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RESEARCH ON THE BIODEGRADABILITY AND ECOTOXICITY OF SOME BIOHYDROGELS

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INTRODUCTION

In order to address pressing issues such as persistent drought conditions or limited water availability, researchers have extensively examined hydrogels, which serve as reservoirs for water retention. They have the capacity to store a substantial amount of water and gradually release it in a controlled manner. Biodegradability stands as a main requirement for these polymeric materials, as they can be employed in the field of agriculture and may present a sustainable mechanism. Additionally, hydrogels must exhibit a lack of ecotoxicity, ensuring that no harmful substances are released into the environment following the biodegradation process. The aim of this study was to test 8 different formulations of hydrogels based on acrylic acid, carboxymethyl cellulose and sodium alginate regarding their biodegradability rate and their ecotoxicity potential.

MATERIALS AND METHODS

The soil resulted from the biodegradation process of the hydrogels with different composition (Table 1), provided by The National Institute for Laser, Plasma and Radiation Physics Măgurele, was tested for the ecotoxicity assessment. Hydrogels were obtained by using the electron beam radiation technique (EB) and are composed of sodium alginate (Alg.), carboxymethyl cellulose (CMC), acrylic acid (AAc.) and potassium persulfate ($K_2S_2O_8$) as a catalyst.

Table 1. Hydrogels composition

Sample Code	Materials			
	Alg. (g/100 ml)	CMC	AAc.	$K_2S_2O_8$
A	1.5	-	+	+
A1	1.5	-	+	-
B	2	-	+	+
B1	2	-	+	-
C	1.5	+	+	+
C1	1.5	+	+	-
D	2	+	+	+
D1	2	+	+	-
M	Control sample (soil without hydrogel)			

+ presence of the component (same dosage)
- absence of the component

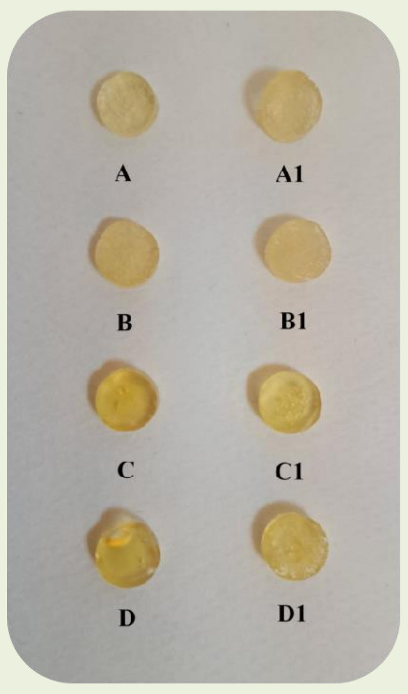

Figure 1. Hydrogel samples obtained through electron beam radiation (EB)

After different periods of time of the biodegradation process of the hydrogels, the soil was tested in order to assess their ecotoxicity on seeds germination and development using the seed germination bioassay method described by Miteluț & Popa (2011) on radish seeds (Fig. 2).

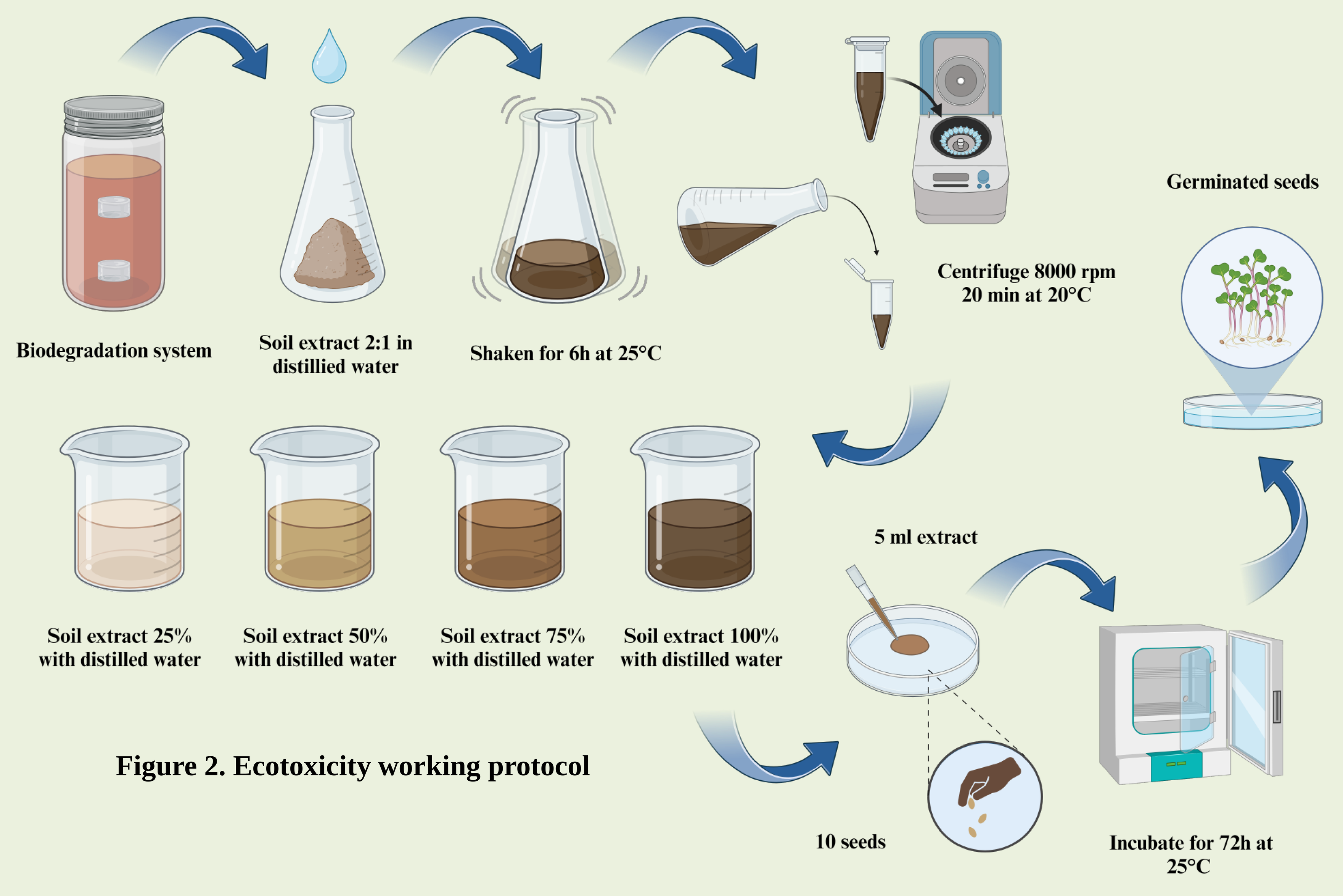

Figure 2. Ecotoxicity working protocol

RESULTS AND DISCUSSIONS

After incubation for 72h in the dark at 25°C, germinated seeds were counted and the root length (cm) was measured (Fig. 3).

The Germination index (Gi) of the samples for each extract concentration (25%, 50%, 75%, 100%) was calculated according to the formula:

$$Gi = \frac{G}{G_0} \times \frac{L}{L_0} \times 100$$

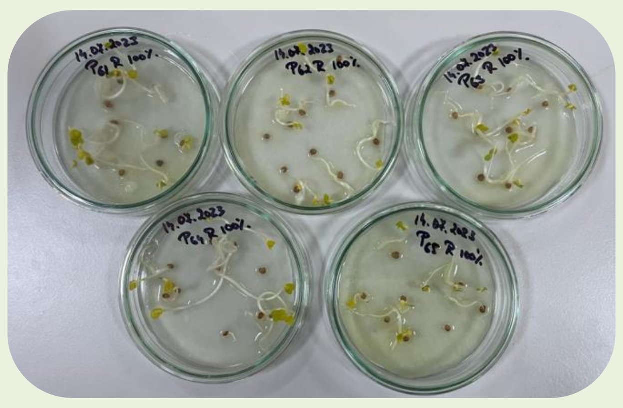
Figure 3. Germinated radish seeds

where G_0 and L_0 represent the germination percentage and rootlet growth of the 100% distilled water control (0% supernatant).

Based on the Gi, The Global Index of Germination (GI) was calculated for each sample, as the average of 50 and 75% dilutions. According to Tiqua (1996), the soil has no phytotoxic effects when the GI values are over 80%.

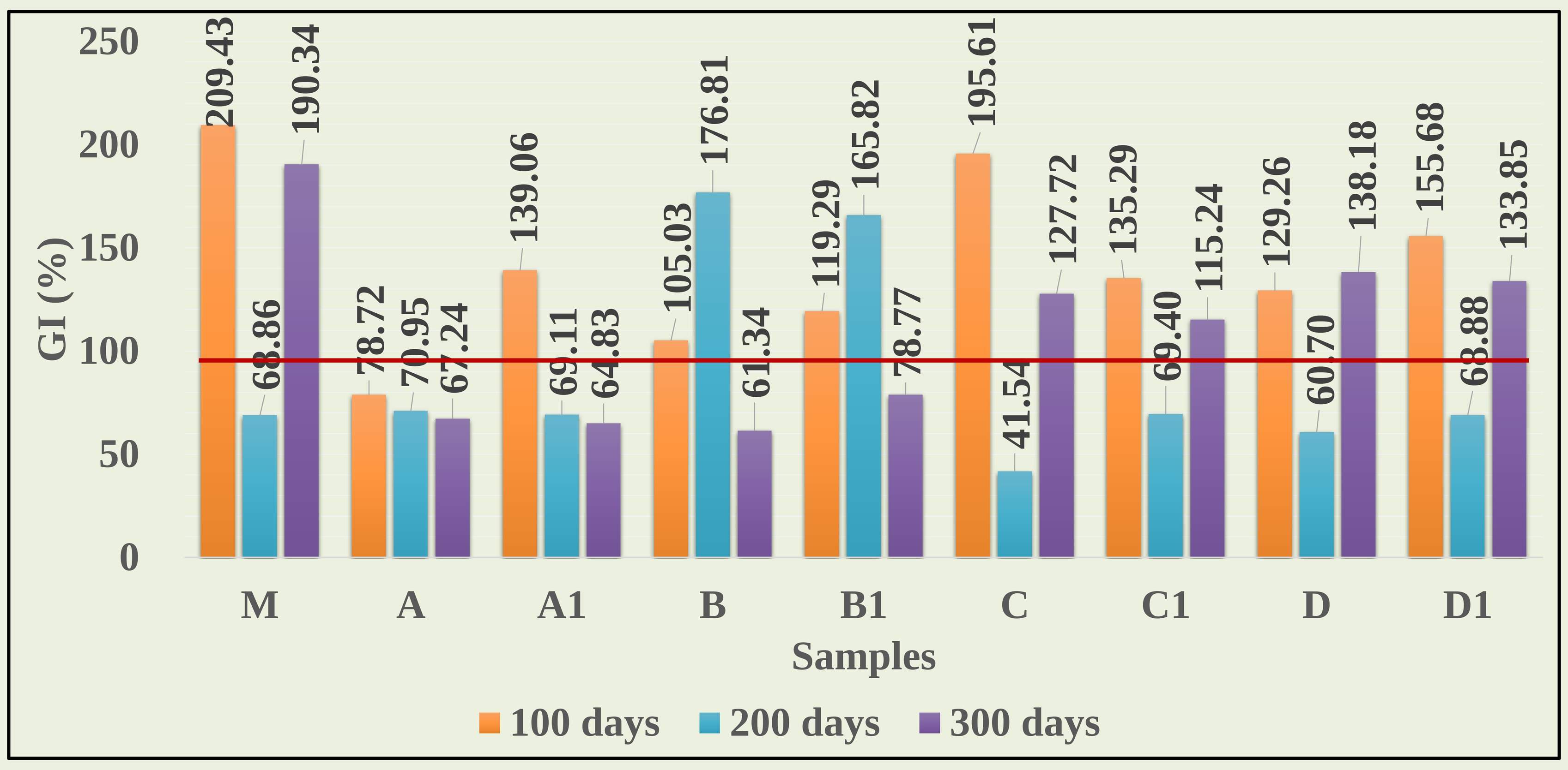

Figure 4. Global Index of Germination GI (%) of the radish seeds

According to the GI values (Fig. 4), the tested soil that resulted after the biodegradation process of the hydrogels after 100 days presented values over 80% for all the samples, most of them recording values over 105% demonstrating a non-toxic effect over the radish seeds.

After 200 days, most of the samples, including the control, had values under 80%. These results could be explained by the possibility of the carbon mineralization decreasing with increasing water salinity during the controlled incubation conditions (Mancer & Bouhoun, 2018), which could impact soil health from the ecotoxicity point of view. Another possible explanation for the results obtained could be the reduced availability of CO_2 in soil resulting in limiting the nitrification process (Azam et al., 2005).

After 300 days of biodegradation, the GI of the samples varied depending of the composition of the hydrogels. The GI presented increased values for the control sample as well as for the samples containing CMC (C, C1, D, D1) as opposed to the hydrogels without CMC (A, A1, B, B1) which are very much below to the control and below the GI limit of toxicity (80%).

CONCLUSIONS

The ecotoxicity effect of the soils resulted after 300 days of biodegradation of eight different formulations of hydrogels were studied using the bioassay germination method.

For the soil resulted after 100 days of hydrogels soil burial, no toxic effect related to the biodegradation of the materials was registered on radish seeds.

The results obtained for the samples collected after 200 days of hydrogels soil burial process, were not conclusive because all the samples tested, including the control (without hydrogels), registered values under the GI limit of ecotoxicity. Further analysis of soil samples are required to better understand this occurrence.

In the case of the samples collected after 300 days of hydrogels soil burial process, the samples resulted from hydrogels containing Alg. and CMC (C, C1, D, D1), demonstrated higher values than the GI limit of ecotoxicity.

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