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# Assessment of nutrient recovery, air emission and farmers' perceptions of indigenous mound burning practice using animal and human wastes in Myanmar

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ABSTRACT

Soil fertility degradation is threatening the sustainability of the global agricultural production system. Unimproved onsite sanitation systems along with inappropriate disposal of fecal sludge (FS) are predominant in the urban areas of low-income countries and rural areas all over the world. At the same time, animal waste is already used as a very common fertilizer, while the use of human waste, which has high nutrient value, is still limited. Since global issues of waste disposal and soil infertility are becoming more serious, research should be carried out to solve these problems. Hence, mound or heap burning, an indigenous agricultural practice which is currently being conducted in some remote areas in the eastern part of Myanmar and other less developed countries in Asia and Africa, was studied in this research. In traditional mound burning (MB) practice in Myanmar, dried cow dung (CD) is burnt and covered with soil to form a mound. This research was conducted (1) to study the level of nutrient recovery from the indigenous practice of MB-CD; (2) to integrate the use of FS into the indigenous practice of MB-CD; (3) to identify the environmental challenges of the practice, such as pathogens contamination and air pollution; and (4) to investigate the perceptions of farmers toward the use of FS in their farms and of the consumers toward consuming FS-fertilized crops. This study found that plant nutrients such as available nitrogen, phosphorous and potassium were increased by approximately 8, 2 and 2 times, respectively, after the 3-month maturation period in both MB experiments with both FS and CD. Moreover, there was no detection of the total coliform, *Escherichia coli* bacteria and *Ascaris lumbricoides* eggs after MB of both FS and CD. The emission factors of CO, $NO_x$, $PM_{2.1}$ and $PM_{10}$ from both MB-FS and MB-CD were found to have a relatively low impact on the environment compared with other burning processes. The perceptions of farmers in the study area also revealed that most of them preferred to use the dried/treated FS in their farms, which was similar to the perceptions of consumers. This research revealed that MB could recover the nutrients from both human and animal wastes, which could then be used as fertilizers applied in agricultural fields with less environmental impact from pathogen contamination and air pollution.

## 1. Introduction

Due to the increasing problems of arable land shortage and soil infertility, local farmers are adopting several soil fertility management methods in a bid to optimize crop production. Simultaneously, the high rate of consumption along with population growth have resulted in a rise in pollution from faecal sludge (FS) including pathogen infections (Asl and Hosseini, 2000). For example, as a result of nutrients transported from surrounding farms and sanitation systems, the degraded eutrophic water quality of Inle Lake in Shan State, the second largest lake in Myanmar and the setting for this research, is reported to be unfit for domestic use. Moreover, the frequent diarrhoea infections caused by pathogen contamination are attributed to the inappropriate FS disposal systems used in the study area (Akaishi et al., 2006; Htwe, 2008), which is the same problem as found by Debela et al. (2017). The inappropriate emptying and disposal of FS are consequences of the limited available budget, lack of appropriate technology, and poor management of the sanitation systems in developing countries (Ingallinella et al., 2002; Fischer et al., 2012).

Research has been carried out on a wide variety of innovative

*Abbreviations:* CD, cow dung; EF, emission factor; FS, faecal sludge; K, potassium; MB, mound burning; N, nitrogen; P, phosphorous

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methods to reuse FS in agricultural soil and recycle its nutrients (Ledere et al., 2015; Hargreaves and Warman, 2008; Smider and Singh, 2014). While advanced nutrient management methods are being developed, the existing indigenous practices should also not be overlooked (Büttner and Hauser, 2003). Besides, if a reuse method is not able to inactivate pathogens such as faecal coliforms, *Escherichia coli*, *Giardia lamblia cysts*, *Ascaris lumbricoides eggs*, etc., the use of both animal and human wastes in agriculture creats a high risk of microbial contamination to plants and soil, and eventually to human health (Landa-Cansigno et al., 2013, Estrada et al., 2004; Brochier et al., 2011). At the same time, it is a matter of fact that in most developing countries, FS does not get the recognition it merits as a potential resource, but is considered taboo and therefore rejected for use on farms (Gjefle, 2011; Appiah-Effah et al., 2015).

Mound burning (MB), part of a shifting cultivation system which is currently being practiced by indigenous people in remote areas of Myanmar and other less developed countries in Asia and Africa (Tadesse, 2015; Myint and Su, 2001) is highlighted in this study. In fundamental terms, MB involves three steps; 1) placing a piece of already burnt CD with some pieces of unburnt CD on the soil surface; 2) topping it with some grass/rice straw; and 3) stacking a big clot of soil on top of this, followed by medium- and fine-size soil to form the mound (Fig. 1a). The combustion process is slowly initiated inside the mound. Generally, the mounds will be spread out after 3 months of MB (Fig. 1b), and upland rice cultivation will be followed by the addition of less or no chemical fertilizer and a crop rotation system until the next fallow period.

While the study of the indigenous MB process itself is a very new topic, no research has ever been conducted on the use of FS in the MB process. Since the plant nutrient value in FS is as high as in CD (Czemiel, 2000; Strande et al., 2014) and the high temperature combustion process enhances the elimination of harmful pathogens, there is a genuine feasibility of using FS in the MB process. Moreover, unlike a typical slash-and-burn land clearing system in shifting cultivation or the open burning of crop residue which usually results in severe air pollution (Gadde et al., 2009; Streets et al., 2003), the indigenous practice of MB involves the semi-closed combustion of the mixture of cow dung (CD) and crop residue/rice straw inside the soil mound, which is shown to produce less air pollution. Technical findings alone are never enough for the practical implementation, the perceptions of farmers and consumers with regard to using FS in agriculture should not be ignored.

This research aimed to investigate the recovery of nutrients such as nitrogen (N), phosphorous (P) and potassium (K) from MB with CD (the conventional biomass used) and FS to assess the technical feasibility of using FS as a resource in agriculture rather than ending up only as a waste. Nevertheless, the potential environmental challenges of MB, such as pathogens contaminations of crops and soil as well as, the emission of gases (CO and $NO_x$) and particulate matters released from the system, were also determined. The social aspect of the farmers' perceptions and consumers' willingness to accept the use of FS as a fertilizer were also studied.

## 2. Material and methods

### 2.1. Background of the study area

The study area is Ywa Ngan Township in the Taunggyi District of Shan State, which is the easternmost part of Myanmar. The area is comprised mostly of hills with a few hectares of flat plains and a valley in the center where the indigenous Danu minority tribe live (Fig. 2). Located at 1219 m above sea level, the temperatures in the Township range from 8° to 30 °C throughout the year. The area receives 1940 mm of average annual rainfall with precipitation peaking during the rainy season from June to September. Out of total population of 80,700 in Ywa Ngan Township, approximately 6% and 94% reside in town and surrounding villages, respectively. The Township covers a total area of 265,724 ha, of which 10% is mainly rain-fed agricultural land with the remainder comprised of forest, fallow and residential land. The soil profile in the study area is silty clay loam soil. Upland rice, peanuts, niger, maize, sunflowers, potatoes, coffee and tea are the major crops grown in Ywa Ngan Township (Ywa Ngan Department of Agriculture and Irrigation, 2016). The full-scale mound burning experiments were conducted in 2016 (February to May) at one of the shifting cultivation sites, approximately 5 km off from the main road, at 21°09′33.3″ N and 96°29′02.4″ E, where MB was being practiced by the local farmers. The questionnaire survey was conducted at the Kyauk Pon Village, nearby the experimental site (Fig. 2).

### 2.2. Experimental setup

During the field-scale MB experiments, the ambient temperature, humidity, and wind speed were ranging from 18 to 30 °C, 33–88%, and 2.5–9.3 mph, respectively. There were 2 mounds used in the experiments. The diameter and height of each mound were 1.5 and 0.3m, respectively. One mound was fed with 180 g of CD and 40 g of rice straw, and then covered with 148 kg of the indigenous soil. The same height and ratio was applied with the second mound, but FS was fed instead of CD. The CD and FS samples used in the experiments were solar dried for 3–5 days to reduce the moisture content to approximately 3–5%. The full-scale MB experiments were done in triplicate. After the combustion process was initiated inside the mound, temperatures at the center of the mound were measured using a calibrated digital thermometer CENTER 300 with K type thermocouple attached with immersion probe. The combustion process normally lasted for about 5 days, followed by 3 months of maturation before the burnt products were spread out for cultivation.

### 2.3. Analytical methods

Composite soil samples (bottom, middle and top) were collected

**(a)** **(b)**

**Fig. 1.** (a) Mound burning right after processing (b) Mound burning after 3 months maturation period.