Proceedings of the 10th World Congress on Civil, Structural, and Environmental Engineering (CSEE 2025)
Barcelona, Spain - April, 2025
Paper No. ICEPTP 179
DOI: 10.11159/iceptp25.179

Six-Year Study of Biofuel Ash to Assess Its Ecological Risk in Lithuania

Kristina Bunevičienė[1], Donata Drapanauskaitė[1], Karolina Barčauskaitė[1], Karolina Gvildienė[2]
[1]Lithuanian Research Centre for Agriculture and Forestry
Instituto av. 1, Akademija, Kėdainių distr., Lithuania
kristina.buneviciene@lammc.lt; donata.drapanauskaite@lammc.lt; karolina.barcauskaite@lammc.lt
[2]Vytautas Mangus University Agriculture Academy
Studentų str. 11, Akademija, Kaunas distr., Lithuania
karolina.gvildiene@vdu.lt

Extended Abstract

In recent years, the use of biofuels for energy production has increased significantly, particularly in forest-rich European countries. It is worth noting that biofuels are a more environmentally friendly alternative to fossil fuels and are considered neutral in terms of greenhouse gas emissions [1]. However, the combustion of biofuels generates a substantial amount of ash annually [2]. According to literature sources, renewable electricity production alone results in approximately 10 million tons of biomass ash per year [3]. It is important to highlight that the physical and chemical properties of different types of ash can vary significantly [4]. Biofuel ash contains essential nutrients for plants, [5] but also includes heavy metals [6]. Despite the presence of heavy metals, biofuel ash can be utilized in agriculture [7] and forest fertilization [8] provided that the concentrations do not exceed the legally permitted limits or the construction sector [9], However, before using biofuel ash, it is crucial to assess the environmental risks associated with its heavy metal content.

This study presents data on biofuel ash collected between 2017 and 2022. The secondary raw material was gathered from various boiler houses in Lithuania. During the study, the chemical composition of the ash was analyzed based on 17 parameters: Corg, K, P, Ca, Mg, Cu, Zn, Cd, Pb, Ni, Cr, As, V, B, Hg, benzo(a)pyrene, and pH. An environmental risk assessment was also conducted. A risk index (RI) was calculated during the experiment to evaluate the potential hazards of heavy metals in biofuel ash. The results indicate that the concentration of inorganic pollutants in biofuel ash varies significantly from year to year, largely depending on the type of wood burned. In most cases, the concentration of various elements exceeded the maximum permissible limits. Additionally, the findings revealed that the overall cumulative ecological risk associated with biofuel ash is very high, primarily due to the elevated concentration of cadmium (Cd). This environmental risk assessment can contribute to better management of biofuel ash quantities and quality control in Lithuania. Given that the measured concentrations of inorganic pollutants frequently exceeded the established legal limits, the Government of Lithuania may consider these research findings to regulate and revise existing standards.

References

[1] Varnagirytė-Kabašinskienė, I., Lukminė, D., Mizaras, S., Beniušienė, L., & Armolaitis, K. "Lithuanian forest biomass resources: Legal, economic and ecological aspects of their use and potential", *In Energy, Sustainability and Society*, vol. 9, pp. 1-19, 2019.

[2] Vassilev, S. V., Baxter, D., Andersen, L. K., & Vassileva, C. G. "An overview of the composition and application of biomass ash. Part 1. Phase-mineral and chemical composition and classification", *Fuel*, vol. 105, pp. 40–76, 2013.

[3] Sigvardsen, N. M., Geiker, M. R., & Ottosen, L. M. "Reaction mechanisms of wood ash for use as a partial cement replacement", *Construction and Building Materials*, vol. 286, 2021.

[4] Abdalla, T. A., Hussein, A. A. E., Ahmed, Y. H., & Semmana, O. "Strength, durability, and microstructure properties of concrete containing bagasse ash – A review of 15 years of perspectives, progress and future insights", *Results in Engineering*, vol. 21, 2024.

[5] Drapanauskaitė, D., Barčauskaitė, K., Bunevičienė, K., Urbonavičius, M., Varnagiris, Š., & Baltrusaitis, J. "Recovery of nutrients from biofuel ash via organic acid-facilitated solid-liquid extraction", *Chemosphere*, vol. 363, 2024.

[6] Ma, D., Sun, J., Zhang, Y., Sun, Z., Wang, X., Zi, J., Stojiljković, D., Manić, N., Tan, H., Rahman, Z. ur, & Vujanović, M. "Evaluation of ash /slag heavy metal characteristics and potassium recovery of four biomass boilers", *Biomass and Bioenergy*, vol. 173, 2023.
[7] Buneviciene, K., Drapanauskaite, D., Mazeika, R., Tilvikiene, V., & Baltrusaitis, J. "Granulated biofuel ash as a sustainable source of plant nutrients", *Waste Management and Research*, vol. 39, pp. 806-817, 2021.
[8] Demeyer, A., Voundi Nkana, J. C., & Verloo, M. G. "Characteristics of wood ash and influence on soil properties and nutrient uptake: an overview", *Bioresource Technology*, vol. 77, pp. 287–295, 2021.
[9] Tamanna, K., Raman, S. N., Jamil, M., & Hamid, R. "Utilization of wood waste ash in construction technology: A review", *Construction and Building Materials*, vol. 237, 2020.