Biochar is a renewable and generally environmentally friendly product that results from the pyrolysis of agricultural waste and other biomass. This material has both a large number of nutrients and physicochemical properties that may favour the growth of microorganisms. Biochar is characterized by a significant porosity, a large specific surface area, and numerous functional groups, which generates a potential of biochar in biotechnological systems, including bioremediation, bioaugmentation, as well as in agriculture and bioenergetics. Biochar is also considered a structure-forming material regulating the resistance of aggregates to stress and improves the soil's ability to retain and transport water. Moreover, the properties of biochar can be improved by immobilization on its surface beneficial fungi to stimulate soil fertility and plant growth. Fungi may also play a role in soil aggregation and stability by particle binding, secreting polysaccharides, and production of hydrophobic compounds that reduce surface wettability.

The use of biochar enriched with microorganisms is a new approach that is an environmentally friendly alternative to chemical fertilizers. However, the impact of biofertilizer application on soil structure parameters and aggregate stability is not fully understood. Moreover, little is known about the effect of biochar application on microorganisms habitats and mechanisms that regulate fungi growth dynamics and activities.

The main aim of the project is to investigate the effect of microbiologically enriched biochar on the physicochemical and biological properties of soil aggregates. Additional goals and assumptions of the project include: 1) the characterization of biochar obtained from organic sludge of the agro-food industry in the context of differences resulting from conditions of the pyrolysis process; 2) the influence of biochar on the surface, structural and mechanical properties of model aggregates; 3) the role of fungi in the formation of the physicochemical properties of aggregates; 4) the influence of aggregate structure on the growth dynamics, activity and number of fungi; 5) description of aggregate structure from nano to microscale; 6) quantitative and qualitative evaluation of changes in soil organic matter; 7) assessment of aggregates wettability in the context of biochar application and the growth of fungi.

The research is based on model aggregates made from biochar and biochar enriched with microorganisms with soils of a different texture class and physicochemical properties. Organic sludge originated from the agro-food industry represent substrates for the preparation of biochar. Preparation of biochar includes a long time of the pyrolysis process, as well as three temperatures. The various condition of the pyrolysis used to modify the parameters of biochar may increase the adsorption of microorganisms and their viability in the soil. Biochar will be enriched with strains of fungi of the genus Trichoderma to assess the influence of microorganisms on the aggregate structure. Prepared aggregates will be incubated under constant temperature and humidity conditions. Then physicochemical and biological parameters of aggregates will be evaluated.

Knowledge about the synergistic impact of enriched biochar on soil physicochemical properties is a step towards sustainable agriculture, reclamation of degraded areas, as well as protection of the soil surface against erosion and climatic factors. The research assumes that the application of biochar and microorganisms will modify aggregate structure affecting the mechanical and water strength, porosity, density, and surface properties. Principal Investigator also assumes that the aggregation will be related to the activity of fungi due to the secretions and hyphae, which are particle binding factors. Moreover, the research will allow us to find a correlation between the parameters of the examined aggregates and the growth dynamics of microorganisms.