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Municipal organic waste management: challenges and opportunities in Tamale, Ghana

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Disposal of Municipal Solid Waste (MSW) in ditches and streams is a common practice in developing countries and this contributes to environmental health problems. Although composting of MSW and its use as fertilizer is one of the sustainable pathways to manage MSW, improve environmental health and increase agricultural productivity, it is yet to be well developed as a successful business. This study analyzes the challenges and opportunities of the MSW composting business in the Tamale area, Ghana, by exploring a case study. DeCo! is a NGO - that produces compost from MSW and other agro-industrial waste in Tamale. DeCo-compost is rich with plant nutrients (4.7 gN, 0.85gP, and 1gK per kg of compost) and no health risks have been reported. DeCo-compost+mineral fertilizer produced significantly higher ($P<0.0001$) yields of maize (3.3±0.7 tons/ha) compared to that which was produced by control (0.45±0.2 tons/ha) or using mineral fertilizer (2.2±0.6 tons/ha).

Background

A high proportion of MSW (municipal solid waste) could be recycled to generate income while also helping to protect the environment. The United States Environmental Protection Agency (2007) has recommended recovery by recycling as one of the most effective waste management techniques. Composting is one of a variety of good management solutions for MSW. It is a microbial based aerobic process which is now considered as an environmentally safe and effective way to reduce organic waste and produce organic fertilizer or soil conditioner (Gajdos, 1992). Problems associated with MSW management in developing countries are quite different from those found in developed countries. Solid waste generation in developing countries is estimated to range from 0.4-0.6 kg/person/day with a large amount of organic waste (food and vegetable waste) while in developed countries estimates range from 0.7-1.8 kg/person/day. Waste density and moisture content is 2-3 times greater in waste generated from developing countries as compared to those in developed countries (Cointreau, 1982; Blight and Mbande, 1996; Arlosoroff, 1982). The high moisture content and organic composition of waste accompanied by the high temperatures in tropical countries may lead to fast decomposition rates.

MSW in Ghana

Generally waste disposal in Ghana is similar to that in many developing countries within the tropical region. Landfills in Ghana are primarily open dump sites without leachate or gas recovery systems. Several of these sites are located in ecologically or hydrologically sensitive areas. Based on an estimated population of 24.7 million (Ghana statistical service 2010) and an average daily waste generation per capita of 0.45 kg, Ghana generates daily about 11,000 tons of solid waste while only 10% of solid waste generated is properly disposed off (Fact sheet SWD in Ghana, 2005). Tamale, a Metropolitan city in northern Ghana, with a population of 371,000 (Ghana statistical service 2010) generates 250 tons/day. Of this amount, 80% is organic but varies depending on season (Tamale Metropolitan Assembly (TMA) 2012 interview).

Ghana is very conducive for composting in terms of waste composition and weather conditions. Despite this, composting is yet to become an option for treatment of waste as resource recovery and reuse. Commercial compost needs to compete with subsidize mineral fertilizer or manure and useful organic waste

which can be available free of charge in some cases. For example; Drechsel (1996) reported that poultry manure which could have been used by farmers without any cost was dumped or burned on road sides in Kumasi. Furthermore, farmers prefer poultry manure since it may be: (1) available at no charge or low priced (US$ 0.09-0.28/30-35 kg bag), (2) effective in terms of providing nutrients for plants, (3) its long term effect on improving soil quality. Therefore, it would be expedient to study demands for compost and the market competition for sustainable compost businesses.

In Ghana there are several individuals and organizations involve in formal or informal compost production. DeCo-Farming is a successful non-governmental organization (NGO) dealing with waste business in Tamale, Northern Ghana. It won the SEED Initiative awards in 2010. DeCo-Sustainable farming is one of the good examples of medium level waste reuse business organizations in Ghana.

There are a number of challenges and opportunities within the composting MSW business. This paper will explore these by analyzing the findings obtained from IWMI (International Water Management Institute) and DeCo-farming.

Materials and methods

This paper is based on a case study of DeCo-farming, its work with SARI (Savanna Agricultural Research Institute) and IWMI's findings on composting in Ghana. It also includes interviews (authors have conducted interviews to collect information in 2012) with experts from the Metropolitan waste management department of TMA, interviews with experts from the University of Development Studies, Ghana (UDS). We also observed the DeCo-compost production site, and maize cultivation trials using DeCo-compost and interviewed farmer group leaders (N=7) in Tamale near the DeCo-farming composting production site. Data from field trials was plotted in IBM SPSS Statistics 19 for statistical analysis. Data was also analyzed using one-way ANOVA combined with Tukey's Post Hock Test.

DeCo-farming

An investigation of compost production was conducted in Tamale, Ghana. MSW conveyed by Zoomlion trucks to DeCo's production site was manually separated as organic waste (biodegradable) and other waste (non-biodegradable). The organic waste was weighed and mixed with specific amounts of other wastes namely, poultry manure, neem leaves, rice husk, straw and shea butter (*Vitellaria paradoxa*) waste. This mixture was passed through the windrow composting process, i.e. piling of waste mixture in long rows of about 1.5 meters in height and 2m wide. One compost pile was prepared with 1 ton of waste. These waste piles were mixed twice a week and moistened as needed for 4-5 weeks. After the 5th week the decomposed waste material matured into compost. This compost was screened for un-decomposed materials, sieved and air dried for 1-2 weeks. Semi dried compost was packed in 50 kg sacks and sold to several farmer's organizations, local NGOs and research institutions. The MSW and the ready compost were analyzed for basic physiochemical characteristics (Table 1). Furthermore, DeCo-compost has been demonstrated its fertilizer value on crops through field trials on 2010 in different locations of Northern region in Ghana (Figure 1). The trials were conducted using no fertilization (control), mineral fertilization (recommended amount) and compost (3 tons/ha) + mineral fertilizer (half of the recommendation, i.e. 26 kgN/ha).

Table 1. Nutrients content in raw material and compost final products. The data on nutrient contents in Tamale soil was from SARI)

Nutrients contents	Poultry manure	% in raw material (mixture)	compost	Soil in Tamale region
Total-N (total nitrogen)	0.65 %	Neem leaves 0.5%	0.5%	0.02 - 0.09% i.e. ≤ 20% crop requirement
Total-P (total phosphorus)	588 mg/kg		848 mg/kg	8 ppm i.e. ditto
Total-K (total potassium)	7784 mg/kg		1017 mg/kg	20 -150 ppm
pH	6.97		8.78	
Organic matter	7.9 %		5.6 %	0.5% - 0.9%
Ca				0.3 - 3.0 cmol+ 'cos of low CEC
Mg				0.3-3.0

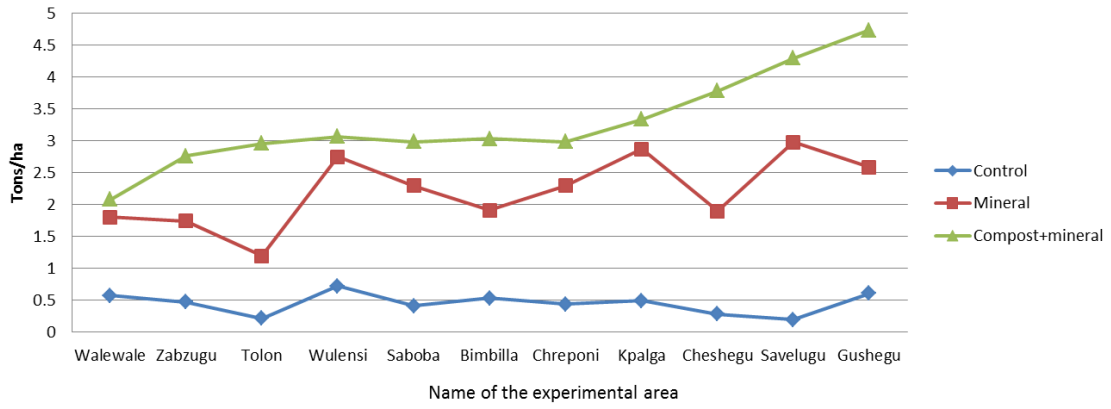

Figure 1. Effect of different fertilizer in maize cultivation in different location of Northern Ghana

Results

DeCo! used about 120 tons of MSW and some other waste (Table 1) annually to produce about 200 tons of compost. This compost was packed in 50 kg sacks and sold at a market price of GH¢ 3-4/50 kg sack (US$ 1 = GH¢ 1.88 on December 2012). The entire production was sold to local NGOs, farmer's communities and research institutes. DeCo recommends compost application of 120 bags/ha (6 t/ha) alone or 60 bags/ha (i.e. 3 tons/ha in addition to a half of the recommended mineral fertilizer (NPK 15:15:15) rate.

In field trials of maize cultivation; compost+mineral fertilizer produced significantly ($F = 76.12$; $P<0.0001$) higher maize yields compared to the control and mineral fertilizer alone. The results showed that the control (no fertilizer) produced 0.45±0.2 tons/ha, mineral fertilizer produced 2.2±0.6 tons/ha, and compost + mineral fertilizer produced 3.3±0.7 tons/ha (Figure 1). In certain areas this treatment, i.e. compost+mineral fertilizer, produced more than 4.5 t/ha (figure 1).

Discussion

All the farmers using the DeCo produced compost in Tamale stated that the compost is very effective, a good source of plant nutrients and thus improved the fertility of the soil. But IWMI (2004) reported that only 30 % (out of 200 respondents) of farmers had positive perceptions about compost and they also asked for field demonstrations to know more about its effectiveness. The preference of DeCo products might be because of the practical demonstration of the product's effectiveness and the responses observed with maize. During field trials conducted in several locations, DeCo-compost + mineral fertilizer produced 2.8 tons/ha more maize yield than the control (no fertilization) and 1.1 tons/ha more than mineral fertilizer alone. This result showed that DeCo-compost combined with mineral fertilizer is very effective. Organic matter (OM) contained in compost might be important in increasing microbial population in soils, which increases the availability of nutrients for plants (Frossard et al. 2000). Therefore, it is recommended that DeCo-compost be used as a complement to mineral fertilizer in ratios of 2:1 ratio as confirmed during the field trials.

In Tamale, DeCo-farming utilizes a very small proportion of the municipal waste generated in the city. However, DeCo plans to increase its production levels in a (yet to be implemented) project in collaboration with Zoomlion. This projects aims to meet the increasing demand for compost. Although the business of DeCo- Sustainable farming is successful, a lot more could be done on the marketing and improvement of nutrients contain in the compost, if the goal of up scaling is to be realized. Tamale, a Metropolitan city in northern Ghana can produce 73,000 tons of organic waste/year, which can produce 36,000 tons of compost. This amount of compost can produce about 1,694 tons of cereal grain [(it is calculated that 1 kg of fertilizer ($N+P_2O_5+K_2O$) can produce about 10 kg of cereal grains (FAO, 1984)]. Since fertilizer is a very important means to increase food production, and fertilizer is progressively becoming expensive (Hargrove, 2008), it is possible that compost fertilizer may be an effective way forward.

It was realized that there are large numbers of farmers who might be interested in the use of compost but most of them are not aware of the benefits of using it. That said the study confirmed that participatory demonstrations are one of the best marketing strategies to increase market share in the compost business.

This argument is supported by the similar results presented by IWMI (2004) and Danso (2002). IWMI (2004) identified the potential buyers of compost in Ghana to be: (1) vegetable farmers, (2) staple crop farmers, (3) backyard farmers, (4) agro-industrial farmers (5) ornamental flower producers and (6) real estate developers as well as landscape designers. In Tamale area, cotton companies are a large group of potential buyers and their mean WTP (willingness to pay) was only US$ 1.4/50kg because they were cautious about the returns from compost (IWMI, 2004). This is similar to the market price for DeCo compost.

Analyzing the sustainability of compost production

Long term success with commercial compost production depends on a number of prerequisites as reported by Danso (2002) with regard to co-compost (Table 2). The farmers group of DeCo-farming stated that market prices are reasonable and they are willing to use DeCo-compost as they are aware of the importance of the OM which is available in the compost. This contradicts the result presented by Danso (2002). This might be because this statement was from the farmers who are benefiting by using DeCo-compost but Danso's data was collected from farmers who have not been using compost fertilizer. Awareness of the use of compost is important, and practical demonstrations are a good and easily understandable way of approaching farmers towards raising their awareness (IWMI, 2004; Pradhan et al. 2011).

Use of compost alone is comparatively expansive when compared to mineral fertilizer. It costs GH¢ 360 to fertilize a hectare of land with compost fertilizer as compared to GH¢ 180 for fertilizing a comparable area of land with mineral fertilizer and here with Sulphate of Ammonia (NPK 15-15-15) - calculation is based on; price of NPK 15-15-15 being GH¢ 27/50 kg and price of Sulphate of Ammonia being GH¢ 18/50 kg, after subsidies- (ref, Ghana News Now 2010). The NPK 15:15:15 as 250 kg/ha (38 kgN/ha) and Sulphate of Ammonia as 125 kg/ha is recommended for maize; i.e total NPK 60-40-40 (MoFA, Ghana)). However, if compost (60 bags/ha) are mixed with 125 kg of mineral fertilizer and 63 kg/ha of Sulphate of Ammonia the total cost will be GH¢ 270/ha, which is higher than the price for recommended NPK. On the other hand, this compost+mineral fertilizer can produce 1 ton maize/ha or earn GH¢ 500 more than can be achieved by mineral fertilizer alone (calculated as GH¢ 0.5/kg maize; ref. -modern Ghana 16th October 2012). With this calculation, use of DeCo-compost combines with half the recommendation NPK is overall economically beneficial for farmers. However, it was realized that the price of the compost can still be reduced by reducing production costs, and that this can be done by: (1) establishing decentralized compost plants, (2) sorting MSW at the household level, and (3) finding alternate Nitrogen sources.

Table 1. Farmers perception of Co-Compost in Ghana (Acceptability study; n=608 and Perception study; N= 200-221)

Acceptability	Kumasi	Accra	Tamale
Acceptable (%)	83	17	74
Unacceptable (%)	84	16	80
Perceptions			
Cheap (%)	15	9	7
Reasonable (%)	37	32	12
Expensive (%)	48	59	81

Source: Danso, 2002.

Conclusions

DeCo-compost with mineral fertilizer produced 2.8 tons/ha and 1.1 tons/ha more maize yield compared to the control (no fertilization) and mineral fertilizer treatments, respectively. This can be expressed another way to say that, farmers can earn GH¢ 550/ha more by using compost+mineral fertilizer compared to mineral fertilizer alone. Farmers themselves were satisfied with the agriculture productivity they achieved by using DeCo-compost. During this study it became clearly evident that active promotion of compost as a

viable fertilizer is required to make composting a successful business. For raising awareness, it is important to conduct practical demonstrations in the field through participatory sessions with farmers.

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References

Blight, G.E. and Mbande, C.M. (1996). *Some problems of waste management in developing countries.* Journal of Solid Waste Technology and Management 23, no. 1, February 1996. pp 19-27.

Cointreau, S. (1982). *Environmental Management of Urban Solid Wastes in Developing Countries:* A Project Guide. Washington, DC: Urban Development Department, World Bank.

Danso, G. (2002). *Farmers Perception and Willingness to pay for urban Waste Compost in Ghana.* M.Sc Thesis. Department of Agricultural Economics and Farm Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Drechsel, P. 1996. *AFRICALAND - Applied research for peri-urban areas.* IBSRAM Newsletter 42:5-7.

Fact Sheet-Nov (2005): SWD (Solid Waste Disposal) in Ghana. http://www.trend.watsan.net/page/576

Frossard, E., Condorn, L.M., Oberson A., Sinaj S. and Fardeau J.C. 2000. Processes governing phosphorus availability in temperate soils. Journal of Environmental Quality 29, 15–23.

FAO (1984) *Fertilizer and Plant Nutrition Guide*. Fertilizer and Plant Nutrition Bulletin 9, FAO, Rome.

Gajdos, R., (1992). *The use of Organic waste materials as organic fertilizer- recycling of plant nutrients.* Acta Hortic., 302: 325-331.

Ghana News Now. (2010). http://www.ghananewsnow.com/2010/06/15/government-subsidizes-price-of-fertilizer/

Hargrove, T., 2008. IFDC, 256-381-6600, http://www.eurekalert.org/pub_releases/2008-08/i-tft082508.php

IWMI (international water management institute) (2004) report. *Closing the rural-urban nutrient cycle via composting and co-composting* Final Project Report.

Modern Ghana, (2012) *Farmers to get more cash for rice, maize, soya bean*–NAFCO. 16 October http://www.modernghana.com/news/424229/1/farmers-to-get-more-cash-for-rice-maize-soya-bean-.html

MoFA Ghana. http://mofa.gov.gh/site/?page_id=826

Pradhan, S.K., Piya, R.C., and Heinonen-Tanski., H. 2011. *Eco-sanitation and its benefits- an experimental demonstration program to raise awareness in central Nepal*. Environment, Development and Sustainability. 13, 507-518.

U.S. Environmental Protection Agency. 2007. *Standards for the use or disposal of sewage sludge* (40 Code of Federal Regulations Part 503). U.S. Environmental Protection Agency, Washington, D.C.

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