Article | Publisher preview available

Anaerobic digestion of elephant camp–derived wastes: methane potential, kinetic study, and biorefinery platform

May 2021 · Biomass Conversion and Biorefinery 13(7)
May 2021 · 13(7)
DOI:10.1007/s13399-021-01576-w

Authors:

Chayanon Nont Sawatdeenarunat
University of Hawaiʻi at Hilo

Sasithorn Saipa
Chiang Mai Rajabhat University

Pitchaya Suaisom

Abstract and Figures

Anaerobic digestion (AD) of elephant camp–derived wastes was studied using series of batch experiments. Three different materials derived from elephant dung namely fresh elephant dung (FD), washing water (WW), and washed fiber (WF) served as the substrates. The theoretical methane potentials of the solid substrates were 786.0 and 580.6 LCH4/gVSadded at standard temperature and pressure, for FD and WF, respectively. In addition, the cumulative methane yields were 275.7±1.6, 266.7±14.3, and 202.6±1.6 NmL/gVSadded for FD, WW, and WF, respectively. Also, there were no signs of an acid accumulation throughout the studies. For the kinetic study, the modified Gompertz equation fitted well with the experimental data with an R^2 more than 0.98. Moreover, FD showed the highest predicted methane production potential of 293.2 NmL/gVSadded. Since the methane yields of FD and WW were not significantly different, in practical terms, FD should be washed and subsequently, the generated WW could be served to anaerobic digestion. However, direct combustion seems to be a more promising biorefinery-based option for WF since its methane potential was relatively low, but the fibers had a high heating value. The integrated AD and thermochemical process could potentially generate more than 14,500 kJ/kg of FD. Graphical abstract

Biomass Conversion and Biorefinery (2023) 13:6175–6184
https://doi.org/10.1007/s13399-021-01576-w

ORIGINAL ARTICLE

Anaerobic digestion of elephant camp–derived wastes: methane potential, kinetic study, and biorefinery platform

materials derived from elephant dung namely fresh elephant dung (FD), washing water (WW), and washed fiber (WF) serve as the substrates. The theoretical methane potentials of the solid substrates were 786.0 and 580.6 LCH_4/gVS_{added} at standar temperature and pressure, for FD and WF, respectively. In addition, the cumulative methane yields were 275.7±1.6, 266.7±14.3 and 202.6±1.6 NmL/gVS_{added} for FD, WW, and WF, respectively. Also, there were no signs of an acid accumulation throughou the studies. For the kinetic study, the modified Gompertz equation fitted well with the experimental data with an R^2 more tha 0.98. Moreover, FD showed the highest predicted methane production potential of 293.2 NmL/gVS_{added}. Since the methan yields of FD and WW were not significantly different, in practical terms, FD should be washed and subsequently, the generate WW could be served to anaerobic digestion. However, direct combustion seems to be a more promising biorefinery-based optio for WF since its methane potential was relatively low, but the fibers had a high heating value. The integrated AD and thermo chemical process could potentially generate more than 14,500 kJ/kg of FD.

Keywords Anaerobic digestion · Elephant dung · Biochemical methane potential · Modified Gompertz model · Biorefinery

1 Introduction

In Thailand, in the past, elephants were raised mainly to work in the forestry industry. However, the significant deforestation and the strict regulations of the Thai government in 1989 had collapsed the logging industry [1]. Due to the aforementioned situations, the elephants were moved out of forests and started being raised in the animal farms, namely, elephant camps. The trend of elephant raising was then turned to be for recreation and touristry activities rather than for the serving industry. Recently, in northern Thailand, the elephant camps are one of the key businesses in the tourism industry resulting in an enhanced community-based economy. It was reported that more than 2700 elephants were raised in Thailand, and more than three-quarters of the elephant population were in th northern region [2]. However, each elephant could daily generate around 30 kg of dung containing a high portion of lignocellulosic biomass and organic matters (i.e., volatile soli [VS] of 34%) [3]. Thus, based on the waste generation and th number of elephants, a total of 61 tons of elephant dung (ED could be generated from the camps in the northern region c Thailand daily and could potentially be one of the mai sources of many environmental pollution.

✉ Chayanon Sawatdeenarunat
chayanon@cmru.ac.th

[1] Asian Development College for Community Economy and Technology, Chiang Mai Rajabhat University, Chiang Mai 50300, Thailand

[2] Energy Research and Development Institute-Nakornping, Chiang Mai University, Chiang Mai 50200, Thailand

Unfortunately, the majority of the activities in elephan camps, that is, animal feeding, barn cleaning, and tourist activities, such as elephant bathing, require a large amount o water. Thus, the camps are normally located nearby rivers and the generated waste could potentially contaminate th river body and could lead to water pollution. ED could contai a high number of fecal coliform bacteria (FCB) [4]. Typically FCB is the promising biological indicator representing th contamination from human and/or animal dung and coul cause many waterborne diseases (i.e., typhoid, dysentery and cholera among others) [5]. This contaminated strear could negatively affect the quality of life of the people livin downstream. Besides, like other animal manures, high nutrients in ED could facilitate the growth of algal biomass an

... Each elephant produces approximately 130 kg of dung daily [2]; improper disposal of such huge quantities of elephant dung (ED) could endanger the ecosystem [3]. Furthermore, elephant sanctuaries are typically located near rivers to facilitate certain activities, such as the elephants' bathing, drinking water, and barn cleaning, which are a big draw for tourist attention [4] . A conventional method of ED disposal has been letting it dry and burning it [5]. ...

... The combined AD and thermochemical process of sugarcane bagasse to valorize the digestate and optimize the benefit of the system was performed by Agarwal et al. [7]. Sawatdeenarunat et al. [4] calculated the energy potential from AB of ED and revealed that more than 14 MJ/kg of fresh dung could be obtained by integrating AD and torrefaction. ...

... At the startup period, the LBR was filled with a mixture of ED and ADPM in the 1:2 (VS-based) ratio [4] , with an initial TS of 200 g, resulting in a C/N ratio between 20 and 30. It should be confirmed that the biogas production from pre-incubated ADPM was not observed before being added to the LBR of each batch. ...

Integration of Solid-State Anaerobic Digestion and Hydrothermal Carbonization

Article Full-text available

Apr 2024

Sasithorn Saipa · Boonya Charnnok · Saoharit Nitayavardhana · Chayanon Nont Sawatdeenarunat

View Show abstract

... A noteworthy example of herbivore feces is elephant dung, which shares similarities with cow dung in terms of its composition and characteristics. Elephant can excrete approximately 30-150 kg/d of dung containing lignocellulosic food residues and organic matters [11] . For instance, in the northern region of Thailand, 33 camps exist that house 627 elephants, capable of generating up to 94 ton/d of elephant dung [12] and available in large quantities in many other areas. ...

... By converting this waste into biogas, it can be put to productive use while also reducing the environmental impact of the waste. ED can be utilized for biogas production in anaerobic digestion, serving as a co-digestion substrate alongside washing water and washed fiber obtained from elephant camps [11] , water hyacinth with ED, pig dung, and bat dung [14]. ...

... This suggests that the addition of NP and longer pretreatment periods can decrease gas production efficiency in comparison to mono-substrate use of ED. A previous study by Sawatdeenarunat et al. [11] found that fresh ED alone had a high potential to produce methane and biogas with cumulative methane yields of 275.7 ± 1.6 NmL/gVS added . The high potential of ED for methane production is attributed to its high cellulose content, which serves as a crucial substrate for the production of methane. ...

Anaerobic co-digestion of elephant dung and biological pretreated Napier grass: Synergistic effect and kinetics of methane production

Article

Aug 2023 · BIOMASS BIOENERG

Thaneeya Rangseesuriyachai · Jarungwit Boonnorat · Naraporn Glanpracha · Khathapon Pinpatthanapong

View

properly dispose of the large quantities of dung being produced in elephant orphanages. ...

... Elephant dung can be seen as a valuable source of lignocellulosic biomass that contains 34% to 47% cellulose, 19% to 28% hemicellulose and 14% to 18% lignin [3,4], but is still not fully utilized [5]. As valueadded products, previous studies have converted elephant dung into a biocoal fuel [2] and methane through anaerobic digestion [3] . The dung of elephants and other animals have also been used for the production of pulp, paper, and composite materials [5]. ...

Synthesis and phosphate adsorption performance of elephant dung biochar modified with magnesium and iron

Article Full-text available

Mar 2022

Navod Dhananjaya Bandara Abeysinghe · Kaewta Jetsrisuparb · Thissa Karunarathna · Jesper T.N. Knijnenburg

View Show abstract

... The combined AD and thermochemical process 57 of sugarcane bagasse to valorize the digestate and optimize the benefit of the system was performed by [6]. 58 Sawatdeenarunat et al. (2021) [7] calculated the energy potential from AB of ED and revealed that more 59 than 14 MJ/kg of fresh dung could be obtained by integrating AD and torrefaction. However, to the authors' 60 knowledge, no research has been conducted on integrating SS-AD of ED and HTC of the produced digestate. ...

Integration of Solid-state Anaerobic Digestion and Hydrothermal Carbonization of Elephant Dung for Elephant Sanctuary Waste Management

Preprint Full-text available

Dec 2023

Sasithorn Saipa · Boonya Charnnok · Saoharit Nitayavardhana · Chayanon Nont Sawatdeenarunat

View Show abstract

... %), and lignin (14.91-18.15 %) (Saripan and Reungsang, 2014; Sawatdeenarunat et al., 2021) . Therefore, disposal of such a quantity of elephant dung is a complicated and lengthy process. ...

Optimization of elephant dung green fuel briquette production using a low-pressure densification technique and its characterizations, and emissions

Article

Feb 2023

Artidtaya Mainkaew · Adisak Pattiya · Surachai Narrat Jansri

View Show abstract

... In this case, the Taguchi "super-ranking" approach was employed for optimisation [25] . The slurry of chicken, layer manure and cow dung with tap water were performed in a digester with a solid to liquid ratio of 1:1. ...

Optimisation of anaerobic digestion of layer manure, breeding manure and cow dung using grey relational analysis

the biogas was in the range of 30-50%. This result is similar to previous studies reported in Sawatdeenarunat, Saipa, and Suaisom (2021) , which disclosed various lignocellulosic biomasses (50% Napier grass and 52% rice straw). Moreover, the daily methane production differed between the NP untreated and the NP pretreated groups. ...

Biogas production by co-digestion of sodium hydroxide pretreated Napier grass and food waste for community sustainability

Article

Mar 2022 · ENERG SOURCE PART A

Khathapon Pinpatthanapong · Jarungwit Boonnorat · Naraporn Glanpracha · Thaneeya Rangseesuriyachai

Energy Potential from Elephant Camp Derived Waste

May 2022

Chayanon Nont Sawatdeenarunat · Sasithorn Saipa · Hathaithip Sinthuya

This research aims to determine an appropriate elephant-camp derived waste management by converting to heat energy. Two waste conversion processes were categorized in this study: (1) directly converted fresh elephant dungs (FD) to heat energy and (2) anaerobically digested FD to biogas and subsequently, converted digestate (DT) to heat energy. Initially, FD were analyzed to examine the ... [Show full abstract]

View full-text

Article Full-text available

Integration of Solid-State Anaerobic Digestion and Hydrothermal Carbonization

April 2024 · BioEnergy Research

Sasithorn Saipa · Boonya Charnnok · Saoharit Nitayavardhana · [...] · Chayanon Nont Sawatdeenarunat

The purpose of this research was to develop an integrated biorefinery process of solid-state anaerobic digestion (SS-AD) and hydrothermal carbonization (HTC) for the co-production of methane and hydrochar using elephant dung (ED) as substrate. With a leachate recirculation rate of 4 times/day, the SS-AD presented the highest cumulative methane yield of 83.2 ± 1.7 NmL/g volatile solid (VS)added ... [Show full abstract]

View full-text

Preprint Full-text available

Integration of Solid-state Anaerobic Digestion and Hydrothermal Carbonization of Elephant Dung for E...

December 2023

Sasithorn Saipa · Boonya Charnnok · Saoharit Nitayavardhana · [...] · Chayanon Nont Sawatdeenarunat

The purpose of this research was to develop an integrated biorefinery process of solid-state anaerobic digestion (SS-AD) and hydrothermal carbonization (HTC) for the co-production of methane and hydrochar using elephant dung (ED) as substrate. With a leachate recirculation rate of 4 times/day, the SS-AD presented the highest cumulative methane yield of 83.2 ± 1.7 NmL/g VS added and VS removal ... [Show full abstract]

View full-text

Article Full-text available

Napier grass (Pennisetum purpureum) is a high yield tropical grass with great potential for anaerobic digestion. Two-phase anaerobic