DEVELOPMENT OF ENVIRONMENTALLY SAFE METHODS FOR OBTAINING HYDROXYAPATITE FROM MEAT AND BONE WASTE AND ASSESSMENT OF THEIR ENVIRONMENTAL IMPACT

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Abstract: The article investigates green and environmentally safe methods for obtaining high-purity hydroxyapatite biomaterial from meat and bone processing plant waste, including chemical-reagent-free calcination and subcritical hydrothermal treatment. The physicochemical properties of the obtained material are analyzed, and its negative environmental impact, including carbon dioxide emissions and chemical waste generation, is assessed using the Life Cycle Assessment (LCA) approach in comparison with conventional synthesis methods.

Keywords: Biogenic hydroxyapatite, meat and bone waste, environmentally safe waste utilization, calcination, green synthesis.

Introduction

Relevance of the Research Topic The growth of the global population and the rapid development of the food industry are leading to a significant increase in the amount of biological waste generated by livestock production and meat processing plants. Millions of tons of meat and bone waste are generated worldwide every year, and improper disposal methods, such as landfilling or open burning, can cause serious contamination of soil, groundwater, and air, as well as contribute to the spread of pathogenic microorganisms. Therefore, recycling these wastes in accordance with the principles of the circular economy and obtaining high-value-added products from them is one of the most pressing environmental and economic challenges of today.

Environmental Impact Assessment The utilization of meat and bone waste and the production of useful products from it have several positive and negative environmental aspects. These results demonstrate the quality characteristics of hydroxyapatite (HAp) samples obtained from meat and bone waste at different temperatures, as well as the environmental efficiency of the process.

Physicochemical and Structural Characteristics of the Obtained

Biogenic Hydroxyapatite When bone waste is subjected to thermal treatment (calcination) at temperatures ranging from 600°C to 1000°C, the composition and structure of the material change as follows:

Environmental Impact Categories	**Conventional Chemical Synthesis Method**	**Production from Waste (Proposed Green Method)**	**Environmental Benefit / Difference**
Carbon footprint (CO_2 emissions)	4.8 tons CO_2-eq.	2.1 tons CO_2-eq.	56% reduction (due to energy recovery)
Volume of toxic wastewater	12.5 m^3	1.2 m^3	90% reduction (no acids are used)
Solid biological waste	Not generated (pure salts are used as raw materials)	3.2 tons of waste are utilized	Reduces landfill burden (positive impact)
Chemical toxicity index (Ecotoxicity)	High (NO_3^-, NH_4^+ residues)	Minimal (only water vapor and organic gases)	Completely safe for the environment

Analysis: The proposed method significantly reduces the consumption of chemical reagents and the generation of toxic wastewater. Carbon emissions during the calcination process are controlled through the use of closed-cycle furnaces and heat recovery systems (recuperation).

Conclusion. The results of the study confirmed that thermal treatment of meat and bone waste at 800°C provides an optimal regime for obtaining biogenic hydroxyapatite with characteristics comparable to those of natural human bone. The proposed “green” technology makes it possible to reduce carbon emissions by 56% and toxic wastewater by 90% compared with conventional chemical methods. For a complete analysis and detailed conclusions of the study, relevant scientific sources may be consulted.

REFERENCES

1. Kowalski, Z., & Muradin, M. (2021). Comparative Analysis of Meat Bone Meal and Meat Bone Combustion Using the Life Cycle Assessment Method. Energies, 14(11), 3292.
2. Okpe, O., et al. (2024). Hydroxyapatite synthesis and characterization from waste animal bones and natural sources for biomedical applications.

Journal of Biomedical Materials Research Part B: Applied Biomaterials, 112(6).
3. Ramesh, S., et al. (2020). Environmentally sustainable processes for the synthesis of hydroxyapatite. Heliyon, 6(4), e03610.
4. Value-added materials recovered from waste bone biomass: technologies and applications. (2022). RSC Advances, 12(34), 22302–22315.