The **aim of the project** is to obtain **bioproducts** for agricultural use from macroalgal biomass, which will enable mitigation of adverse changes occurring in the environment. Food production in the modern world is largely dependent on climate change and environmental pollution, including soil, as a result of anthropogenic activities. Therefore, actions should be taken that will allow the production of healthy and high-quality food under unfavourable environmental conditions.

As part of the project, **macroalgal biomass**, both **marine** (collected from the Baltic Sea coast) and **freshwater** (collected from ponds/lakes), will be used as a raw material for the production of bioproducts. This biomass is the result of the **eutrophication of water bodies**, caused by an increase in the concentration of nitrogen and phosphorus ions in water, which come mainly from mineral fertilizers. The use of this biomass for agricultural purposes will allow the return of valuable macronutrients for plants to the soil. On the one hand, this biomass is waste, and on the other hand, it is a source of many active compounds that can support plant growth and improve the physicochemical properties of the soil. Products based on macroalgae will be produced by **thermochemical processes** (without oxygen access) – **torrefaction** (~200–300 °C) and **pyrolysis** (~350–900 °C) and **hydrothermal processes** (180–250 °C under increased pressure). In the first stage of research, the obtained **biochar** and **hydrochar** will be characterized and compared in terms of their chemical composition and properties using numerous techniques (e.g., ICP-OES, XRF, FTIR, TGA, SEM-EDX, BET, etc.). The application potential of the obtained bioproducts will be verified in a **pot experiment on plants**. They will be used as **soil additives**, both in natural soil and in soil contaminated with heavy metals. Biochar and hydrochar, due to their sorption properties, have the ability to bind heavy metal ions in the soil, limiting their availability to cultivated plants, which will allow the cultivation of plants with a low content of heavy metals, which can then be used, for example, for agricultural purposes. In addition, biochar and hydrochar are known for their positive impact on **soil physicochemical properties** (the ability to retain and exchange nutrients in the soil, improve water retention, support the absorption of nutrients by plants and microbiological activity), **plant growth and yields**, and **the environment** (carbon sequestration, reduction of greenhouse gas emissions (CH_4, N_2O), reduction in the leaching of elements from the soil). This effect will be verified in planned experiments on plants, in which biometric and physiological parameters will be measured, and thanks to international cooperation with **Palacky University Olomouc (Faculty of Science, Laboratory of Growth Regulators, Olomouc, Czech Republic)** also biochemical parameters, such as the content of plant phytohormones. These analyses will allow us to explain the mechanism of action of tested bioproducts on plants. The literature data indicate that the use of macroalgae as a raw material for biochar/hydrochar production, comparison of their physicochemical properties, and examination of application potential, especially in agriculture, is insufficiently known.

The project also plans to **increase the functionality of the obtained biochar/hydrochar** by their **activation** and **modification**. For this purpose, the obtained bioproducts will be subjected to chemical activation, using potassium hydroxide, and modification using low-temperature plasma or metal oxide nanoparticles. The macroalgal-based chars obtained in this way will be characterized by a larger specific surface area, greater porosity, and sorption capacity, which may be beneficial in the context of immobilization of pollutants in the soil. Sorption studies in an aqueous system using the pristine biochar/hydrochar and their activated/modified forms will allow for a comparison of their ability to remove heavy metal ions.

One of the main assumptions of the project is to apply the **closed-loop economy** approach, which allows the use of waste as raw materials for the next process. Therefore, the liquid residue after hydrothermal carbonization of waste macroalgal biomass, which is a source of active compounds, will be used as a **biostimulant of plant growth**. These products are particularly effective when plants are exposed to abiotic stress, such as soil contaminated with heavy metals. This fraction, due to its chemical composition, will also be used in the **biosynthesis of metal oxide nanoparticles**, which will be used to modify pristine biochar/hydrochar.

The use of products based on macroalgal biomass in agriculture can have a positive impact on the soil, plant, and environment, which will consequently enable the production of healthy, high-quality food, with limited use of traditional agrochemicals. Based on the conducted experiments, a product will be selected – biochar or hydrochar, natural or activated/modified, from marine or freshwater macroalgae biomass, which has the greatest positive effect on the growth of plants cultivated in natural and heavy metal-contaminated soil, their chemical composition and the population of microorganisms in the rhizosphere. The proposed solution is therefore in line with the assumptions of **sustainable agriculture**, and **chemical engineering tools** such as thermochemical and hydrothermal methods of waste biomass processing enable the achievement of these goals. The results obtained within the submitted project can be applied in any country affected by the eutrophication process and exposed to unfavourable environmental conditions that limit crop production.