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Vermicomposting as manure management strategy for urban small-holder animal farms – Kampala case study

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ABSTRACT

Inadequate organic waste management can contribute to the spread of diseases and have negative impacts on the environment. Vermicomposting organic waste could have dual beneficial effects by generating an economically viable animal feed protein in the form of worm biomass, while alleviating the negative effects of poor organic waste management. In this study, a low-maintenance vermicomposting system was evaluated as manure and food waste management system for small-holder farmers. A vermicomposting system using the earthworm species *Eudrilus eugeniae* and treating cow manure and food waste was set up in Kampala, Uganda, and monitored for 172 days. The material degradation and protein production rates were evaluated after 63 days and at the end of the experiment. The material reduction was 45.9% and the waste-to-biomass conversion rate was 3.5% in the vermicomposting process on a total solids basis. A possible increase in the conversion rate could be achieved by increasing the frequency of worm harvesting. Vermicomposting was found to be a viable manure management method in small-scale urban animal agriculture; the return of investment was calculated to be 280% for treating the manure of a 450 kg cow. The vermicompost was not sanitised, although hygiene quality could be improved by introducing a post-stabilisation step in which no fresh material is added. The value of the animal feed protein generated in the process can act as an incentive to improve current manure management strategies.

1. Introduction

Like many other fast-growing urban centres in the developing world, Kampala, the capital of Uganda, does not have the infrastructure nor the economic capacity to properly treat and dispose of solid waste (Lohri et al., 2013; Memon, 2010). In Kampala, an estimated 1500 tonnes of solid waste is generated every day, of which only 40% is collected and taken to landfill (OAG, 2010). The majority (92%) of the solid waste taken to landfill is organic material (Komakech et al., 2014b). At the landfill, this organic material decomposes anaerobically and produces the potent greenhouse gas methane (Eleazer et al., 1997). In Kampala there is one official landfill, which operates as an open dump, and many unofficial open dumps. Greenhouse gas emissions from open dumps have been estimated by Manfredi et al. (2009) to be 1000 kg CO_2 equivalents tonne^{-1} waste and therefore the organic waste discarded on open dumps has a high global warming factor. Kampala has around 4000 cows, 3000 goats, 9000 pigs and 250,000 chickens, which together generate a considerable amount of manure (Komakech et al., 2014a). Most of the manure produced (59%) is discarded in one way or another (left untouched, dumped in storm channels), while 32% is spread untreated as fertiliser (Komakech et al., 2014a). Animal manure is a known source of zoonotic pathogens (Pell, 1997) and it is thus a major risk factor for the spread of disease among both animals and humans if left untreated (Albihn and Vinnerås, 2007). Organic waste and animal manure contain valuable plant nutrients and organic compounds that can restore degraded soils and ensure sustainable long-term agricultural activity (Diacono and Montemurro, 2010). Properly treating the organic waste fraction reduces the environmental impact by avoiding greenhouse gas emissions from landfills (Hoornweg and Bhada-Tata, 2012) and decreasing/avoiding the need for chemical fertiliser (Pimentel et al., 2005).

Over the past decades, African soil fertility has degraded to alarming levels with intensified farming (Morris et al., 2007). Henao and Baanante (2006) reported that the yearly net loss of NPK from soils in many African countries, including Uganda, is

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greater than 60 kg ha^{-1}. Organic fertilisers are important in the process of regenerating, and also maintaining, soil fertility (Diacono and Montemurro, 2010; Meng et al., 2005).

In Kampala, the demand for livestock products have increased in recent years due to urbanisation, population growth and increased income (Lumu et al., 2013). However, high quality animal feed protein is expensive and hard to find (Katongole et al., 2012).

By vermicomposting the organic waste, both these issues could be tackled. During the vermicomposting process the organic waste is converted into two valuable products: organic fertiliser (Arancon et al., 2004; Atiyeh et al., 2000) and worm biomass, which can be used as a protein source in animal feed (Mitchell, 1997). In this way, animal feed is produced directly from waste.

The most commonly used earthworm species in vermicomposting are *Eisenia feotida* and *E. andrei* (Dominguez and Edwards, 2010). Another possible species, the African night crawler (*Eudrilus eugeniae*), is a large worm that is native to the African continent (Dominguez et al., 2001). Compared to the commonly used *E. feotida*, *E. eugeniae* is larger, have a similarly high reproduction rate but has somewhat smaller tolerable temperature range; it does not survive below 12 °C or above 30 °C for prolonged periods (>50 days) (Viljoen and Reinecke, 1992). For Kampala, with a mean minimum temperature of 17.5 °C and a mean maximum temperature of 27.9 °C over the year (World Meteorological Organization, 2014), the usage of *E. eugeniae* is favourable.

The aim of this study was to evaluate the potential of vermicomposting as manure and food waste management strategy for small-holder urban animal farmers. Vermicomposting technology was selected as it has been demonstrated to efficiently reduce material volume, while at the same time generate worm biomass that can be used as animal feed protein (Ibáñez et al., 1993) and vermicompost, a valuable organic fertiliser (Garg et al., 2006). A low-maintenance vermicomposting system for the treatment of cattle manure and food waste was set up was run for 172 days, key parameters were analysed after 63 days and at the end of the experiment. Samples of the inflow material, produced vermicompost and generated worms were collected; process efficiency was evaluated and an economic assessment of the treatment potential conducted.

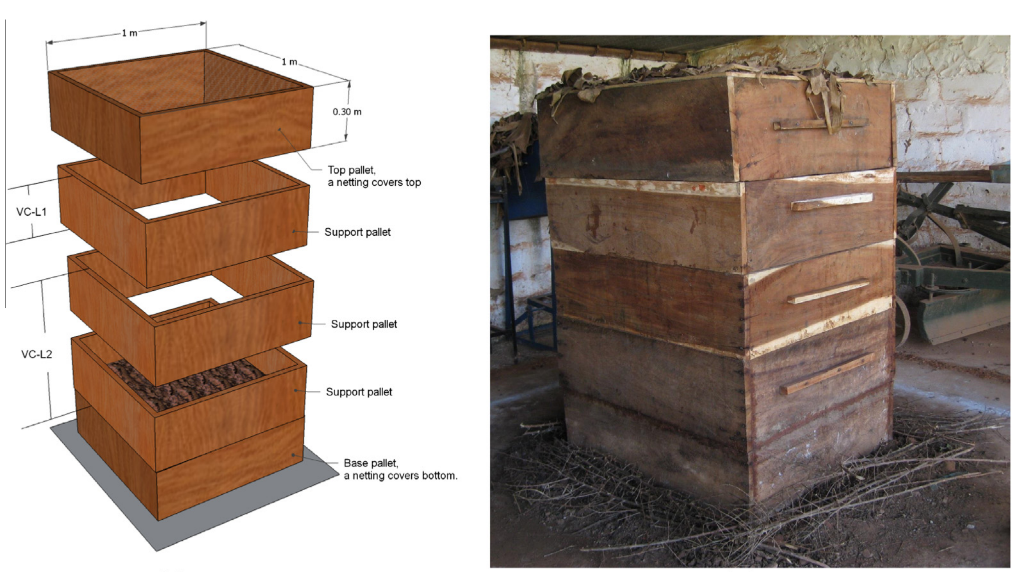
2. Material and methods

2.1. Vermicompost unit

The vermicomposting unit was placed at the Makerere University Agricultural Research Institute Kabanyolo (MUARIK) on the outskirts of Kampala, Uganda, and was run by research technicians at the site. The treatment unit consisted of custom-made hardwood pallet frames – made of wood from the tree *Albizia coriaria* (local name *mugavu*), used for its anti-termite properties – that were stacked on top of each other. At the start of the experiment the unit consisted of a base pallet, a support pallet and a top pallet (Fig. 1a). With the accumulation of material in the unit, additional support pallets were added, to a maximum of three support pallets (five pallets in total). The base pallet had netting on the bottom, to prevent rodents from entering, and was filled with bedding material in the form of matured compost. The bedding material acts as a refuge for the worms when the conditions in the compost become unfavourable (*e.g.* high temperature or ammonia concentration (Dominguez and Edwards, 2010)). Damp newspaper balls were placed at the edges of the pallet to encourage cocoon laying, a method that had been observed to improve the rate of cocoon production in previous experiments. The top pallet was covered with netting to support banana leafs, used to block out light (Fig. 1b).

2.2. Addition of earthworms and waste to the treatment unit

Earthworms of the indigenous species *E. eugeniae*, found in manure piles, were used in the treatment unit. At the start of the experiment 1700 earthworms were placed in the bedding material and the waste added on top. The unit was top feed, *i.e.* fresh waste was added on top of processed waste with a feeding frequency varying between every day to every third day. After one month (day 29) another 1900 earthworms were added to the system. The unit was mainly fed three-day-old manure (around 80% of total feed added), but also food waste (around 20% of total feed added). The amount of waste added to the unit was adjusted in accordance with the amount consumed by the earthworms (Table 1). At the start of the experiment, the feeding rate was quite high (49 ± 10 kg per week in week 5–9). It was noted that the



(a) (b)

Fig. 1. Schematic representation (a) and photo (b) of the vermicompost treatment unit. The unit was made up of hard-wood pallets (1 × 1 × 0.30 m) stacked on top of each other. The base and top pallets had a netting covering the bottom/top, the base pallet was filled with bedding material. The two levels analysed are shown in the schematic representation.