Abstract

Solving the issue of neutralizing sewage sludge is one of the most serious problems of the national waste management. The Regulation of the Minister of Economy, effective from January 1, 2016 (Journal of Laws of 2015, item 1277), prohibiting the waste storage, had an impact on new solutions research, aimed at their management. Innovative processing technologies make it possible to use sludge as a product used in various industries. Converting sewage sludge into a fertilizer or soil conditioner causes that it is traded like any industrially produced fertilizer, and most importantly, it loses its status as a waste. Such treatment of waste is particularly important in the light of the communications of the European Commission on the European Union's roadmap towards a circular economy. One of the planned objectives is to completely avoid the problem of waste by transforming it into high-quality secondary raw materials that will be re-circulated.

The aim of the research was to develop a method of managing sewage sludge and by-products of coal and biomass combustion to create a product intended for use for natural purposes - reclamation of anthropological soils, closing waste landfills or as a building material. The physicochemical properties of the analyzed products will meet the requirements set out in standards and regulations, and the method of their preparation will allow waste management without the need to use complex and costly technologies.

Sludge-ash mixes were prepared by mixing the sludge with mineral components in a weight ratio of 1: 1 based on the dry mass of the sludge. Due to the high hydration of industrial laundry sludge, it was combined with selected mineral waste in a 1: 2 volume ratio. In order to select the most valuable components and the mixtures prepared on their basis, they were assessed in terms of fertilizing properties - by conducting physicochemical tests and a phytotoxicity test. The paper also presents research on the independent management of ashes and slags generated after sewage sludge incineration (ASS) as a raw material for the production of building materials as well as other applications specified in Art. 96 section 1 (Journal of Laws 2020, item 797). The research methods included the determination of selected physicochemical properties, heavy metal content, tests of geometric properties and determination of particle size distribution, observation of the element concentration spectrum, X-ray diffraction (XRD) phase composition tests, EDS analysis and thermogravimetric analysis coupled with mass spectrometry (TG-MS) with exhaust gas analysis using a mass spectrometer.

The conducted research showed the possibility of using the prepared mixtures as a product intended for natural purposes. The concentrations of heavy metals (Cd, Cu, Ni, Pb, Zn, Cr) determined in municipal and industrial sewage sludge did not exceed the permissible content specified in the annex to the Regulation of the Minister of the Environment of February 6, 2015 (Journal of Laws of 2015, item 257) and can be used in agriculture and for land reclamation for agricultural purposes, for land reclamation for non-agricultural purposes, and for adapting the land to specific needs resulting from waste management plans, spatial

development plans or decisions on building conditions and land development, for plant cultivation intended for the production of compost, for the cultivation of plants not intended for consumption and for the production of fodder. The determined content of macronutrients (N, P, K, Ca, Mg) in all analyzed sewage sludge was higher than that present in natural fertilizers, and mixtures prepared on the basis of municipal sewage sludge from the first collection series from the Pomorzany Sewage Treatment Plant together with ashes after combustion wood and after incineration of sewage sludge, meet the requirements set out in the Regulation of the Minister of Agriculture and Rural Development (Journal of Laws 2008 No. 119 item 765) and can be used as an organic and mineral fertilizer. Preparation of sludge mixtures with the addition of ash after wood combustion and fly ash contributes to the increase of pH, which improves the process of further stabilization of sewage sludge. The analyzed waste can be successfully processed in the R12 process - waste exchange in order to undergo any of the processes listed in items R1-R12 (Journal of Laws of 2013, item 21) into a waste product or a product and can be used for the production of organic fertilizers -mineral or building materials. The proposed method transforms waste from various industries into high-quality secondary raw materials that can be recycled.

Future research plans will include the continuation of work on the method of using sludge-ash mixtures both for natural and industrial purposes, and research on the possibility of recovering phosphorus present in waste after sewage sludge incineration (SSA), using post-process waste as a recyclate in construction, and phosphorus as a component for the production of fertilizers.

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