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Life Cycle Assessment for Black Soldier Fly Larvae Dried Production

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Rudy Agung Nugroho[1]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University

Rudy Agung Nugroho

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Abstract

Background: *Hermetia illucens* L. has gained popularity in recent years as a potential ecologically friendly response to both the present and potential future food/feed crisis. The larvae of *H. illucens*L., also known as black soldier fly larvae (BSFL), is an alternative solution to tackle the issue of organic waste bioconversion. However, understanding the environmental loads associated with biowaste bioconversion using BSFL to produce dried BSFL is a pivotal point to keep the environment sustainable. This study reported a life cycle assessment (LCA) of the biowaste bioconversion process of BSFL and determined the environmental impact analysis to make recommendations for modifications to lessen environmental consequences.
Methods: The data used was starting from biowaste production, biowaste bioconversion, prepupa production; and BSFL frass production. All these system productions were evaluated using the OpenLCA 1.11 withTRACI 2.1 methods based on a gate-to-gate approach.The system boundary of the dried larva production system is designed for both the processing and production of one cycle of BSFL. Further, five environmental impact categories, namely global warming potential (GWP), acidification (AC), terrestrial eutrophication (TE), fossil fuel depletion (FFE), and eco-toxicity (ET) were determined. The study was conducted at the PT Biomagg Sinergi Internasional, Depok, West Java, Indonesia.

Results: Based on the results of the study, the impact values of GWP, AC, TE, FFE, and ET, per 100 kg of BSFL dried production werewas6.687 kg CO_2eq; 0.029 kg SO_2-eq; 0.092 kg N-eq; 16.732 MJ surplus; 121.231 CTUe, respectively. Production of prepupa had the highest hotspots in these emissions, followed by the production of dried BSFL.

Conclusions. Efforts to reduce environmental impacts that can be done are by implementing an integrated rearing system for the utilization of substrate from a single type of known substrate for BSFL and using alternative drying methods for BSFL dried production.

Life cycle assessment goal and scope definition

1 The goal and scope definition step ensures that the LCA is performed consistently.

1.1 The present goal is to identify and analyze input-output based on inventory data from BSFL-dried products and determine potential environmental impacts in the form of global warming potential (GWP), acidification (AC), terrestrial eutrophication (TE), fossil fuel depletion (FFE), and ecotoxicity (ET).

1.2 The scope: The system boundaries used gate to gate.

Inventory analysis of extractions and emissions

2 The following processes were evaluated: biowaste preparation for BSFL substrate, bioconversion of biowaste, production of prepupa, and production of the dried larva. The $CH_4$and N_2O gases emmision were calculated based on the previous study performed by Martenat et al. (2019)

Mertenat, A., Diener, S., and Zurbrügg, C. (2019). Black Soldier Fly biowaste treatment–Assessment of global warming potential. Waste management. 84: p. 173-181.

2.1 At biowaste preparation for BSFL substrate, the volume of biowaste (1000 kg), the total need of diesel for crushing biowaste, and the operation time of the chopper machine were recorded.

2.2 The number of egg that was hatched (100 g) and the energy of electricity consumed (0.264 kWh) during the hatching process were noted.

2.3 In the bioconversion of biowaste, the volume of biowaste (1000 kg), themass of baby larvae of BSFL (100 kg), and the energy of electricity consumed (0.264 kWh) were also recorded

2.4 The volume of crushed biowaste (1000 kg), baby larva (100 g), and electricity (0.264 kWh) during the production of prepupa were obtained and noted

2.5 The wet prepupa (1000 kg), electricity energy consumed, and hour of microwave used in production of dried prepupa per 100 kg, were kept

Life cycle impact assessment (LCIA)

3 The data used was starting from biowaste production, biowaste bioconversion, prepupa and frass production, and BSFL-dried production. This data was primary data that directly was taken from the PT Biomagg Sinergi Internasionalwere evaluated using the **OpenLCA** 1.11.0 (GreenDelta, Berlin), **Ecoinvent database version 3.8** (Secondary data) and **TRACI 2.1** method based on a gate-to-gate approach.Secondary data such as data biowaste, electricity, diesel, and chopper were obtained from the dataset of Ecoinvent 3.8 database.

The LCI involved input waste (biowaste), emissions, and energy consumption of each subprocess were based on the principle of mass balance. Meanwhile, the Impact environment that includes GWP, AC, TE, FFE, and, ET, were evaluated. Additionally, all inventory data was obtained and calculated from this facility (PT Biomagg Sinergi Internasional, Depok West Java, Indonesia), except for CH_4 and N_2O emissions. The published values for $CH_4$and N_2O emissions during BSFL bioconversion were used (Martenat et al. 2019)

Mertenat, A., Diener, S., and Zurbrügg, C. (2019). Black Soldier Fly biowaste treatment–Assessment of global warming potential. Waste management. 84: p. 173-181.

Interpretation

4 The global warming potential (GWP), acidification (AC), terrestrial eutrophication (TE), fossil fuel depletion (FFE), and ecotoxicity (ET). were determined and interpreted based on the results of the **TRACI 2.1** method based on a gate-to-gate approach. The following link is the raw data calculation of the measurement of the impact assessment interpretation
https://figshare.com/account/home#/projects/161443
https://doi.org/10.6084/m9.figshare.22224034

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