates with 70 % in the upper horizons of the sampled profile (Tab.2).

Tab.2 Part (%) of organic matter fraction in the sampled profile

Depth / Fraction	> 10 mm	5-10 mm	3-5 mm	2-3 mm	< 2 mm
0-5cm	38	22	14	16	10
5-10cm	44	18	8	10	20

However, finer fractions (< 3 mm) of organic matter retain more water for a longer period of time (Tab.3). The combination of additive organic materials such as GOH can increase rapid water retention in the soil (*Kováříček et al., 2010; Mayerová et al., 2023a).* The GOH is able to retain water (Fig.3,4). The differences in water retention between fraction < 3 mm and GOH decrease with time. Half the amount of GOH (750 g) retains the same amount of water as fraction < 3 mm after 71 days (Tab.3) and retains more water than fractions > 3-10 mm (3-5 mm, 5-10 mm and > 10 mm) after 8 days without water. Fractions above 5 mm are not able to retain water for a longer time and quickly lose retention after only 4 and 8 days.

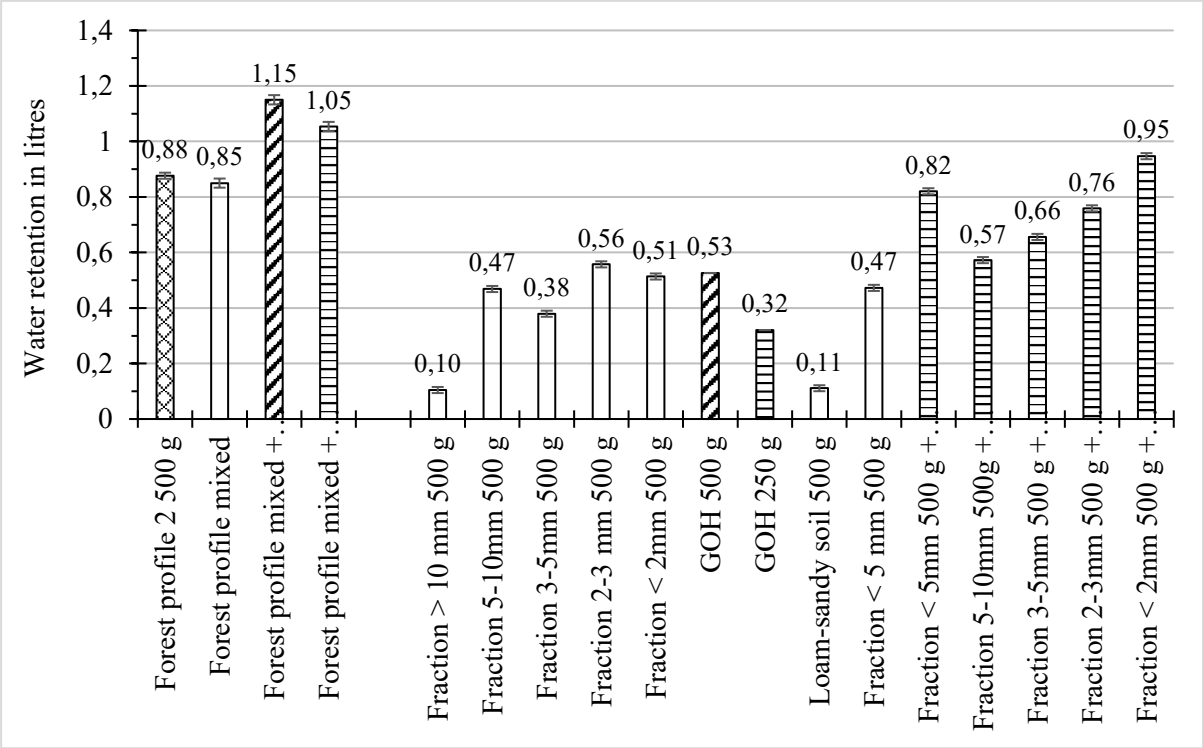
The addition of GOH shows higher retention in the current fraction and soil profiles (Graph 1). Water retention is higher in GOH variants, by 20-40 % after 4 days. In the Graph 2, there is a clear balance between water volume in the mixed and non-mixed forest profile until 8 days, but later the mixed profile starts to lose of water. The mixed profile with GOH has higher retention. The decrease in retention with 250 g GOH is delayed by 14 days later and with 500 g GOH by 41 days. The decrease in retention is slower in GOH variants than in mixed profile without GOH.

Forest floor (L,F,H,Ah) is the main layer of water retention and organic matter. However, it comes to the forest floor reduction connected with disturbance (*Yanai et al., 2003a; Yanai et al., 2003b*) and therefore the application of GOH is more important. The higher water retention and longer water retardation of GOH can contribute to better condition of vegetation (*Mayerová et al., 2025*).

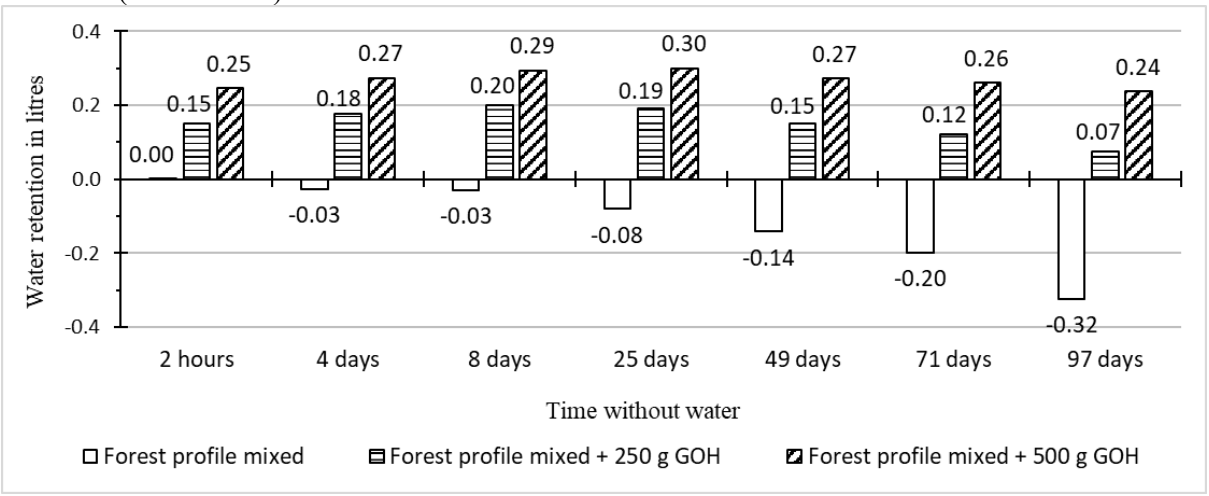
Tab.3 Water retention (in litre) of individual variant in time without water (mean values)

Material/Time without Water	2 hours	4 days	8 days	25 days	49 days	71 days	97 days
Fraction > 10 mm 500 g	0.115	0.110	0.094	-0.002	-0.084	-0.141	-0.194
Fraction 5-10 mm 500 g	0.863	0.468	0.321	0.153	0.082	0.021	-0.055
Fraction 3-5 mm 500 g	0.428	0.379	0.358	0.237	0.149	0.071	-0.024
Fraction 2-3 mm 500 g	0.591	0.557	0.514	0.392	0.286	0.193	0.049
Fraction < 2 mm 500 g	0.541	0.514	0.467	0.364	0.253	0.154	0.001
GOH 500 g	0.546	0.526	0.510	0.444	0.389	0.344	0.287
GOH 250 g	0.339	0.320	0.304	0.236	0.187	0.148	0.103
Control (Loam-sandy soil) 500 g	0.129	0.111	0.093	0.003	-0.050	-0.053	-0.054

Graph 1 Water retention after 4 days without water in the observed variants (mean values +/- standard deviation)



Graph 2 Difference in water retention of forest mixed profiles as compared with unmixed control (mean values)



CONCLUSIONS

Results of the study show a high potential for water retention by granular organic hydrosorbents as a desirable component of the current soil structure. Granular organic hydrosorbents represent modern, easily applicable environmental form of utilising biowaste as a secondary product of agriculture processes and energetics. The use of alternative sustainable organic materials leads to enhance of water retention in soil and seems to be good way how to confront to changing climate and extremes. Increasing the organic matter content in the soil profile using modified organic materials leads to an increase in ecosystem services and condition for vegetation survival.

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