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BIODEGRADABILITY AND ECOTOXICITY ASSESSMENT OF NEW AGRICULTURAL HYDROGELS BASED ON ACRYLIC ACID, CARBOXYMETHYL CELLULOSE AND SODIUM ALGINATE

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Introduction

Water availability is one of the principal challenges faced by the world, especially in semiarid and low precipitation regions, in respect to agriculture. Therefore, many research has been conducted in order to find solutions for this problem, hence super absorbent polymers (hydrogels) were developed. Agricultural hydrogels have the ability to absorb water up to 400 times their own weight, releasing it gradually into soil, reducing this way the leak of fertilizers and herbicides and improving soil quality by reducing the frequency of irrigation. In order to comply with safety and sustainability principles, the use natural biopolymers present more advantages, like availability and biodegradability.

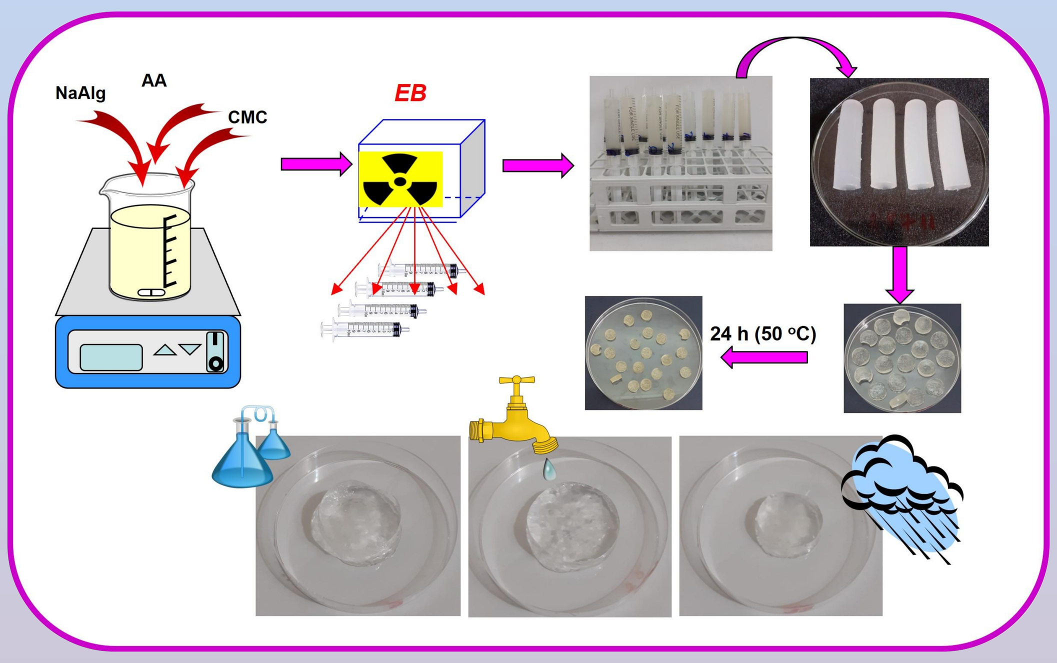
Aims: The aim of this study was to characterize eight formulations of hydrogels in respect to their biodegradability and ecotoxicity.

Materials and Methods

The hydrogels based on acrylic acid, carboxymethyl cellulose and sodium alginate were obtained by National Institute for Laser, Plasma and Radiation Physics applying electron beam technology. The biodegradability was tested using the soil burial method adapted after the standard SR EN ISO 846. The evaluation was performed by gravimetric testing and using FTIR spectroscopy. The spectra analysis was conducted for samples after 45 days of biodegradation and compared to the control sample which repersents the hydrogels before the biodegradation process.

The ecotoxicity was assesed using the seed germination bioassay according to Miteluț & Popa (2020) on seeds of *Lactuca sativa* and *Raphanus sativus.* The GI (Global Index of Germination) is a very sensitive index (Tiquia et al., 1996) indicating nonphytotoxicity of the soil when the values are higher than 80%.

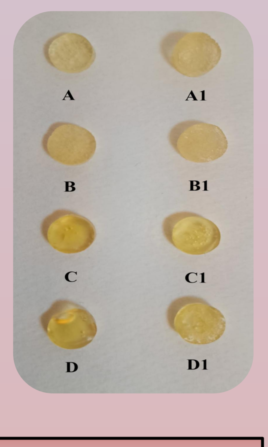
Sample	Sodium alginate (g)	Carboxymethyl cellulose (g)	Acrylic acid (g)	$K_2S_2O_8$ (g)
A	1.5	-	20	0.1
A1	1.5	-	20	-
B	2.0	-	20	0.1
B1	2.0	-	20	-
C	1.5	2	20	0.1
C1	1.5	2	20	-
D	2.0	2	20	0.1
D1	2.0	2	20	-



Hydrogel obtaining process

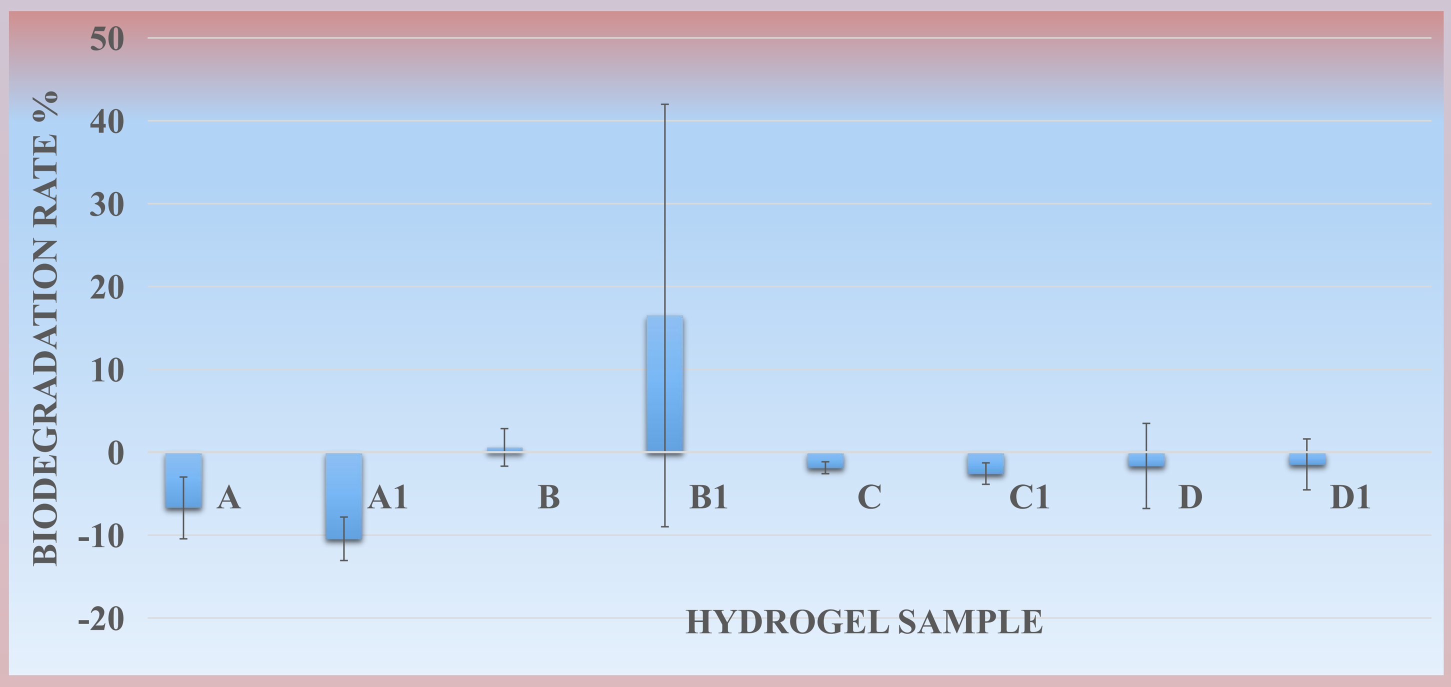
Results and Discussions

BIODEGRADABILITY TEST

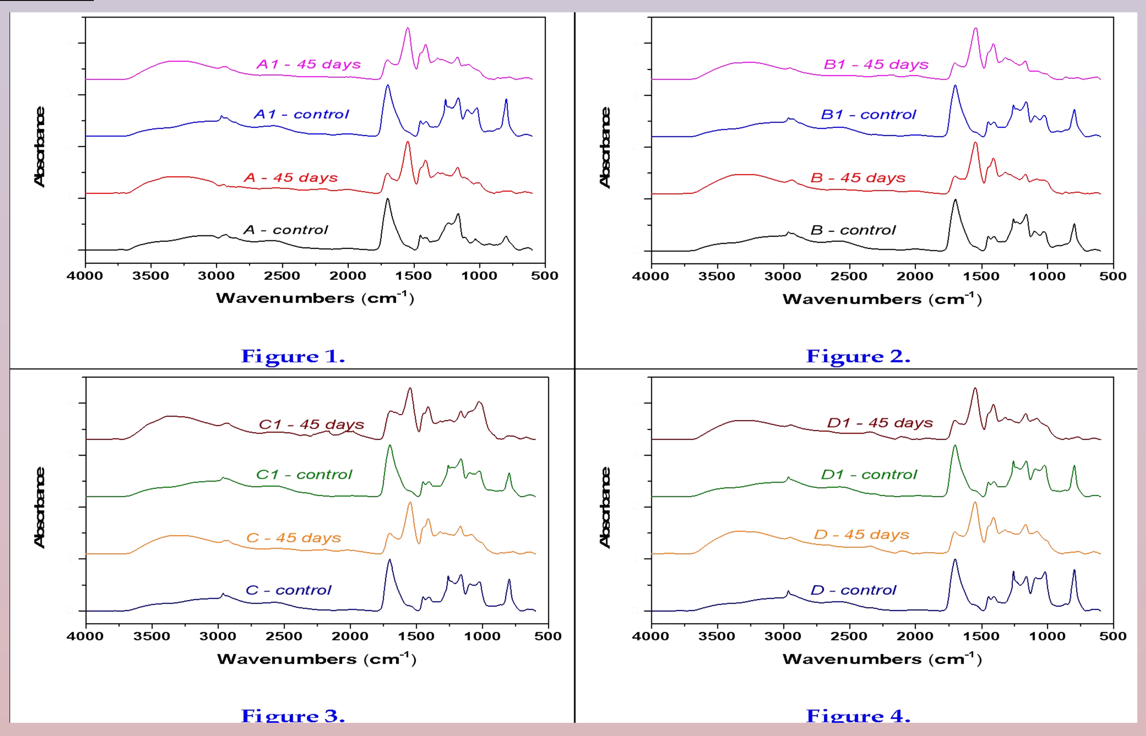


Hydrogel samples

Biodegradation system



The hydrogels biodegradation rate after 45 days

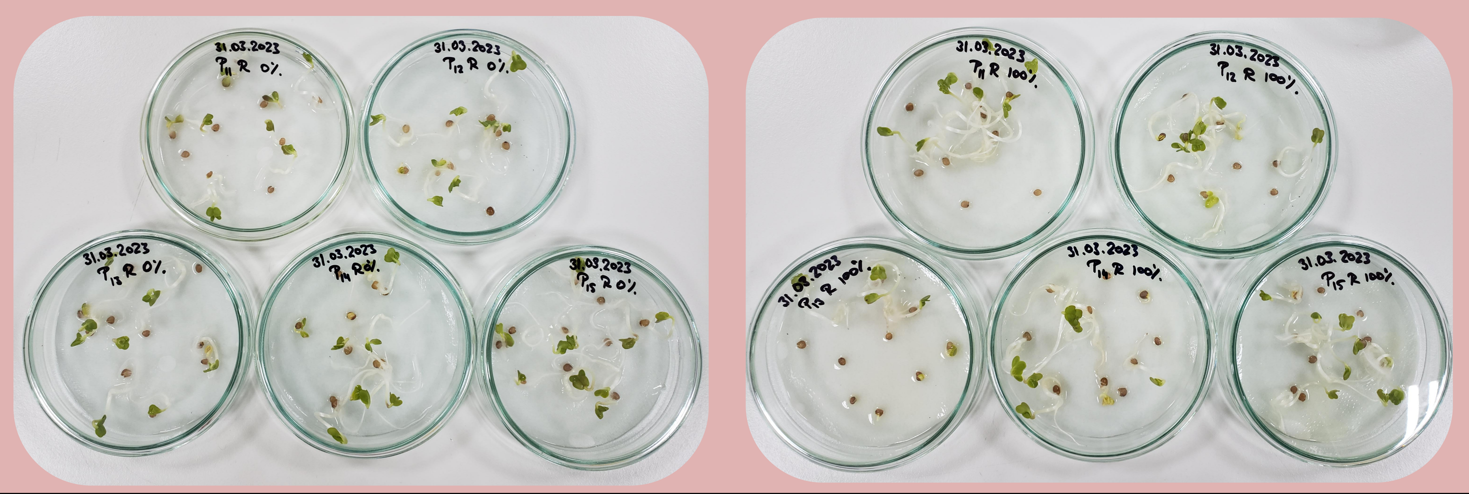


FTIR spectra of hydrogel samples, before (control) and after degradation process.

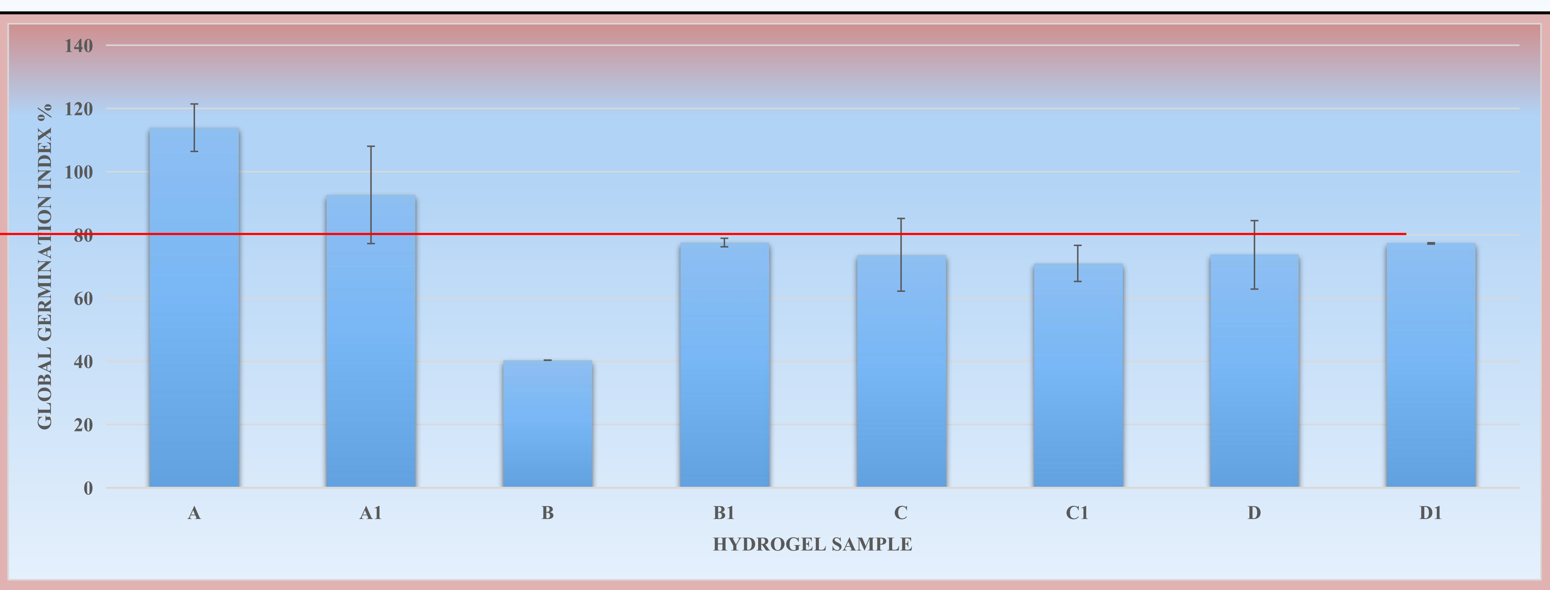
The biodegradability testing showed a greater rate of biodegradation for the sample containing a higher amount of sodium alginate (Sample B1) with 16.5% biodegradation of the polymeric material. The hydrogel containing the same composition and $K_2S_2O_8$ (sample B) achieving a 0.58% biodegradability rate after 45 days in soil.

The bands in the hydrogels FTIR spectra are due to the O–H (at 3259 cm^{-1}), C–H (at 2927 cm^{-1}), C=O (at 1598 cm^{-1}), COO– (at 1408 cm^{-1}), CH_2 (at 1305 cm^{-1}), C–O–C (at 1123 cm^{-1}) and C–O (at 1026 cm^{-1}) groups from sodium alginate, O–H (at 2997/2887/2660 cm^{-1}), C=O (at 1697 cm^{-1}), C=C (at 1635/1615 cm^{-1}), CH_2 (1432 cm^{-1}), C=O and OH from the carboxylic groups (at 1238/1184 cm^{-1}) and CH_2 rocking mode (at 978/816 cm^{-1}) from the acrylic acid and O–H (at 3303 cm^{-1}), C–H (at 2923 cm^{-1}), COO– (at 1586 cm^{-1}), CH_2 (at 1420 cm^{-1}), OH in the carboxylic groups (at 1320 cm^{-1}) and C–O (at 1030 cm^{-1}) from the carboxymethyl cellulose.

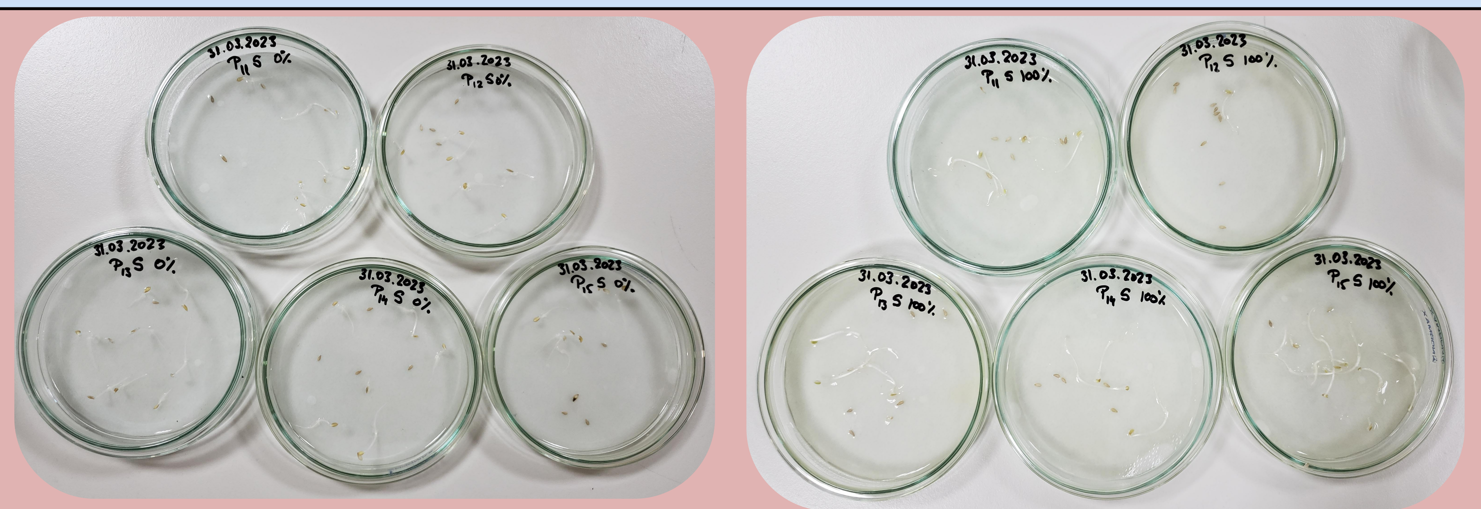
ECOTOXICITY TEST



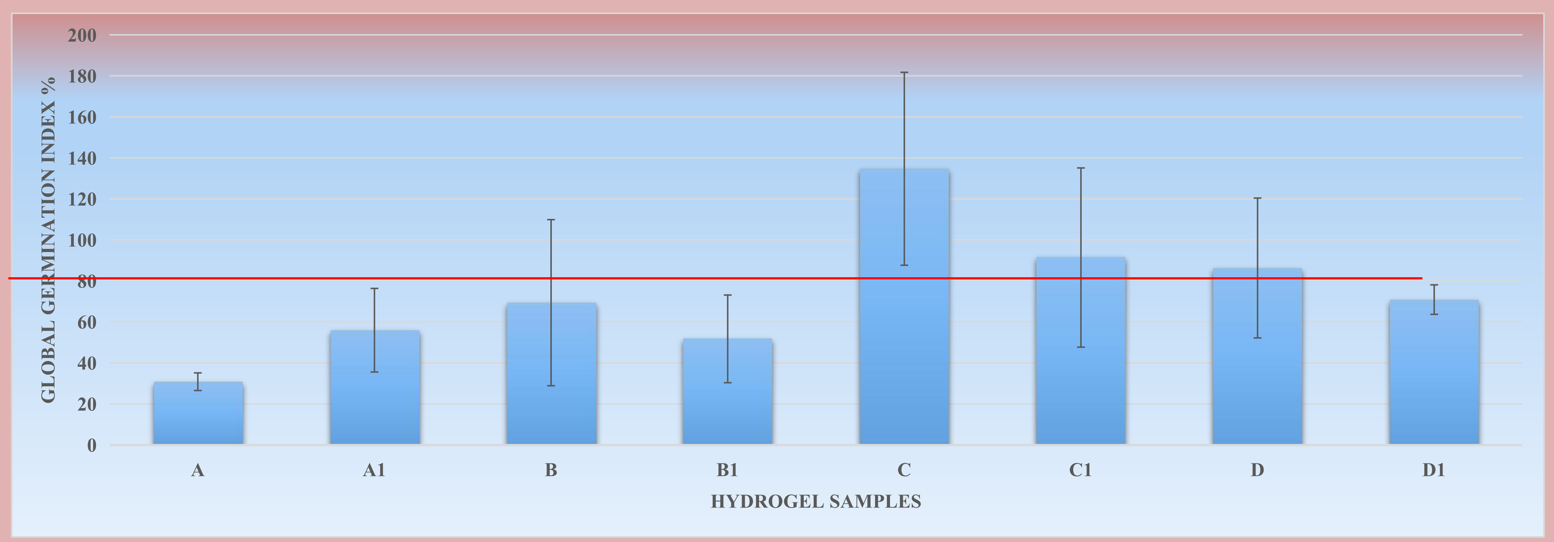
Radish seeds germination in soil extract without (left) and after 45 days biodegradation (right)



The Global Germination Index (GI) in the case of radish seeds



Lettuce seeds germination in soil extract without (left) and after 45 days biodegradation (right)



The Global Germination Index (GI) in the case of lettuce seeds

Regarding the ecotoxicity of the polymers, the germination rate and rootlet length were close or lower for the tested samples, compared to control with few differences. The global index of germination was close or higher than 80% for samples A and A1 for the radish seeds and C, C1 and D for the lettuce seeds.

Conclusion

The results of the study showcased a promising process of biodegradation of the hydrogels for the materials containing a higher amount of sodium alginate after 45 days of biodegradation in soil. However, the results obtained for sample B1 with high stardand deviation should be confirmed with further testing after 200 days period of biodegradation.

Degradation of all hydrogels in controlled conditions during 45 days was further confirmed by the changes observed in the FTIR spectra through the increasing or decreasing of absorbances and the shifting of some bands. Modification of the spectra are due to the initial cleavage of the hydrogels cross-links networks and to the finally cleavage of covalent bonds by difference microorganisms present in the soil.The ecotoxicity assessment showed no significant phytotoxicity of the soil extract after 45 days of biodegradation for the radish seeds (with the exception of sample B) as opposed to the lettuce seeds that presented a greater rate of inhibition of the germination capacity and root growth, the Global Germination Index not exciding 70% for most samples.

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