The growth of the world's population has led to an increasing demand for food. An increase in yield is mainly achieved by the correct fertilization of arable land. This, in turn, has generated an increased demand for fertilizers, the main components of which are nitrogen, phosphorus, and potassium. The use of mineral fertilizers, based on compounds of these elements, is one of the most important factors in the fight against hunger in the world. Phosphorus, as one of the most important macronutrients, is a key element in achieving high yields. The greatest quantity of phosphorus is produced by phosphate extraction. However, phosphate deposits are limited due to slow recovery and the sparse availability of phosphorus in EU countries. Global production is restricted to a few countries, including China, Vietnam, and the USA. For this reason, the European Commission classified phosphorus as a critical raw material in 2017. Therefore, the recovery of phosphorus from alternative sources is urgently required.

Sewage sludge is a source rich in phosphorus, nitrogen, and other nutrients. The production of sewage sludge in Europe is increasing rapidly. The direct use of sewage sludge as a nitrogen and phosphorus rich fertilizer is very challenging for legal reasons. As a general rule, sewage sludge does not comply with Council Directive 86/278/EEC of 12 June 1986 for organic fertilisers as it contains pathogens and other undesirable substances. Hydrothermal carbonization appears to be a promising method for the conversion of hard-to-dispose sewage sludge. Hydrothermal carbonization occurs in an aqueous medium with increased temperature and autogenous pressure. These conditions lead to the removal of pathogens and other microorganisms. This process produces a liquid phase and a solid phase. A solid hydrothermal carbonization product can be successfully used as an ecological solid fuel. Process water is a very interesting product which has a wide range of applications. In recent years, the transformation of the process fluid by aerobic oxidation, anaerobic fermentation, wet oxidation, and distillation has been considered. Unfortunately, none of these methods have led to the recovery of phosphorus. However, there are other methods. One of which is the recovery of struvite from the process fluid, which allows the recovery of up to 100% of the phosphorus dissolved in the liquid.

The main objective of the research work is to acquire and develop basic knowledge about the recovery of phosphorus and nitrogen from liquids after the hydrothermal carbonization of sewage sludge by struvite precipitation. The effects of the pH value of the sewage sludge on the phosphorus content of the processing liquid and the influence of the pH value of the processing liquid on the recovery of the struvite are also investigated.

The first part of the HTC process in an acidic environment will be implemented with the addition of a sufficient quantity of acid to the feedstock to lower its pH value. The study involves performing several pH-equality tests to investigate the effect on the dissolution of nitrogen and phosphorus in the liquid. Acid conditions favour higher phosphorus extraction, especially with the addition of mineral acid to recover the nutrients. Additionally, solid products will be tested to investigate phosphorus-nitrogen migration and to optimize process conditions.

In the second part, the recovery of struvite from the postprocessing water will be investigated. The chemical formula of struvite is as follows $MgNH_4PO_4 \cdot 6H_2O$ and it contains equal amounts of nitrogen, phosphorus and magnesium. The process consists of balancing the amount of ions by adding a sufficient amount of phosphorus, nitrogen, and magnesium. A series of struvite formation tests with different pH values will be performed in order to determine the influence of the pH value of the process water on struvite recovery. Furthermore, an investigation into how the dosage of reagents affects the struvite yield will be conducted by the application of a further 20% of magnesium ions.

The chemical and physical properties of solid fractions will be determined: carbon, hydrogen, nitrogen, phosphorus, and sulphur contents as well as the calorific value, surface structure of the sample, pore size, and other relevant parameters.

The liquid phase will be thoroughly investigated, e.g.: pH value, conductivity, density, phosphorus, nitrogen, magnesium, and calcium contents, chemical composition, heavy metal content, COD parameter, and organic carbon content.

In addition, the basic life cycle assessment will be evaluated.

The results will provide new fundamental insights into hydrothermal carbonization and nutrient recovery options and contribute to the optimization of the recovery process of phosphorus and nitrogen from sewage sludge.