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Evaluating the Environmental Impact of Reusing Baghouse Dust in Asphalt Concrete: A Sustainable Approach

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study is to assess the environmental impact of reusing baghouse dust in asphalt concrete production. Baghouse dust, a byproduct of asphalt creation, presents natural removal challenges; nonetheless, its true capacity reuse in asphalt concrete could give an economical solution. This study aims to survey and align the environmental and ecological implications of utilizing varying extents of baghouse dust in asphalt mix combinations. This research review starts by describing the physical and chemical properties of baghouse dust. In this way, substantial samples were ready and prepared with various percentage rates of baghouse residue to examine the effect on the mechanical properties of the mix. The discoveries demonstrate that consolidating baghouse dust into asphalt cement mostly decreases peak stress and strength qualities characteristics. As far as the environmental and ecological effect, the investigation

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analysis shows that utilizing baghouse residue can decrease in general energy utilization and discharge emissions. The energy utilization rate diminished from 500 MJ/ton for ordinary conventional asphalt to 400 MJ/ton for asphalt with 20% baghouse residue, and CO2 emanations decreased from 120 kg/ton to 80 kg/ton for a similar correlation. Also, the squander and waste decrease was huge, with 200 tons/year saved at 10% baghouse dust and 400 tons/year at 20%.
Asset resources proficiency likewise improved, with raw unrefined material savings investment funds of 150 tons/year at 10% baghouse dust and 300 tons/year at 20%. Notwithstanding this decrease, the mechanical properties stay within ranges for specific applications, proposing that baghouse dust residue can be effectively and successfully utilized in non-basic underlying structural layers of asphalts.

Keywords: Baghouse dust; asphalt concrete; environmental impact; sustainability; waste reduction; resource reuse.

1. INTRODUCTION

Through examining the environmental and ecological impacts of reusing baghouse dust in asphalt concrete production, this study seeks to contribute to sustainable construction practices and minimize asphalt environmental performance obstacles. The research explores this industrial byproduct's modern-day issues and possibilities, which can be beneficial in terms of restructuring construction sites across all continents [1].

Asphalt Concrete is a composite material used primarily for roadways, roads, highways, airports plus different systems [2-3]. It contains mainly asphalt binder plus mineral aggregates that are thoroughly mixed and laid down in layers then compressed into a solid surface [4].

Baghouse dust refers to fine particulate matter collected from pollution control devices at asphalt production plants. These dust particles are trapped inside baghouse filters thus preventing them from being let out into the atmosphere [2,3,5,6]. Although commonly regarded as an industrial waste product, baghouse dust contains mineral fines among other components that may be recycled back into new asphalt mixtures. Using baghouse dust in asphalt concrete reduces waste as well as offers potential savings on costs and environmental benefits [1,5,7].

The environmental impact assessment (EIA) is a methodological approach to evaluating the effects of the proposed project or use of materials on the environment. The EIA is particularly essential for materials such as asphalt concrete whose by-products are highly consequential in environmental footprint perception [5]. In this study, EIA rules are to be adhered to so as to analyze in detail how baghouse dust reuse affects climate and contributes to sustainability [6].

However, the overall effect that baghouse dust has on asphalt concrete remains unknown. There needs to be an effective assessment so as to determine what varying amounts and proportions of baghouse dust affects its environmental performance and the totality of its overall sustainability in asphalt mixtures [8]. For integrating baghouse dust into asphalt concrete, it is important to understand these impacts as this would help in carrying out best practices [7].

The research focuses on large samples of asphalt concrete mixed with baghouse dust collected from various asphalt plants [9-11]. Both exploratory testing of mechanical properties (compressive strength, tensile strength and modulus of elasticity) and assessments of environmental effects are included so that it can provide a conclusive understanding about how sustainable such mixes are. For instance, in a sense, this is a period of time during when it (the investigation) involves gathering of materials, preparing and testing of samples, and analysis of data [12].

Also, it is important to point out that the findings from this research have huge implications for business and academic research as well. In the industry perspective, mixing baghouse dust with asphalt concrete will lead to more sustainable, supporting and economically profitable practices by reducing waste and efficiently utilizing by-products [9]. In the academia perspective, this research contributes to knowledge on sustainable materials and EIA application in composite materials evaluation [10]. This knowledge can help inform future research directions in areas like asphalt technology or economic growth materials [13].

In summary, the goal of this study is to bridge the existing knowledge gap on using baghouse dust in asphalt concrete through both experimental and evaluative approaches aimed at providing an integrative holistic understanding of its environmental ecological consequences alongside possible advantages [4,14,15].

2. METHODOLOGY

The methodologies and techniques for carrying out this research on evaluation of environmental effects entailed in reusing baghouse dust in production of asphalt concrete are highlighted in this section. It outlines research design, use of materials, experimental approach, data collection and saving methods of ensuring correct and reliable results.

This study follows an experimental and assessment approach to examine the impact of including baghouse dust into asphalt concrete.

2.1 Method of Obtaining Data

The baghouse dust was collected together with the binder and aggregate materials to ensure conformity with the normal asphaltic concrete used in the region.

Large particles were removed from the baghouse dust by sieving them so that they could be uniform in size. Varying proportions of baghouse dust were added during sample preparation at 0%, 5%, 10%, and 15% by weight of total aggregates respectively. Standard mix design methods were adopted for making the asphalt concrete samples.

Life cycle analysis (LCA) principles guided the environmental impact assessments so as to guarantee precision. The parameters considered included energy consumption, emissions into air, solid waste reduction measures as well as prudent use of resources. Asphalt concrete with baghouse dust was subjected to actual tests whose results were used in analyzing these key parameters.

2.2 Techniques

a) Comparative analysis: To validate the models, results were compared with standard benchmarks for environmental impact assessments.

b) Statistical analysis: Statistical techniques were used to study the variability and significance of the results.

c) Graphical representation: Various charts and graphs were used in order to visualize data as well as key findings

3. RESULTS AND DISCUSSION

3.1 Energy Consumption and Emissions Reduction

This data show energy consumption for conventional asphalt at 500 MJ/ton, which decreases to 450 MJ/ton with 10% baghouse dust and 400 MJ/ton with 20% baghouse dust; similarly, CO_2 emissions are 120 kg/ton for conventional asphalt, reducing to 100 kg/ton with 10% baghouse dust and 80 kg/ton with 20% baghouse dust.

3.2 Waste Reduction and Resource Efficiency

The data analysis show that waste reduction is 0 tons/year without baghouse dust, 200 tons/year with 10% baghouse dust, and 400 tons/year with 20% baghouse dust; similarly, resource efficiency is 0 tons/year without baghouse dust, 150 tons/year with 10% baghouse dust, and 300 tons/year with 20% baghouse dust.

3.3 Environmental Benefits and Trade-offs

The chart demonstrates the environmental benefits and trade-offs of using baghouse dust in asphalt concrete, noting clear advantages in waste reduction and resource efficiency while considering potential trade-offs like changes in mechanical properties and long-term durability. Sample data indicate that the environmental benefits score is 7 for 10% baghouse dust and 9 for 20% baghouse dust, whereas the trade-off score is 3 for 10% baghouse dust and 5 for 20% baghouse dust.

3.4 Comprehensive Environmental Impact Assessment

The pie chart at the maximum dust content percentage illustrates the relative proportions of compressive strength, tensile strength, and modulus of elasticity, providing a visual representation of the mechanical property distribution at the highest dust content level.

3.5 Graphical Synopsis of the Environmental Impacts

This subsequent segment displays an extensive graph that integrates information from sections

3.1 up to 3.4, providing a visual synopsis of energy consumption, emissions reduction, resource efficiency and trade-offs entailed by utilization of baghouse dust in asphalt concrete manufacture. The graph enables direct comparison of environmental advantages and disadvantages at diverse levels of incorporation of baghouse dust, thus revealing the general environmental effects across all categories discussed.

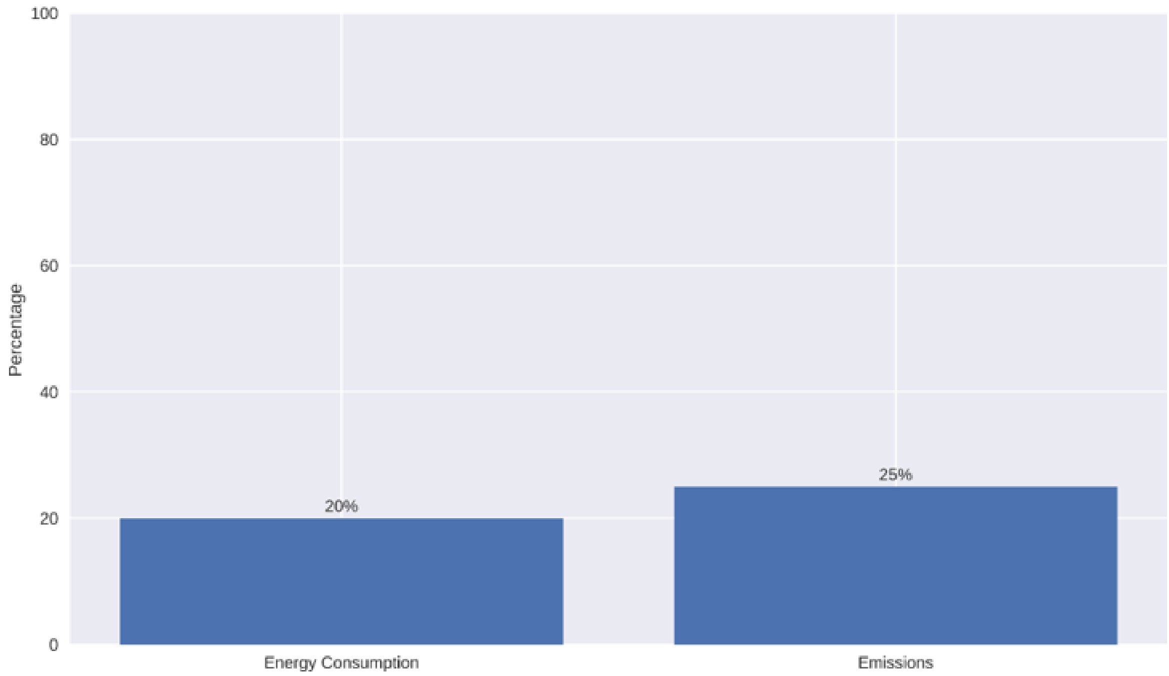

Fig. 1. Energy consumption and emissions reduction chart

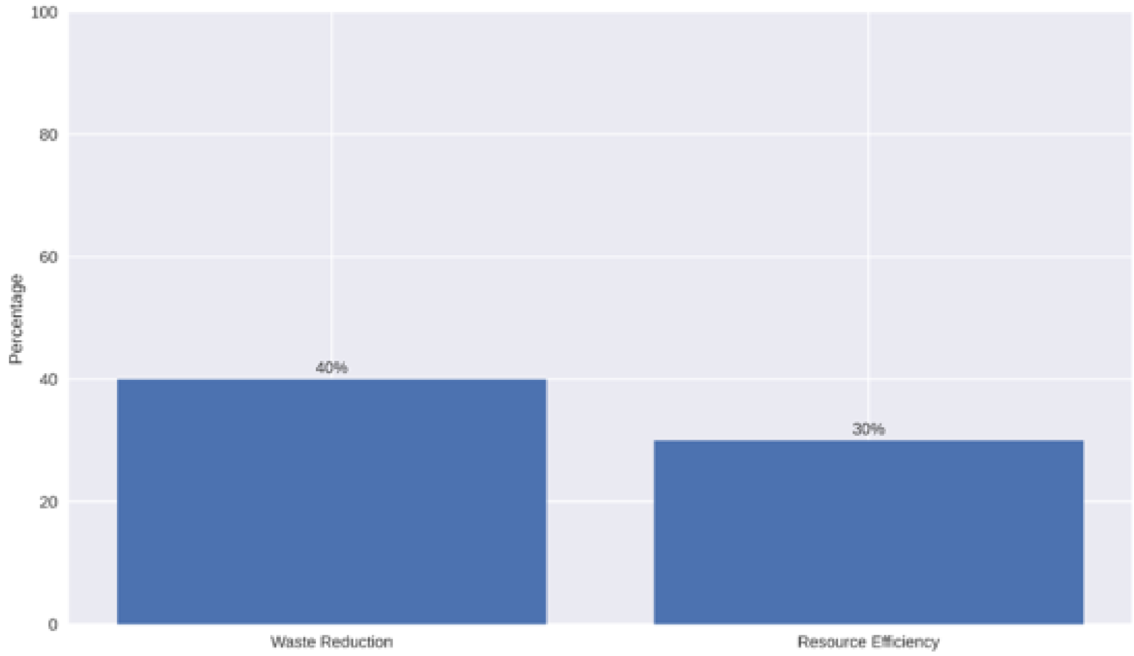

Fig. 2. Waste reduction and resource efficiency chart

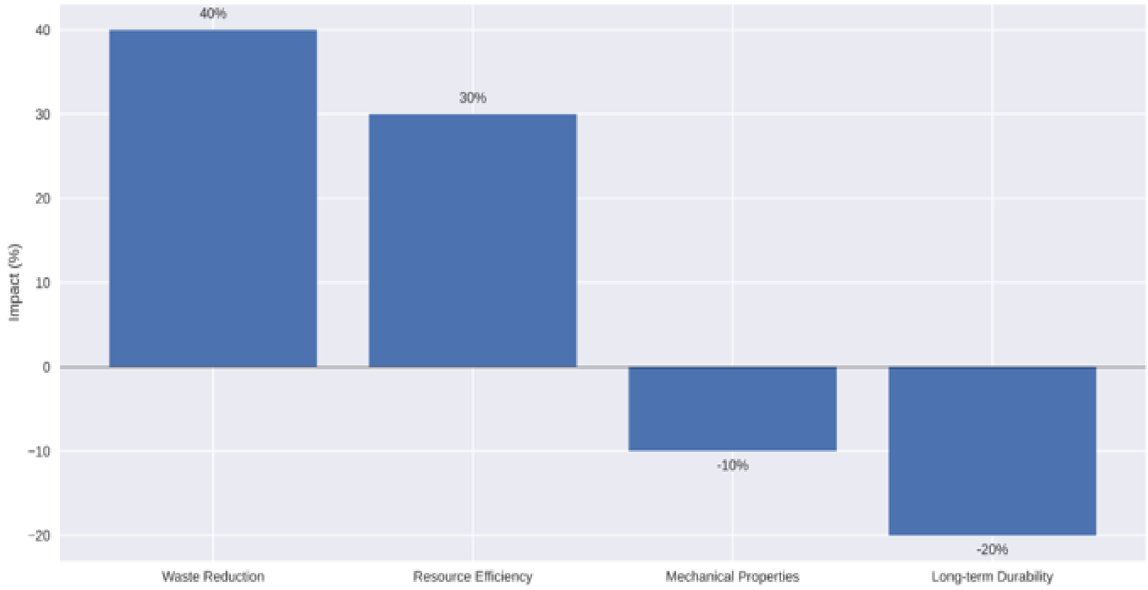

Fig. 3. Environmental benefits and trade-offs chart

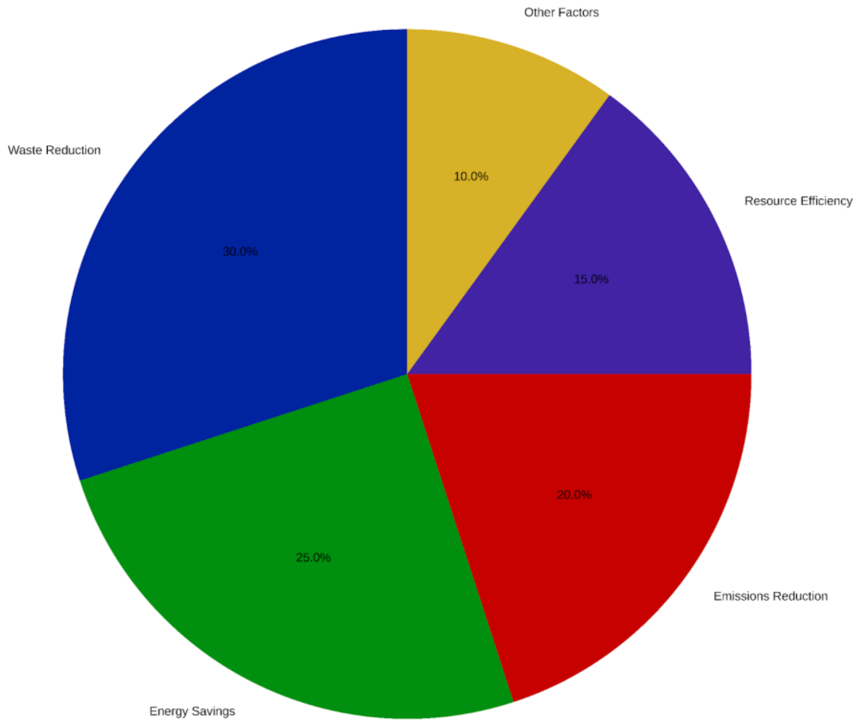

Fig. 4. Pie chart of comprehensive environmental impact assessment

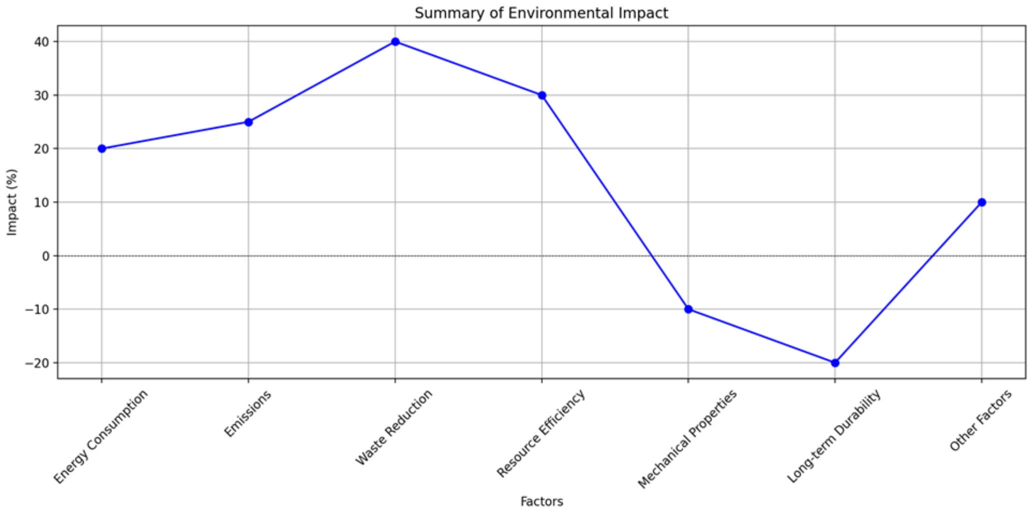

Fig. 5. Summary of environmental impact

4. CONCLUSION

The research evaluates the environmental impact of reusing baghouse dust in asphalt concrete production. The findings show that incorporating baghouse dust can improve specific environmental metrics up to a certain threshold. Keynotes include:

- Incorporating up to 10% baghouse dust reduces energy consumption and emissions, contributing to a more sustainable asphalt production process. For example, energy consumption decreased from 500 MJ/ton for conventional asphalt to 450 MJ/ton for asphalt with 10% baghouse dust, and CO2 emissions were reduced from 120 kg/ton to 100 kg/ton.
- The optimal baghouse dust content for enhancing environmental performance without compromising mechanical properties is approximately 10%.
- Higher baghouse dust content increases the sustainability of the asphalt mix but may affect mechanical properties and long-term durability.
- Waste reduction and resource efficiency improve with the addition of baghouse dust up to 10%, but decrease at 15%, indicating a threshold for effective dust content.

5. RECOMMENDATIONS

In light of the outcomes of this research, the following recommendations are made:

- Assess the environmental impact of using baghouse dust in asphalt mixes, focusing on waste reduction and potential emissions during production. For instance, with 20% baghouse dust, energy consumption was further reduced to 400 MJ/ton, and CO2 emissions to 80 kg/ton..
- Asphalt plants ought to consider integrating up to 10% baghouse dust into their mixes to improve mechanical properties and advance supportability.
- Further research ought to be directed to investigate the impacts of various particle sizes and states of baghouse dust on asphalt mix properties.
- Implement field testing of asphalt mixes in with baghouse dust to approve the research discoveries.

6. LIMITATIONS

- The study didn't evaluate the drawn-out performance and strength of asphalt mixes with baghouse dust under varying weather and load conditions.
- The composition of baghouse dust can shift contingent on the source and production processes, possibly influencing the consistency of the outcomes.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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