Abstract of PhD disseration

Title: "Modular treatment of industrial wastewater in the integrated systems based on advanced physicochemical and biological processes"

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The treatment of industrial wastewater constitutes, in each case, a major technological and technical challenge as a consequence of the considerable diversity of industries generating a wide range of pollutants. These are caused by the significant variety of pollutant types, the vast scope of concentrations of these contaminants and frequently the content of specific compounds of both organic and inorganic origin. Commonly used conventional treatment methods, such as bio-degradation based on activated sludge, coagulation, biological denitrification or lime precipitation, often do not provide the expected process efficiency. Also, advanced methods such as membrane separation and ion exchange have certain limitations, in particular in relation to maximum concentrations of pollutants in raw wastewater or the necessity of extensive pretreatment to eliminate substances that threaten the integrity of membranes and ion exchange resin. The above indications highlight the importance of research and implementation of modern processes for industrial wastewater treatment, which would be featured by increased efficiency and significant selectivity towards specific pollutants.

As a result of the literature review, and on the basis of personal professional and scientific experience, the following were adopted for the study as pollutants and dedicated removal methods:

- Substances of organic and inorganic origin susceptible to oxidation - advanced oxidation process, modification of the Fenton reaction using an alternative source of hydrogen peroxide
- Nitrate nitrogen - process for the chemical reduction of nitrate(V) ions to gaseous nitrogen using metallic iron and urea
- Sulphate ions(VI) - a process for the chemical precipitation of sulphate ions in the form of ettringite using calcium aluminium cement

All indicated methods, after proper process optimisation, were significantly effective in removing pollutants both in the preliminary testing phase using model (synthetic) wastewater with known pollutant concentrations and in the final testing phase using real wastewater from the metallurgical industry.

The preliminary tests completed on the process efficiency of the removal of a particular type of pollutant and other accompanying parameters were the basis for determining the technological interrelationships between the methods used and selecting the most favourable configuration of the following processes in an integrated industrial wastewater treatment system.

The most advantageous configuration of the integrated system was considered to be:

- Module I. – Fenton reaction modification
- Module II. – chemical reduction of nitrate(V) ions
- Module III. – chemical precipitation of sulphate ions(VI)

During the process tests conducted in the integrated treatment system, great efficiency was obtained:

- For the modification of the Fenton reaction – the pollutant removal rate (expressed as COD) was above 80% (maximum 91.5%) for the model wastewater and between 75% and 82.5% for the actual wastewater.
- For the process of chemical reduction of nitrate(V) ions – the degree of removal of pollutants was above 80% (maximum 90%) for the model wastewater and between 76% and 82.1% for the actual wastewater,
- For the process of chemical precipitation of sulphate(VI) ions – the degree of removal of pollutants was above 80% (maximum 98%) for the model wastewater and from 91.7% to 95.2% for the actual wastewater.

The conducted research and the obtained results confirmed the suitability and feasibility of implementing the developed solution on a technical scale for industrial wastewater treatment. The achieved results were also the basis for the development of preliminary technological guidelines intended to provide a baseline for the design of the integrated treatment system.