Nickel removal from chromium-nickel steel processing wastewater

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ABSTRACT

Nickel ions are not biodegradable in the environment, and due to their toxicity, exposure to high concentrations of nickel can have negative effects on the entire ecosystem. Intensified industrial development has contributed to an increase in wastewater containing harmful substances, including heavy metals. For these reasons, this wastewater must be properly treated before being discharged into the environment. Surface treatment of stainless steel, in the pickling and electropolishing processes, generates post-production wastewater containing high concentrations of nickel, chromium, iron and copper, which far exceed quality standards. Due to the technological process used, the wastewater produced is characterized by a very low pH (pH about 1-2), which requires the use of a neutralization process to properly treat the wastewater before it is discharged into the sewer system.

The dissertation consist of a series of four thematically consistent scientific articles published in peer-reviewed international journals. The main objective of the dissertation was to determine the effectiveness of natural materials in removing nickel ions from wastewater from chromium-nickel steel processing. Based on a literature review of the use of natural materials in the removal of nickel ions, the materials with the highest efficiency in removing nickel ions from aqueous solutions and wastewater were identified. A classification of materials used by researchers was proposed in order to recognize research trends developed in recent years in the topic of biosorbents, and on this basis, potentially interesting directions for future research were diagnosed. In further scientific work, the possibility of using natural materials to treat process wastewater from the electropolishing of stainless steels was evaluated. Among the materials used were peat from five health resorts in Poland (Połczyn Zdrój, Goczałkowice Zdrój, Wieniec Zdrój, Kamień Pomorski and Kołobrzeg), plant material *Eclipta alba* and eggshells dried and calcined. The study evaluated the efficiency of removal of metal ions (nickel, iron, chromium and copper) from process wastewater generated during electropolishing of chromium-nickel steels using the mentioned materials. The effect of co-existing iron, chromium and copper ions on the efficiency of removing nickel ions from process wastewater was also examined. The effect of process wastewater from the electropolishing of stainless steel on the acute

immobilization of *Daphnia magna* organisms was then determined. Peat from five different health resorts located in Poland was used in the process of sorption of metal ions from the above-mentioned process wastewater. The effect of the process of sorption of pollutants, as well as traditional precipitation with $Ca(OH)_2$, on the efficiency of wastewater treatment and immobilization of aquatic organisms *Daphnia magna* was determined.

Based on the conducted research and a review of the scientific literature, it can be concluded that the use of biosorption techniques for the removal of nickel ions and other heavy metals is a topic of increasing interest among researchers. The results obtained allow us to confirm the accuracy of the established hypotheses, which show that the use of natural materials in the wastewater treatment process makes it possible to reduce the concentrations of nickel ions in wastewater from the treatment of chromium-nickel steels. All of the tested materials made it possible to reduce the concentrations of nickel ions and other metals (iron, chromium, copper) in process wastewater characterized by a low pH of 1-2. It was also confirmed that co-occurring in the wastewater with nickel ions, other ions (iron, chromium, copper), affect the efficiency of their removal from process wastewater. For the type of wastewater studied, it was shown that iron and chromium ions are removed first, followed by nickel and copper ions. This was confirmed both in the case of studies using peat and *Eclipta alba* plant material. Immobilization studies have determined that a reduction in the negative impact of wastewater from the steel electropolishing process on the aquatic organism *Daphnia magna* can be achieved by using peat in the treatment process. The use of peat both as a stand-alone or as an additional step in wastewater treatment makes it possible to reduce the concentrations of metal ions in wastewater, thereby reducing its toxicity.

Keywords: nickel, biosorption, industrial wastewater, electropolishing, heavy metal ions, *Daphnia magna*