

Municipal wastewaters, living-farming wastewaters, industrial, agricultural (liquid manure) and other waste solutions are lately regarded as cheap and easily accessible sources of the phosphorus components – one of important elements necessary for humans, animals and plants life. To the most important recovered phosphate salts one can include various calcium (mainly: hydroxyapatite $\text{Ca}_5(\text{PO}_4)_3\text{OH}$, HAP and brushite $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$, DCPD) and magnesium ammonium phosphates (struvite $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$, MAP). Chemical removal of phosphates from waste solutions and their further utilization is generally termed as **phosphorus recycling**. All of phenomena accompanying this problem, apparatus constructions and specified suggestions of practical implementation are the world's novelty. Usually three main arguments are raised: limited geological resources of natural phosphorus compounds, eutrophication of inland waters (concentration of phosphorus in inland waters should not exceed 0.03 mg/dm^3) together with relatively high concentration of phosphates in various types of wastewaters – these arguments motivate the attempts of solving in the world the problems connected with recovery of the useful chemical forms of phosphorus.

Controlled precipitation followed by mass crystallization of sparingly soluble phosphate salts are complex problems. Final effect depends on many factors connected with the environment of these processes, as well as on these processes parameter values. Main reason of difficulties arising during proper design and exploitation of industrial plant of the phosphorus recycling is both chemical composition of the wastewaters (strongly stochastic variable), and frequently observed variation in time of individual component concentrations. Besides main component of the wastewaters – phosphate(V) ions – the impurities are of decisive importance, present in different composition, ratios and concentrations depending on specific conditions of their generation place. Part of these impurities, sometimes in unpredicted way, inhibits or catalyses the course of chemical precipitation reactions, strictly integrated with nucleation and crystal phase growth, considerably affecting the final crystals habit, their possible agglomeration and chemical purity of the product. Also process parameters (e.g. raw materials concentrations, temperature, pH) and reactor–crystallizer work parameters (interior geometry, character and intensity of mixing, circulation, mean residence time of suspension in a crystallizer, distribution of inlet ports of the raw materials, etc.) affect globally the course and final results of phosphates recovery process.

Recovery of phosphate(V) ions should be done in a controlled way, based on full knowledge about nucleation and struvite crystals growth kinetics. Struvite crystals should be properly shaped, homogeneous and of possibly maximal sizes. Product should not contain excessive amount of impurities derived from wastewater, especially heavy and toxic metals, which concentration should not exceed the appropriate limits. Under such conditions one can recommend the recovered phosphate salt as an attractive for agriculture mineral fertilizer NPMg, slowly revolving the nutrient components (*eco-friendly fertilizer*).

Project aim is determination of nucleation and crystal growth kinetics of sparingly soluble salt – magnesium and ammonium phosphate(V) hexahydrate, $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$, struvite ($\text{p}K_{\text{sp}} = 9.0 - 13.36$) in continuous reaction crystallization process. The substrates in the process will be diluted aqueous solutions of phosphate(V) ions containing from 0.2 to 1 mass % PO_4^{3-} (waste solutions, wastewaters of various origin), as well as crystalline magnesium and ammonium compounds or their aqueous solutions. The struvite production process will run in a continuous DT MSMPR (*Draft Tube, Mixed Suspension Mixed Product Removal*) type crystallizer with internal circulation of suspension driven by propeller stirrer. Steering, control and acquisition of measurement data streams will be done with PC computer (Labworldsoft and BioScadaLab software).

Impurities present in a crystallizer feed have decisive influence on all kinetic components of struvite reaction crystallization process. It especially concerns some metal ions, which in alkaline environment of struvite mass crystallization form sparingly soluble hydroxides (e.g. aluminium, copper, iron, zinc). Calcium ions, on the other hand, can form with phosphate(V) ions a dozen or so different, sparingly soluble, crystalline and amorphous salts. In the discussed process system two competing chemical reactions of phosphate(V) ions run: with magnesium and ammonium ions (struvite) and with calcium ions (calcium phosphates). In result solid product may be a mixture of these both salts, together with sparingly soluble hydroxides of metals and other substances present in wastewater. All these factors, together with process parameters and parameters of the continuous crystallizer work, will be considered during accomplished of the Project aim.

Kinetics of nucleation and struvite crystals growth will be determined based on crystal size distribution of the products. For their mathematical description the kinetic models for the ideal MPMR type crystallizer (SIG and SDG MSMPR models) will be applied.