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Development of Sustainable Construction Materials : MSWI Bottom Ash Optimization

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ABSTRACT
This paper explores the development of a Decision Support System (DSS) aimed at optimizing the use of Municipal Solid Waste Incineration (MSWI) bottom ash in construction materials. With increasing waste generation and the need for sustainable construction practices, the utilization of MSWI bottom ash presents an opportunity to mitigate environmental impact. The DSS integrates multi-criteria decision-making methods, environmental assessments, and material performance evaluations to provide an optimal solution for incorporating MSWI bottom ash in construction applications. The system's effectiveness was validated through case studies and sensitivity analysis, showing potential for widespread adoption in the construction industry. This paper presents the development of a decision support system (DSS) to optimize the utilization of MSWI bottom ash in construction materials. The DSS integrates expert knowledge, machine learning algorithms, and linear programming to provide a comprehensive solution for MSWI bottom ash utilization.
Index Terms : MSWI Bottom Ash, Decision Support System (DSS), Sustainable Construction, Waste Utilization, Environmental Impact

I. INTRODUCTION

The utilization of Municipal Solid Waste Incineration (MSWI) bottom ash in construction materials is a promising approach to reduce waste disposal issues and promote sustainable development. However, the optimal utilization of MSWI bottom ash in construction materials requires careful consideration of various factors, including ash properties, material composition, and environmental impacts.

MSWI bottom ash is a significant waste management issue due to its high volume and potential environmental impacts. The utilization of MSWI bottom ash in construction materials offers a promising solution to reduce waste disposal issues and promote sustainable development. However, the optimal utilization of MSWI bottom ash in construction materials requires careful consideration of various factors, including ash properties, material composition, and environmental impacts.

II. BACKGROUND

The construction industry is one of the largest consumers of natural resources and a significant contributor to environmental degradation. With the global population increasing and urbanization accelerating, there is an urgent need to explore alternative, sustainable materials for construction. One promising approach is the utilization of waste by-products, such as Municipal Solid Waste Incineration (MSWI) bottom ash, in construction materials.

MSWI bottom ash is a by-product of the incineration process used to manage municipal solid waste. While traditionally considered a disposal problem, bottom ash contains various components that can be repurposed in construction, such as metals, glass, and other inert materials. Utilizing bottom ash in construction not only reduces the environmental footprint but also offers economic benefits by lowering material costs.

1.2 Research Problem

espite the potential benefits, the utilization of MSWI bottom ash in construction materials is not widely adopted due to uncertainties related to material properties, environmental concerns, and a lack of standardized guidelines. A Decision Support System (DSS) can address these challenges by providing a systematic approach to evaluating and optimizing the use of MSWI bottom ash in various construction applications.

1.3 Research Objectives

This research aims to develop a DSS that facilitates the optimal utilization of MSWI bottom ash in construction materials by:

- Integrating multi-criteria decision-making methods.
- Conducting environmental impact assessments.
- Evaluating the performance of construction materials containing MSWI bottom ash.
- Validating the DSS through case studies and sensitivity analysis.

III. RELATED WORK

A comprehensive literature review was conducted to identify the key factors influencing MSWI bottom ash utilization in construction materials. The literature review revealed that ash properties, material composition, and environmental impacts are critical factors affecting MSWI bottom ash utilization.

2.1 Municipal Solid Waste Incineration (MSWI) Bottom Ash

MSWI bottom ash is the residue left after the incineration of municipal solid waste. It typically contains metals, minerals, glass, ceramics, and unburnt organic material. Various studies have explored the potential use of MSWI bottom ash in construction materials, such as concrete, asphalt, and road sub-base layers.

2.2 Decision Support Systems in Construction

Decision Support Systems (DSS) are computer-based tools that assist decision-makers by providing systematic analyses of complex problems. In construction, DSS has been employed for project management, material selection, and sustainability assessments. However, their application in optimizing waste utilization, particularly MSWI bottom ash, is still underexplored.

2.3 Environmental and Performance Considerations

The environmental impact of using MSWI bottom ash in construction must be carefully evaluated, including potential leaching of harmful substances and carbon footprint reduction. Additionally, the performance characteristics of construction materials containing bottom ash, such as strength, durability, and workability, are critical for ensuring their practical applicability.

IV. RESEARCH METHODOLGY

Methodology:

The DSS was developed using a multi-step approach:

1. Expert knowledge integration: Expert knowledge was integrated to identify the key factors influencing

MSWI bottom ash utilization in constructionmaterials.
2. Machine learning algorithm development: Machine learning algorithms were developed to predict the optimal material composition and environmental impacts of MSWI bottom ash utilization.
3. Linear programming formulation: Linear programming was used to formulate the optimization problem and provide a comprehensive solution for MSWI bottom ash utilization.

3.1 Development of the DSS Framework

The DSS framework was developed using a combination of multi-criteria decision-making (MCDM) methods, environmental impact assessments, and material performance evaluations.

3.1.1 Multi-Criteria Decision-Making (MCDM) Methods: Techniques such as Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) were used to weigh and rank various factors influencing the utilization of MSWI bottom ash in construction.

3.1.2 Environmental Impact Assessment: Life Cycle Assessment (LCA) was conducted to quantify the environmental impacts associated with using MSWI bottom ash in construction materials.

3.1.3 Material Performance Evaluation: Laboratory tests were conducted to evaluate the performance of construction materials incorporating MSWI bottom ash, focusing on parameters such as compressive strength, durability, and workability.

a) Case Studies and Validation

The DSS was applied to various case studies involving different construction applications, such as concrete production, road sub-base layers, and brick manufacturing. Sensitivity analysis was performed to assess the robustness of the DSS recommendations under different scenarios.

V. Results

The DSS was tested using a case study of MSWI bottom ash utilization in concrete production. The results showed that the DSS can effectively optimize MSWI bottom ash utilization in construction materials, reducing waste disposal issues and promoting sustainable development.

4.1 DSS Framework Outcomes

The DSS successfully integrated the various criteria and provided recommendations for the optimal utilization of MSWI bottom ash in different construction applications. The system was able to balance environmental impact, material performance, and cost-effectiveness.

4.2 Environmental Impact Analysis

The LCA results showed a significant reduction in carbon footprint and resource consumption when MSWI bottom ash was used in place of traditional construction materials.

However, the potential for leaching of harmful substances was identified as a key concern that needs to be managed through proper treatment and testing.

4.3 Material Performance

Materials incorporating MSWI bottom ash demonstrated comparable performance to traditional materials in terms of compressive strength and durability. Workability was slightly reduced, requiring adjustments in mix design and water content.

VI. Discussion

5.1 Implications for Sustainable Construction

The findings suggest that the DSS can be a valuable tool for promoting the sustainable use of MSWI bottom ash in construction. By providing a systematic approach to decision-making, the DSS helps address the uncertainties and barriers that have hindered the wider adoption of MSWI bottom ash.

5.2 Challenges and Limitations

The main challenges identified include the variability in the composition of MSWI bottom ash and the need for extensive testing to ensure safety and performance. Additionally, the DSS framework may need to be adapted for different regional contexts, considering local regulations and construction practices.

VII. Results

1. Result shows optimal use of waste MSWI bottom ash

2. Strength determine and comparative analysis of waste material MSWI composition

VIII. CONCLUSION

The development of a DSS for optimal utilization of MSWI bottom ash in construction materials is a significant step towards promoting sustainable development and reducing waste disposal issues. The DSS can be used by waste management professionals, construction industry experts, and policymakers to optimize MSWI bottom ash utilization in construction materials.

This research developed a Decision Support System (DSS) that optimizes the use of MSWI bottom ash in construction materials. The DSS was validated through case studies, demonstrating its potential to support sustainable construction practices while addressing environmental and performance concerns.

Future research should focus on expanding the DSS to include a wider range of construction applications and exploring the use of other waste materials in combination with MSWI bottom ash. Additionally, further work is needed to refine the environmental impact assessment, particularly concerning leaching behavior.

IX. REFERENCES

[1] P. Apostoli, S. Giusti, D. Bartoli, A. Perico, P. Bavazzano, and L. Alessio, "Multiple exposureto arsenic, antimony, and other elements in art glass manufacturing," Am. J. Ind. Med., vol. 34, no. 1, pp. 65-72, 1998.

[2] R. Barbosa, N. Lapa, D. Dias, and B. Mendes, "Concretes containing biomass ashes:mechanical, chemical, and ecotoxic performances," Constr. Build. Mater., vol. 48,pp. 457-463, 2013.

[3] EC, "Council of the European Union, 2003/33/EC, Council Decision establishing criteria and procedures for the acceptance ofwaste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC," Off. J. Eur. Commun., pp. 27-49, 2003.

[4] CEMWE, "Criteria and evaluation methods for waste ecotoxicity," French Ministry of the Environmental Directorate for Pollution Prevention and Risk Control, Paris, France, 1998.

[5] I. A. Chen, "Synthesis of Portland Cement and Calcium Sulfoaluminate-Belite Cement for Sustainable Development and Performance,"

[6] Z. Chen, Y. Liu, W. Zhu, and E. H. Yang, "Incinerator bottom ash (IBA) aerated geopolymer," Constr. Build. Mater., vol. 112, pp. 1025-1031, 2016.

[7] H. Cheng and Y. Hu, "Municipal solid waste (MSW) as a renewable source of energy: current and future practices in China," Bioresour. Technol., vol. 101, no. 11, pp. 3816-3824, 2010.

[8] J. M. Chimenos, A. I. Fernández, L. Miralles, M.Segarra, and F. Espiell, "Short-term natural weathering of MSWI bottom ash as a function of particle size," Waste Manag., vol. 23, no. 10, pp.

[9] J. B. Choi, S. M. Bae, T. Y. Shin, and K. Y. Ahn, "Evaluation of daphnia magna for the ecotoxicity assessment of alkali leachate from concrete," Int. J. Ind. Entomol., vol. 26, no. 1, pp. 41-46, 2013.

[10] K. Chuenwong, S. Chiarakorn, and B. Sajjakulnukit, "Specific energy consumption and carbon intensity of ceramic tablewares: small enterprises (SEs) in Thailand," J. Clean. Prod., vol. 147, pp. 395-405, 2017.

[11] Comité Européen de Normalisation, "Construction products: assessment of release ofdangerous substances - Guidance on the use of ecotoxicity tests applied to construction products," Brussels, 2017.

[12] G. Cornelis, T. Van Gerven, and C. Vandecasteele, "Antimony leaching from uncarbonated and carbonated MSWI bottom ash," J. Hazard. Mater., vol. 137, no. 3, pp. 1284-1292, 2006.

[13] J. A. Cusidó and L. V. Cremades, "Environmental effects of using clay bricks produced with sewage sludge : Leachability and toxicity studies," Waste Manag., vol. 32, no.6, pp. 1202-1208, 2012.

[14] R. del Valle-Zermeno, J. Gomez-Manrique, J. Giro-Paloma, and J. M. Chimenos, "Material characterization of the MSWI bottom ash as a function of particle size. Effects of glass recycling over time," Sci. Total Environ., vol. 581-582, pp. 1345-1353, 2017.

[15] P. Duxson, J. L. Provis, and G. C. Lukey, "Designing precursors for geopolymer cements," J. Am. Ceram. Soc., vol. 91, no. 12, pp. 3864-3869, 2008.

[16] P. Duxson, J. L. Provis, G. C. Lukey, S. W. Mallicoat, W. M. Kriven, and J. S. J. van Deventer, "Understanding the relationship between geopolymer composition, microstructure and mechanical properties," Colloids Surf. A Physicochem. Eng. Asp., vol. 269, no. 1-3, pp. 47-58, 2005.

[17] P. Duxson, J. L. Provis, G. C. Lukey, S. W. Mallicoat, W. M. Kriven, and J. S. J. van Deventer, "Geopolymer technology: the current state of the art," J. Mater. Sci., vol. 42, no. 9, pp. 2917-2933, 2007.