Global environmental problems, including climate change, biodiversity loss and severe pollution of individual ecosystems, lead to changes in many areas of the economy. Increasingly, the emphasis is on sustainable agriculture and circular economy, which allow for a significant reduction in the amount of waste produced and pollutants emitted. Soil, as a limited natural resource as well as a source of healthy food, should be treated in a unique way. Unfortunately, in many world regions it is contaminated with chemicals (heavy metal ions, antibiotics and pesticides) and requires remediation procedures.

The main goal of this Project is to explain the physicochemical phenomena, knowledge of which may be crucial in restoring soil its productive capacity. By carrying out a series of sorption and desorption measurements, the immobilization of metals and metalloids, classified as microelements stimulating the growth and development of organisms (Cu, Se) and highly toxic ions (Cd, As), as well as herbicides (glyphosate, diuron) used to increase the amount of the obtained crop, in the modified soil environment will be investigated. The soil modification will be performed using substances strongly modifying the soil structure, its microbiome or physicochemical properties. There will be:

- exopolysaccharide of soil bacteria *Rhizobium leguminosarum bv. Trifolii* - macromolecular compound being a natural component of the soil environment,
- ionic polyacrylamides - stable soil conditioners,
- biomass - waste from the fruit and vegetable industry,
- biochar, activated carbon - completely biodegradable carbon fertilizers,
- hydrogel based on acrylamide and acrylonitrile,
- fly ash - waste from the energy industry,
- zeolite - obtained from fly ash in the process of hydrothermal conversion.

Sorption and desorption processes of metals/metalloids/herbicides will be performed by static method, using soils of great agricultural importance in Poland, i.e. luvisol, chernozem and alluvial. Their modification will be carried out with the simultaneous use of solid modifier (biomass, carbonaceous material, hydrogel, fly ash or zeolite) and macromolecular compound (exopolysaccharide or polyacrylamide). Additionally, in order to determine the interaction between pollutants and the components of the soil sorption complex, the experiments will be carried out on clay fractions isolated from selected soils. The implementation of this Project will allow to determine: (1) the interactions between the individual components of tested systems, (2) the mechanisms of metals/metalloids/herbicides sorption in the soil, without and with ‘modifiers’, (3) the stability of ions and herbicides binding to the soil and its clay fraction, (4) the dependence of sorbed/desorbed amounts of individual ions and herbicides on the soil structure and properties, (5) the effect of herbicides on metal/metalloid sorption in soil and vice versa. The most important effect of the research will be determination of simultaneous impact of substances characterized by different structure on the mobility of metals/metalloids/herbicides in the soil environment.

Soil modifiers included in this Project should clearly affect the mobility of metals, metalloids and herbicides in the soil environment. Preliminary studies carried out by the Project’s PI showed that the presence of polymeric substances (e.g. polyacrylamide soil flocculants) causes a significant increase in the adsorbed amount of heavy metal ions on the clay mineral surface (kaolinite and montmorillonite). However, it has not been established whether this phenomenon is analogous to selected soil types, and how it is determined by the addition of solids such as hydrogel, biochar, fly ash or zeolite. There are many publications in the literature describing the adsorption process on the solid surface in the systems containing only one dissolved substance (adsorbate). The reports on the adsorption performed in the mixed systems, i.e. containing two dissolved substances of different properties (e.g. metal ion + herbicide or macromolecular compound + herbicide) simultaneously, are still scarce. This additionally prompts us to take up this subject and to investigate so far unexplained complex mechanisms occurring in the soil environment.