The aim of the project is to propose methods of utilization/valorization of seaweeds (macroalgae) collected from the European coastline. Two exemplary water reservoirs will be selected – coast of the Polish Baltic Sea (mainly green macroalgae) and Atlantic Ocean in the region of Brittany, France (red, brown and green macroalgae), due to the cooperation with the University of Southern Brittany (UBS) – Laboratory of Marine Biotechnology and Chemistry. Representatives of all groups of seaweeds – green, brown and red will be examined. This biomass will be used for the production of innovative **algal-based bioproducts for agriculture**, such as: (1) seaweed extracts, (2) metallic nanoparticles biosynthesized with the obtained seaweed extracts and (3) post-extraction residues enriched with microelement ions via biosorption. The seaweed extracts and metallic nanoparticles will serve as natural biostimulants of plant growth. The biomass enriched with microelement ions will be used as a component of fertilizers. The project assumes also the application of "Zero waste principle". Therefore, we propose also the second method of the utilization of waste algal biomass and products made during its processing. The raw seaweed biomass, post-extraction residues, as well as synthesized nanoparticles will be also evaluated as **biosorbents for the removal of toxic metals from wastewater**. The biomass loaded with toxic metal ions can be then incinerated to produce "bio-ore" and energy.

For the production of seaweed extracts, **novel extraction techniques**, such as Enzyme Assisted Extraction (EAE) and Ultrasound Assisted Extraction (UAE) will be used. Metallic nanoparticles will be biosynthesized with the obtained seaweed extracts and microelements that are essential for the proper plant growth, for example Fe, Zn, Cu. **Biosorption** process will be used for two technologies – production of fertilizers components with microelements and removal of toxic metal ions from wastewater. All products for agricultural purposes will be characterised in term of **chemical composition** (e.g., micro- and macroelements, toxic metals, polyphenols, amino acids, polysaccharides, vitamins, plant hormones etc.) and their **properties** (antioxidant, antibacterial, antifungal, antiviral etc.,) using modern analytical techniques, such as for example: ICP-OES, HPLC-UVDAD, HPAEC, HPSEC–RI, FTIR, SEM-EDX etc., also research facilities at USB. In the case of wastewater treatment, mainly ICP method will be used for the evaluation of the **removal of toxic metal ions (**e.g., **Cr(III), Pb(II), Zn(II), Cu(II)) from polluted solutions using algal-based biosorbents**. The biosorption properties will be evaluated in the experiments on biosorption kinetics and equilibrium. Mechanism of biosorption will be explained (e.g., ICP, FTIR, SEM-EDX techniques).

The effect of the extracts, suspension of metallic nanoparticles and enriched post-extraction residues on seed germination, plant growth and development will be evaluated. The utilitarian properties of the seaweed products will be verified in **germination tests** on model plants (e.g., radish, garden cress, cabbage) and the best candidates will then be used for **pot trials** (e.g., cabbage). The best method of application (soil, foliar, seed treatment) in terms of plant growth/yield, as well as recommended doses of applied preparations will be indicated. In the case of biosorption process, the best experimental conditions will be determined – the effect of pH, the initial metal ions concentration in the solution, the content of biosorbent in the solution, etc. The removal of metal ions in single- and multi-metal system (e.g., wastewater) by algal-based sorbents will be examined.

The main reason for taking up this subject is the care for the natural environment. The starting point is the biomass of algae. Their excessive growth/proliferation, which is one of the causes of eutrophication of water reservoirs, is a worldwide phenomenon and a problem to be necessarily solved. Abundant amounts of biomass have been recorded in many coastal regions around Europe. Macroalgae can drift long distances what can lead to their accumulation on the seashore, therefore decreasing the recreational value of beaches. In most cases, this biomass is currently treated as waste. On the other hand, seaweeds are considered as renewable components of the marine environments that are rich in many bioactive compounds such as micro- and macroelements, proteins, amino acids, vitamins, carotenoids, polyphenols, polysaccharides (alginate, fucoidan, laminaran, ulvan), phytohormones, etc. Therefore, algae can be used, for example, as a resource for the fabrication of natural, safe and eco-friendly products which meet the goals of **sustainable agriculture**. Cheaper solution is the utilization of this biomass or residues obtained during its processing as effective biosorbents for the removal of toxic metals from wastewater.

The research hypothesis assumes that the obtained seaweed products will improve plant growth and their chemical composition, and when necessary will be valuable biosorbents to remove toxic metal ions from wastewater. The results of the present project will enable to choose the best seaweed candidate for the production of algae-based products for agriculture, as well as the best technology of algal biomass valorization. The outcome of the submitted project, which proposes sustainable management of valuable seaweed resources, will be universal for all countries that are struggling/dealing with excessive amounts of seaweed biomass.