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Combustion of pelleted sewage sludge with reference to coal and biomass

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ABSTRACT

The increasing production of sewage sludge and its properties and methods of disposal are impacting the environment and legislation in Poland. According to Regulation of the Economy Minister of 16 July 2015 on procedures for the release of waste for landfilling of waste [29], thermal disposal of such waste has become extremely important due to its gross calorific value, which is greater than 6 MJ/kg, as well as problems regarding its use and application. Consequently, increasingly restrictive legislation (beginning 1 January 2016) has been introduced concerning sewage sludge storage in Poland.

Sewage sludge incineration is an attractive option because it minimizes odour, significantly reduces the volume of the starting material and thermally destroys organic and toxic components of the off pads. Additionally, it is possible that ashes could be used. Currently, as many as 11 plants use sewage sludge as fuel in Poland; thus, this technology must be further developed in Poland while considering the benefits of co-combustion with other fuels.

This paper presents the results of experimental studies from a comparative analysis of the mechanisms and kinetics of the combustion of pellets of sewage sludge, coal and biomass. The process of fuel-pellet combustion, which was conducted under air-stream conditions, operates via kinetic diffusion under the predominant influence of diffusion factors. In comparison with biomass, a higher temperature is required to ignite sewage sludge by flame. The properties of biomass and sewage sludge result in intensification of the combustion process. Unlike coal, the combustion process for sewage sludge not only involves char combustion but also devolatilisation and the combustion of volatiles.

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1. Introduction

According to a Law that took effect on 14 December 2012 [1], sewage sludge is a waste. Wastes are defined as substances that the holder discards, intends to discard or is required to discard. As characterised by Polish standard PN-EN 12832: 2004 [27], sewage sludge is a mixture of water and solids that are separated from various types of plants as a result of natural or artificial processes. According to the EU definition [5], sewage sludge is the same entity as biomass. Experimental research regarding the combustion of sewage sludge compared to biomass and coal is, therefore, necessary. On the one hand, sewage sludge is treated as waste; on the other hand, it is treated as a full-fledged energy fuel that exhibits dry combustion kinetics similar to brown coal. According to Regulation of the Economy Minister of 16 July 2015 on procedures for the release of waste for landfilling of waste [29], thermal disposal of such waste has become extremely important due to its gross calorific value, which is greater than 6 MJ/kg. The combustion processes for coal and biomass and the properties and thermal utilisation of sewage sludge and its combustion in relation to coal and biomass fuels are presented in [2,7,8,10–14,17–21,24,28,31,32,34,35,37]. Choosing an appropriate method for sludge disposal should depend on the properties of the sludge. The physical, chemical, sanitary, and technological properties of sewage sludge are important and change depending on the type and method of sewage treatment. Because of its unusual properties, sewage sludge is different from coal and biomass. Sewage sludge combustion (similar to coal and biomass) includes drying, devolatilization and the combustion of volatiles and char. Among other fuels, sewage sludge is distinguished by its high hydration levels (92–99.5%), its high organic-compound composition, and its primary dependency on the types of plants and processes used for treatment. For example, raw sludge contains 75–85% of the organic content in the dry weight; sludge stabilised approx. 50% of organic matter in content of the fertilizer compounds. Furthermore, sewage sludge exhibits

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higher secretion odour and bacteriological contamination and may contain substances that are particularly harmful to the environment, including heavy metals [9].

Fig. 1 summarises the methods of sewage sludge disposal in municipal and industrial wastewater treatment plants in 2000, 2005, 2010, and 2013 in Poland [6]. Overall, the following conclusions were made:

- Municipal sewage sludge and industrial sewage sludge were managed differently depending on the year, with the greatest interest in this method for the disposal of municipal sewage sludge and industrial sludge occurring in 2010 and 2013, respectively.
- Similar amounts of municipal and industrial sewage sludge were stored.
- Larger quantities of industrial sewage sludge than municipal sewage sludge were stored until 2013.
- Thermal treatment was subjected to more industrial sewage sludge than municipal sewage sludge.
- Sewage sludge was only used for agricultural and industrial purposes in 2000, when more industrial sewage sludge was disposed of.
- Municipal and industrial sewage sludge were often used to grow plants and produce agriculture compost; however, more attention was given to this disposal method for industrial sludge in 2013. Sewage sludge was used for land reclamation, including for agricultural purposes after 2000.

The specific properties of sewage sludge result in a thermal utilisation process that is not neutral to the environment. Among other considerations, this is due to emissions of CO, SO_2, NOx, particulate matter, PAHs, dioxins and furans, as well as the possibility that the resulting ash has accumulated loads of heavy metals.

As shown in Fig. 1, the amount of sewage sludge recycled by thermal methods increased for both municipal sludge and industrial applications, potentially due to their nature, which was influenced by contamination associated with heavy metals and pathogenic organisms.

2. Thermal utilisation of sewage sludge

Depending on the fuel and the type of sewage sludge burned, the combustion process can be divided into two types of thermal utilisation processes, conventional burning and incineration. The

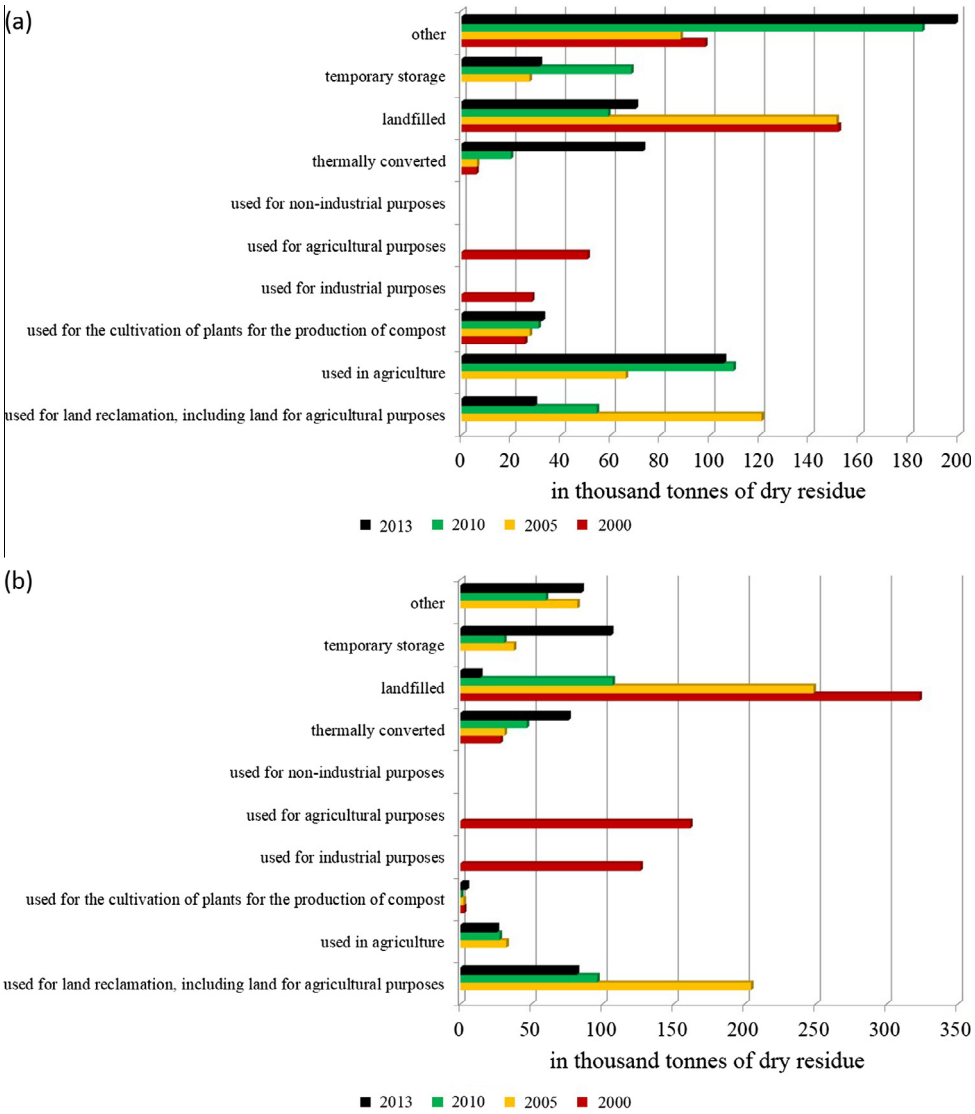

Fig. 1. Sewage sludge management methods in 2000, 2005, 2010, and 2013 in Poland: (a) municipal, (b) industrial [6].

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