Phosphorus (P) is an irreplaceable nutrient, building and functional component of all living organisms. However, excess P in the environment can lead to eutrophication, which in aquatic ecosystems results in deoxygenation of water, increased turbidity and hydrogen sulfide concentrations, deterioration of the taste and smell of water and, consequently, the death of aquatic organisms. More than 30% of the P load entering surface waters comes from wastewater. Given the widespread environmental (i.e., preventing eutrophication and restoring water quality) and economic (i.e., overcoming the scarcity of P resources) benefits, it is crucial to separate and recover P from wastewater. In recent years, the efforts of many researchers have focused on recovering P in the form of vivianite, which is a natural mineral formed by the reaction of iron (Fe), P and water. It can be used as a slow-release fertilizer, as well as a reagent for the production of lithium-iron phosphate (essential in the manufacture of lithium-ion batteries and rechargeable batteries). Due to the fact that the predominant form of iron found in wastewater is Fe^{3+}, efficient crystallization of vivianite is possible only after prior reduction of Fe^{3+} to Fe^{2+}. The reduction process can be carried out by biologically using iron-reducing bacteria.

Despite the growing interest in the process of recovering P in the form of vivianite, there is still a knowledge gap on how to optimize the key operational parameters of the crystallization process, as well as the characteristics of the vivianite extracted from wastewater. Therefore, the project will conduct a comprehensive characterization of the vivianite crystallization process, including the characteristics of the vivianite formed from wastewater with high P and/or Fe content. In the proposed project, it is envisaged that both the biological iron reduction process, the vivianite crystallization process and their combinations will be studied in detail using various research scenarios. This approach will enable a comprehensive characterization of the examined processes in terms of factors affecting their efficiency, such as operational parameters or wastewater type and composition.

An important advantage of the project is the comprehensive combination of technological, microbiological research, advanced measurement techniques and mathematical modeling. Technological studies will include evaluation of: i) the efficiency of the iron reduction process, ii) the kinetics of the vivianite crystallization process, iii) the efficiency of P/Fe recovery from wastewater in the vivianite crystallization process. Microbiological studies conducted in parallel will characterize the microbial communities conducting the iron reduction process. Metagenomics, one of the latest molecular biology techniques, will be used for this purpose. In addition, advanced measurement methods will be used on an ongoing basis in each of the test scenarios (different operating parameters, types of wastewater, etc.) to assess the structure, composition and size of vivianite crystals. The fertilizer properties of the obtained vivianite and the bioavailability of the P contained in it to plants will also be determined during the tests. In order to optimize the process in terms of P/Fe recovery efficiency, mathematical modeling and computer simulation will be used.

The novel and interdisciplinary approach to the research on the process of P/Fe recovery in the form of vivianite is guided by the conviction that the project's results will provide an understanding of the vivianite crystallization process and thus increase the potential for P/Fe recovery from wastewater, bringing Wastewater Treatment Plants closer to transformation into Water Resource Recovery Facilities.