Mgr inż. Robert Kowalik
Politechnika Świętokrzyska

Abstract of doctoral dissertation

Speciation model in risk analysis of heavy metal translocation in sewage sludge

In the dissertation, the issue of the risk of heavy metal translocation in sewage sludge to the soil and water environment has been addressed. Sewage sludge is an inevitable byproduct of wastewater treatment processes. On the one hand, it is a valuable resource that can be used for agricultural or environmental purposes. However, for sewage sludge to be introduced into the soil, it must not cause contamination. The requirements for sewage sludge are related to the content of heavy metals and parasite eggs. During wastewater treatment processes, heavy metals are released from them and then accumulate in sewage sludge. Differences in treatment technologies can affect the total content of heavy metals in sewage sludge. However, information about the total content of metals is not sufficient to draw conclusions about the real risks associated with their use. The toxicity of heavy metals depends on their speciation form. They can exist in four different forms of mobility, depending on their tendency to migrate into the geochemical substrate. All legal regulations regarding the use of sludge worldwide focus only on the total amount of heavy metals present in the sludge.

In the first stage of reaserch demonstrates that the total content of heavy metals is not an objective criterion when assessing the risk. Many research teams have conducted risk analyses of using sewage sludge for environmental purposes using various indicators. A comprehensive review of available indicators of heavy metal pollution was conducted, but despite the fact that most of them included the concept of heavy metal mobility, none of them provided accurate information about their migration tendencies.

In this dissertation, a new environmental risk indicator for heavy metal contamination called ERD was developed. This indicator is based on the content of metals in fractions FI to FIII and introduces weight factors for each of these fractions. This way, the third fraction is not completely omitted, but it is not treated equally to fractions FI and FII.

The mobility of heavy metals in sludge was studied using the BCR method. The entire process is time-consuming and costly. In order to reduce the number of mobility tests performed, a Bayesian model was developed to predict the content of heavy metals in individual fractions, and consequently, the ERD indicator value. The model was created using GENIe 3.0 software, utilizing research results. The variables correlating with heavy metal mobility included the size of the wastewater treatment plant, the season of sample collection, wastewater treatment technology, pH of the sludge, and its stabilization method. Implementation of the developed Bayesian model, after entering the relevant data for a potential wastewater treatment plant, allows for determining the probability value of the ERD indicator and, consequently, the possibility of its natural utilization.

Sewage sludge from MBR wastewater treatment plants has elevated concentrations of heavy metals compared to other treatment technologies. However, most of these metals are primarily concentrated in stable sludge fractions. Seasonality studies have shown an increased total content of heavy metals in sewage sludge samples collected in the autumn. The research demonstrates that the mobility of heavy metals is closely related to the size of wastewater treatment plants.

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