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"Influence of sewage sludge on shaping selected properties of degraded soils"

Abstract

The increase of waste generation is caused by the high level of consumption and industrialization of society. Municipal and industrial wastes produced in various areas of human activity do not participate in the natural process of matter circulation occurring in nature, while some of them pose a serious threat to the natural environment. Industrial development and increasing urbanization imply a constant need to look for new waste management strategies and systems.

A special type of waste is municipal sewage sludge, which is a product of human living processes and economic activities. A significant reduction in the possibility of landfilling sewage sludge as of January 1-st, 2016, forces municipal enterprises to seek other paths for sludge management.

In terms of the "Zero Waste" policy, the aim should be to reduce the amount of sewage sludge generated and optimally use it for composting, thermal utilization and energy recovery, as well as valuable raw materials for agriculture such as the biogenic elements nitrogen, potassium and phosphorus or organic matter. This dissertation focuses on the possibility of managing sewage sludge by improving the physical and water properties of soils degraded by both high heavy metal content and soilless places.

Due to the specific nature of natural science research work, in this dissertation the author used empirical data obtained from his own research, obtained from established experimental plots and pot experiments. Soil samples for the pot experiments, with extremely different soil fractions, were taken in situ in the village of Płoki (Trzebinia municipality). These samples were taken from sites where high levels of heavy metals had previously been diagnosed, in order to analyse the effect of the sewage sludge dose on changes in their concentration. Soil with the humus layer removed as degraded soil was used for the plot tests. The plots were established in Klecza Dolna (commune of Wadowice), in an area of fallow agricultural land.

The same dewatered sewage sludge was used in the plot and pot tests. The lime-hydrated sewage sludge was taken from sludge plots located at the Trepcza wastewater treatment plant near Sanok. It was then mixed evenly with the sampled soil material at three

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doses of 50, 100 and 200 Mg-ha^{-1}, respectively, to verify the effect of the fertiliser dose on soil parameters. After three months, sampling and laboratory analyses were undertaken.

A novel approach in the impact assessment is the inclusion of prediction of individual properties, through the use of neural networks. The input (explanatory) data were the contents of the individual dust sand and clay fractions and the composite three sediment doses, while the output data were the individual parameters.

As shown by the network models generated in this dissertation, their fits to the experimental data remained at a high level. Only for total porosity and total nitrogen were significant underestimations recorded, and for total carbon a significant overestimation.

An important contribution to the study is also the compilation of water parameters for all types of soil analysed, illustrated by soil water characteristic curves. This curve is a holistic representation of the water properties, represented in terms of the relationship between moisture content and soil suction. It allows the determination of limiting values, corresponding to the different forms of water and the level of its availability to plants. Among the most important are maximum hygroscopicity and permanent wilting point, water retention reserves, differential porosity and their change after sludge application.

The results, according to the author, showed new light on the possibility of predicting the impact on soil parameter change with sewage sludge with the support of advanced statistical tools such as artificial neural networks. They also indicate a very important aspect of the possibility of changing water parameters, including soil water retention, through the application of municipal sewage sludge. This makes it possible to conclude that the application of sludge not only allows the soil to be supplied with elements and nutrients, but also significantly improves soil retention, introducing more favourable conditions for the cultivation and existence of crops. In conclusion, this study can be used for further rational management of sludge, assuming its use mainly for the reclamation of degraded areas, improving their physico-chemical and water properties.

Keywords: sewage sludge, degraded soil, field studies, heavy metals, soil physical parameters, water characteristic curve, neural networks, retention,

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