Comparative Life Cycle Assessment of Elephant Dung Management: A Case Study of Paper and Biochar Production at Maetaeng Elephant Camp, Chiang Mai

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INTRODUCTION

Maetaeng Elephant Camp, Chiang Mai is one of the popular elephant conservation site. The camp have 70 elephant, which generate approximately 17,500 kg of dung per day, creating significant environmental and operational challenges. Although the dung is currently managed through composting and paper making, these method cannot reduce the generated dung as much as desired, leading to waste accumulation. This study propose biochar production through pyrolysis as an alternative waste management option. To determine the environmentally sustainable solution, a Life Cycle Assessment (LCA) method based on ISO14040 is conducted under a cradle-to-gate boundary, comparing paper and biochar production to support sustainable decision making at the camp.

OBJECTIVES

1. To compare the environmental impacts between paper and biochar production from elephant dung, using a Life Cycle Assessment (LCA).
2. To propose biochar production from elephant dung as a sustainable management alternative at Maetaeng Elephant Camp, Chiang Mai.

METHODS

1.Goal and Scope Definition

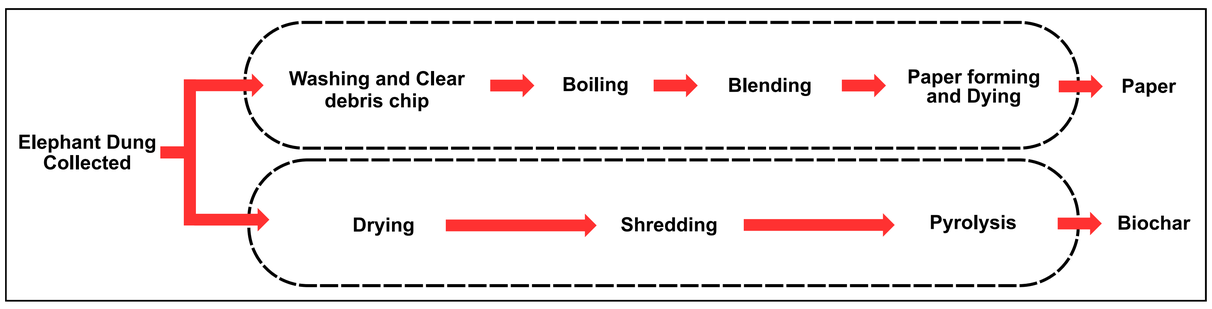


Figure 1. The system boundary (cradle-to-gate) of 1 kg paper and biochar production.

2.Inventory Analysis (LCI)

Inventory list

Input Data
- On-site survey
- Interviews with staff
- Direct measurement

Output Data
- Relevant literature
- Calculation



3.Impact Assessment (LCIA)

3.1 Impact Categories Selection

To investigate the impact, this study selected relevant environmental impact categories based on the ReCiPe2016 Midpoint (H) method (Fig.2).

3.2 Environmental Impact Calculation (midpoint level)

The environmental impact were calculated by multiplying activity data (inventory list) with emission factor (EF).

Table 1. Midpoint calculation example of global warming potential (GWP) based on electricity consumption of paper and biochar production.

Parameters	Paper	Biochar
Activity data (Electricity)	4.48 kWh	20 kWh
Emission factor	0.193	0.214
Midpoint result	0.87	4.28
Unit of result	kg CO_2-eq	

3.3 Normalization

To provides a more detailed evaluation of individual, environmental impacts midpoint results were normalized to compare the relative significance of different impact categories (Fig.3).

3.4 Classification

Midpoint normalized results were grouped into damage pathway representing human health, ecosystem quality, and resource scarcity (Fig.2).

3.5 Endpoint conversion

To making the results easier to interpret for decision-making, damage pathway results (Fig.2) were aggregated to obtain the overall endpoint damage scores (Fig.4) by divided with endpoint normalization factors.

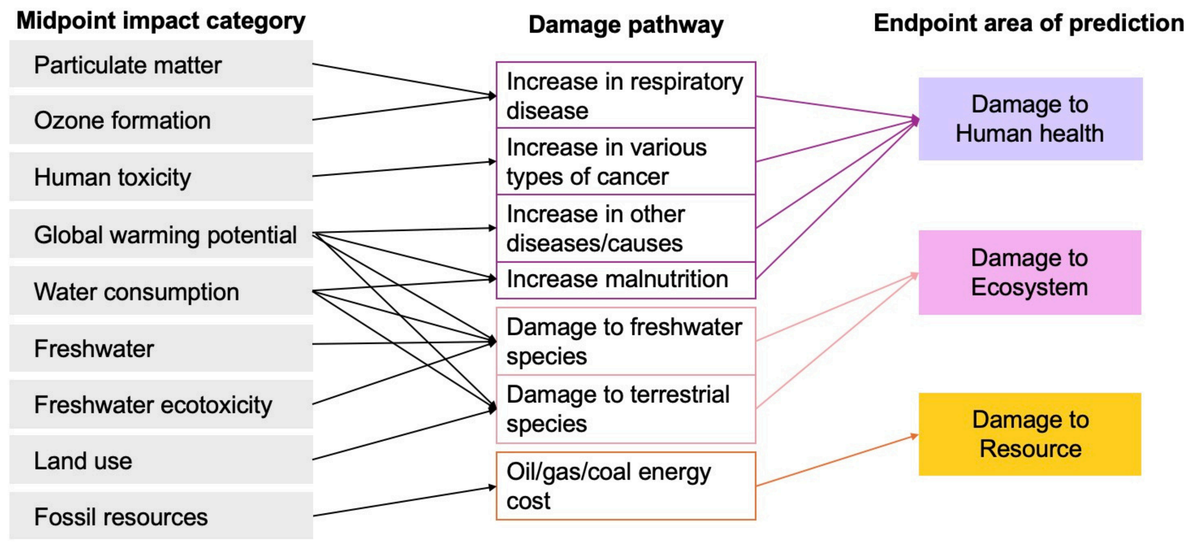


Figure 2. Midpoint-to-endpoint damage pathway based on the ReCiPe2016 LCIA method.

RESULTS

Relative Contribution at Midpoint Level

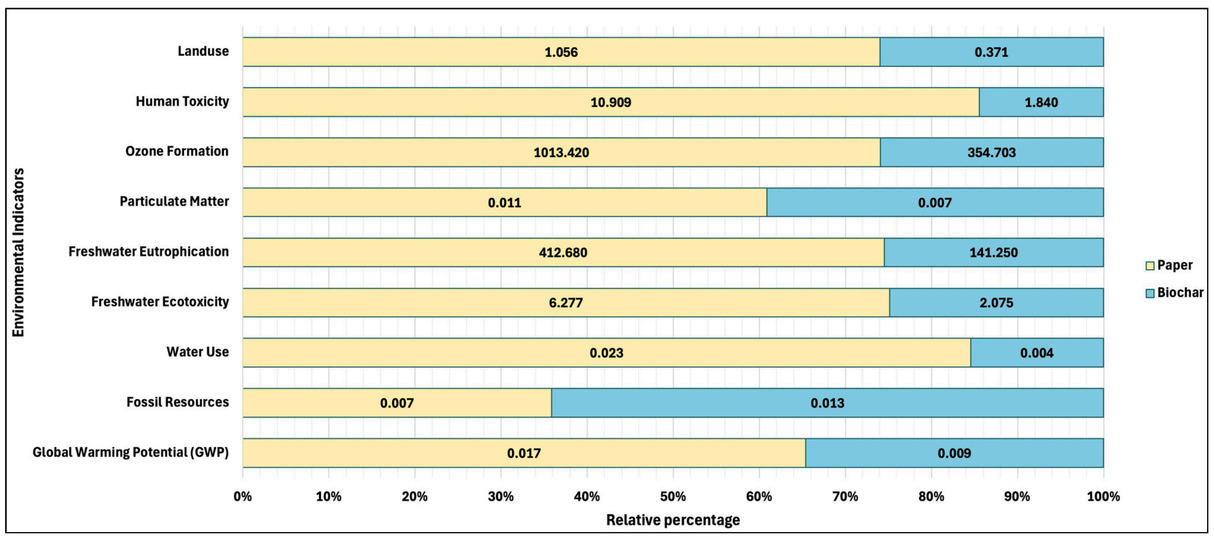


Figure 3. Relative contribution of midpoint environmental impact categories for elephant dung paper and biochar production based on the ReCiPe 2016 midpoint approach.

Endpoint Damage Scores

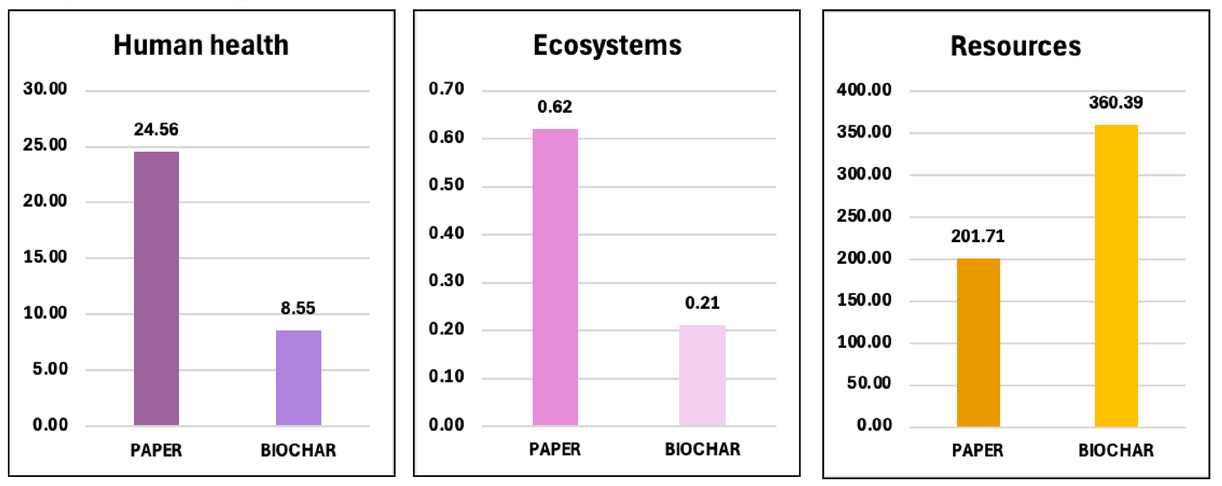


Figure 4. Endpoint damage results for the human health, ecosystem, and resource scarcity category comparing paper and biochar production systems.

DISCUSSION AND CONCLUSION

Paper production shows higher environmental impacts in most midpoint categories compared to biochar, except for fossil resource consumption. At the endpoint level, paper causes greater damage to human health and ecosystems due to high water use and chemical inputs, while biochar shows higher resource scarcity because of the energy required for pyrolysis. Overall, biochar can be considered a promising alternative for managing elephant dung waste at the camp.

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