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Summary of the doctoral dissertation

mgr inż. Agnieszka Rajmund

Doctoral thesis supervisor: prof. dr hab. inż. Franciszek Czyżyk
Assistant promoter: dr inż. Aleksandra Steinhoff-Wrześniewska

Effect of light soil fertilization with sewage sludge and compost on the infiltration of pollutants into groundwater

The aim of the study was to show the influence of sludge and compost fertilization on the penetration of constituents (pollutants) into groundwater and on soil fertility. The research was to indicate more beneficial form of applied sludge (directly after stabilization or composted) from the point of view of agricultural use and environmental protection. In the years 2008-2013, a 6-year series of comparative tests in lysimeters was carried out. In the experiment, stabilized sewage sludge from rural municipal sewage treatment plant and compost made from this sediment were used annually for light soil fertilization in lysimeters. The same doses of nitrogen were applied correspondingly to the fertilization level of 200 kg $N \cdot ha^{-1}$, supplied in the sludge and compost. Three variants were used: zero – without fertilization, fertilization with sludge and compost, in triplicate, for two species of perennial plants: Giant miscanthus *(Miscanthus×giganteus)* and Virginia mallow (*Sida hermaphrodita* (L.) Rusby).

Throughout the test cycle, atmospheric precipitation and the volume of lysimeters leachates were systematically measured. The collected samples of rainfall, lysimeter leachates, sludges, composts and soil were subjected to basic physico-chemical analyzes. The analysis of the chemical composition of sludges and composts used in the experiment, throughout the entire test cycle, did not reveal any exceedances of heavy metal concentrations permitted by Polish law. Lysimeter studies show that the volume of leachates was mainly influenced by: the size and type of precipitation, the form of fertilizer (sludge, compost), evapotranspiration of plants during the growing season and the species of cultivated plants. The largest amount of leachate, during the research period, was noted for the variant without fertilization, while the lowest in variants fertilized with compost. Larger amounts of leachate were recorded in lysimeter planted with gigantic miscanthus. Concentrations of the physico-chemical indicators analyzed in the lysimeter effluents in the study were compared with the Regulation of the Ministry of the Environment of 21 December 2015 on the criteria and method of assessing the status of groundwater bodies. The leachate studies carried out during the years 2008-2013 show that: the applied sludge and compost did not significantly affect the increase of indicators: pH, NH_4^+, K^+, Mg^{2+}, Na^+ and Cl^-, which allowed to qualify the

obtained leachates in the 1st water quality class, independently on the fertilization variant and plant species. In fertilizer variants, NO_3^- and Ca^{2+} concentrations increased, which deteriorated the quality of effluent water, which was qualified respectively for the 3rd and 2nd quality class, regardless of the plant species.

The water quality of lysimeter leachates deteriorated in relation to the electrolytic conductivity (E), which is an indicator of the concentration of the total amount of dissolved components (impurities). The use of sewage sludge and the compost made of it, reduced the quality of water from 1st to the 2nd grade of quality. The type of fertilization and plant species used in the experiment did not affect changes in sulphate concentrations in the effluents. The studied effluents in the 2008-2013 multi-year period were in 2nd water quality class. The analysis of results in single years shows, that destruction of plants by frost during the cold and snowless winter, influenced the increase in concentrations of pollutants in lysimeter leachates in 2012. The amount of leached pollutants was determined on the basis of the measured lysimeter leachate volumes and the concentrations contained in single components. In 2008-2013, loads of biogenic pollutants (NPK) added to the lysimeter with precipitation, sludge and compost, and discharged with leachate were calculated. Quantities of N_{tot} and general phosphorus in the varieties of fertilization with sludge and compost were similar. The amount of brought K^+ in the sludge was 2.5 times lower than in the compost. The components discharged in the lysimeter effluents of the zero variant were the smallest for both plant species. The NPK quantities in this variant came only from precipitation and were much smaller than the fertilizer variants. However the percentage of discharged components in this variant was usually the largest, as plants had an impact on the drained NPK. In case of variants with fertilization with sludge and compost, the load was slightly larger in lysimeters planted with miscanthus giganteus than virginia mallow. The NPK leaching from the soil was influenced by the form of the supplied fertilizer (sludge, compost) to a lesser degree, than the dose of ingredients and the level of their uptake by plants. The amounts of leached NPK from the soil, in both variants, were similar.

Soil analysis showed the impact of fertilizer form (sludge, compost) on increasing the content of C_{org}, K^+, Ca^{2+}, Mg^{2+} in soil. Larger amounts of these components were usually found in soil fertilized with compost. In the soil in the zero variant there was a loss of these components. The form of fertilizer did not significantly affect the increase of N and P in the soil. It indicates that the components brought into the soil were mostly taken up by plants. The form of fertilizer (sludge, compost) affected yield of plants, which in both species was larger in variants of fertilization with sewage sludge, while yields of Miscanthus giganteus were much larger than mallow's yields.