

Study of the effect of UV Exposure and Soil Type on the Biodegradation of Gelatin-Based Films

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GOAL OF THE STUDY

The aim of this study is to evaluate the degradation behavior of gelatin-based films containing varying concentrations of glycerol when buried in five soil types with distinct physicochemical characteristics: coniferous forest soil, deciduous forest soil, cinnamon soil, resinous (black) soil, and light sandy soil, typical of Southeastern Bulgaria -Fig.1.

METHODOLOGY OF THE INVESTIGATION

Soil samples from the five soil types were distributed in shallow containers with an area of approximately 20 cm². Biopolymer film samples, with a thickness from 250 to 500 µm, were buried at a depth of 1 cm in soil-filled containers and divided into two groups for the period of three months. The first group of soil samples and biopolymer films was placed under ambient conditions (average temperature of 22 - 25°C, relative humidity 42.9%). The second group was irradiated by UV light with wavelengths between 185 and 254 nm, emitted by five 8 W lamps, at room temperature for the same three-month period.

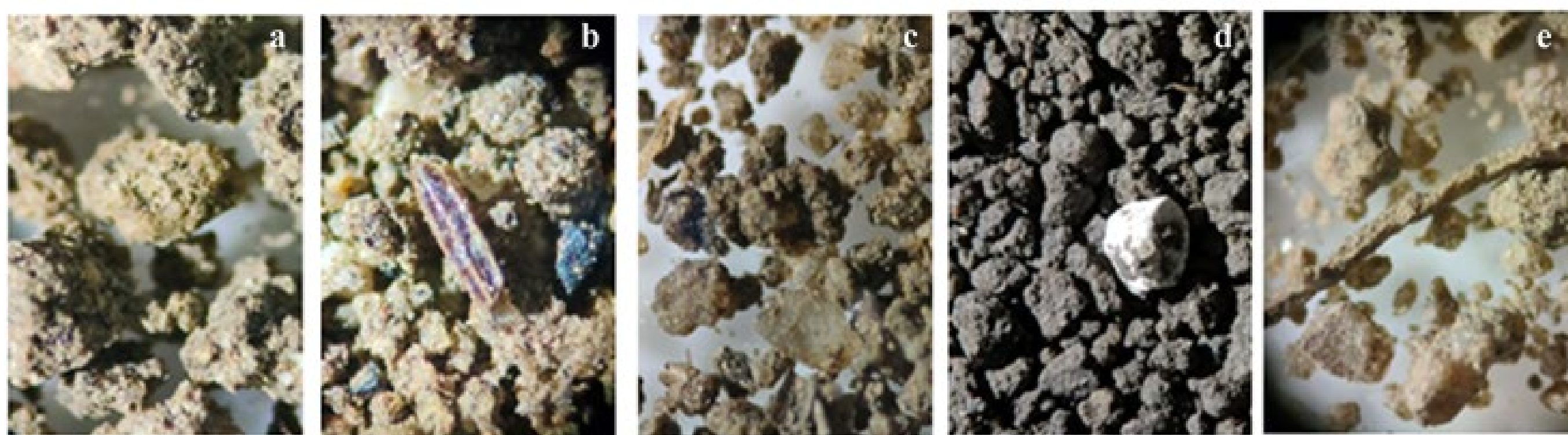


Fig. 1. Optical microscopy for soil's sample's surface morphology at 100× magnification, allowing for detailed visualization of soil's features such as granular structures, fiber arrangements and surface roughness. (a) Soil 1 - coniferous forest soil; (b) Soil 2 - deciduous forest soil; (c) Soil 3 - cinnamon soil; (d) Soil 4 - black soil (smolnik), (e) Soil 5 - light sandy soil.

Gelatin films prepared with varying concentrations of glycerol (ranging from 0% to 75%) exhibit distinct changes in appearance and transparency. As the glycerol content increases, the films become more elastic and flexible (Table 1), but their optical clarity decrease. Films with low glycerol content (12.5%) are transparent but brittle, whereas those with higher plasticizer concentrations (50.0–75.0%) display increased haze and softness, indicative of over-plasticization.

Table 1. Percentage change in tensile properties of gelatin-based biofilms with addition of glycerol plasticizer.

Concentration of glycerol, %	Tensile strength, %	Elongation at break, %	Young's modulus, %
12.5	−67.94	23.86	−71.24
25.0	−71.39	2864.02	−92.61
37.5	−86.25	4619.70	−98.46
50.0	−87.47	10793.90	−99.83
75.0	−90.54	14983.30	−99.95

MAIN RESULTS FROM THE STUDY

It was found that increasing the glycerol content significantly accelerates the degradation of biofilms, regardless of the soil type and exposure conditions. Black soil “smolnik” - soil 4 creates the most intense conditions for degradation both under atmospheric conditions and under UV irradiation, and gelatin films demonstrate excellent biodegradation potential in this soil environment. Soil 5, light sandy soil due to poor moisture retention and low biological activity, slows down the degradation process, almost dry “mummification”, which leads to partial preservation of the film structure even after 12 weeks. UV irradiation increases the degradation rate in all soils, the effect being more pronounced in samples with a high glycerol content and in soils with good moisture and microbiological activity.

CONCLUSIONS

The observed differences highlight the synergistic effects of soil microbial activity and UV induced photodegradation, which vary depending on soil composition, pH, bulk density and plasticizer content in the films. These findings confirm the complex interaction between film composition and environmental conditions in determining the degradation ability of gelatin-based biodegradable materials. This is essential for the development of environmentally friendly alternatives to synthetic plastics in the packaging and related industries.

Exploring the incorporation of natural additives or crosslinking agents could enhance the mechanical stability–biodegradability balance of gelatin-based films. The present results indicate strong potential for their application in biodegradable packaging and controlled-release agricultural films, where soil and UV conditions vary widely. A broader understanding of these degradation dynamics will support the design of next-generation biopolymer systems aligned with circular economy principles.