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Fertiliser Derived from Fecal Sludge in Sri Lanka: Analysis of Plant Nutritional Value and Heavy Metal Contamination

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Introduction

Many developing countries like Sri Lanka face severe issues concerning their organic waste streams. The most obvious problem is urban waste disposal. In many municipalities waste services are restricted to collection and disposal only, whereas treatment and recycling options are hardly implemented, resulting in environmental pollution instead of resource recovery.
Furthermore, most current sanitation systems waste agricultural resources from human excreta since they are either disposed of (e.g. pit latrines, ashes of incinerated sewage sludge) or enter the aquatic system.
It is assumed that new approaches towards a processing of these two waste streams are needed to make them accessible for agriculture. Especially the use of co-composted fecal sludge (FS) and organic municipality waste (MSW) as a fertilizer could be a promising method, which could contribute to soil improvement and to resource protection by recycling of nutrients and organic carbon as well as protecting citizens towards hazardous substances. Consequently, there is a need for assessments of its plant nutritional value and its properties.
This study will give a perspective on the potential to utilize the mentioned urban waste streams based on the results of chemical analyses of four different FS and MSW derived co-composts to be used as agricultural resource.

Material and Methods

Four varieties of the co-compost were analysed in the agricultural laboratory at the University of Applied Sciences in Osnabrueck.

Table 1: treatment code and description of analysed treatments

Treatment code	*Description*
SL FS	Dewatered fecal sludge compost
SL FS-RH	FS and rice husks, ratio (mass) 4:1, co-compost
SL FS-MSW	Municipal Solid Waste (MSW) + dewatered Fecal sludge, ratio (mass) 10:1, co-compost
SL FS-MSW P	FS-MSW Pellets

Organic Matter (OM) and organic carbon (C_{org}) were determined by loss ignition and C/S ELTRA elementary analyser CS-500 (Severin 2014).

Total Nitrogen was analysed following the Dumas combustion method with a LECO elementary analyser (Runge 2000), while all other macro nutritional elements and heavy metals were extracted by using the microwave digestion in a closed vessel and the aqua regia extraction method (Miller 1998).
Statistical Analysis was done by calculating the mean of the tested duplicates (n=2) and determining the standard deviation (SD). In all figures, whiskers indicate SD, while in table it is in parentheses. The presented values display the mean (M).

Results and Discussion

Organic Matter and C_{org}

In all treatments relatively high concentrations of organic matter (OM) and organic Carbon (C_{org}) were obtained (comp. Figure 1). Highest concentrations of OM and C_{org} are in the samples of SL FS-RH (299,24 g C_{org}/kg). It is very likely that the observed concentrations are due to mixed in rice husk in the feedstock for composting.

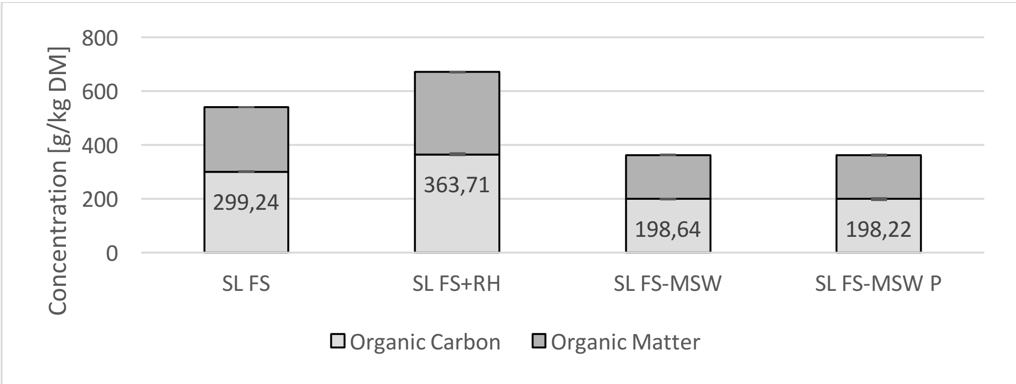

Figure 1: Average concentrations in means of organic matter and organic carbon content, error bars indicating Standard Deviation (n=2).

Co-compost with MSW (SL FS-MSW, SL FS-MSW-P) showed comparably low values indicating that the amount of impurities is rather high. Since it is sieved to 5mm grain size, it is assumed that sand fractions and other inorganic impurities in MSW lead to the reduced concentrations.

Content of plant nutritional elements

Nitrogen (N), analysed as Total N (N_{tot}), can be regarded as representative and in line with previous research (Nikiema et al. 2013; Cofie et al 2016), taking into consideration that it can be a heterogeneous substance. It can also be stated that FS is a possible N source for further enrichment of co-compost. However, it will be necessary to evaluate its mineralisation in greenhouse and field trials, since Total N has a limited reliability as factor for Nitrogen fertilization.
Municipal compost and fecal sludge have been reported to be a valid P source for agricultural practices (Zhang et al. 2006; Rose et al. 2015).
Highest contents were detected in the composted fecal sludge treatment SL FS while co-composting it with other sources in a ratio of 1:10 it was found to be just slightly increased or even reduced (Figure 2). Hence it is assumed that fecal sludge is the major P-source of co-composts.
Furthermore, studies made on the availability of P provided by MSW indicate that available P content is high because of the increased Phosphatase enzyme activity (Crecchio et al. 2004).

As expected in compost, all treatments revealed high Ca concentrations. Highest Ca concentrations of tested samples had been detected in co-composts of municipal solid wastes, SL FS-MSW-P with 39,84 g Ca/kg. The obtained results correspond with findings from reviewed literature saying that Ca content is generally above 10 g Ca/kg (Hargreaves et al. 2008). It can be observed that both, FS and MSW, are the source for the Ca content and add up to the obtained high amounts, while FS co-composted with rice husk (SL FS-RH, 19,75 g Ca/kg) showed decreased Ca content.

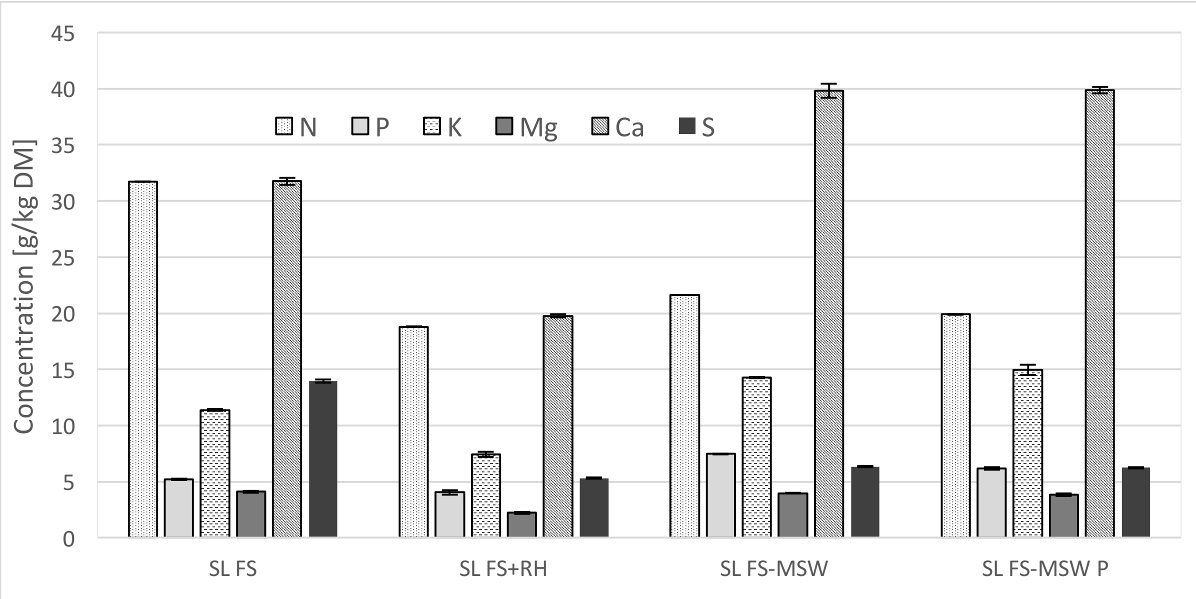

Figure 2: Average concentrations in means of macro nutrients in g/kg dry matter (DM), error bars indicating Standard Deviation (n=2)

Compared to K and Ca, Magnesium (Mg) content is low but in line with comparable data obtained from literature (Hargreaves 2008). SL FS was detected with only 4,1 g Mg/kg. Nevertheless, these treatments can be regarded as the major Mg source compared to its co-composted treatments. Supplementary research needs to be done to clarify the availability of Mg by the plants, since K and Ca are present in much higher concentrations. Especially in hot tropical climates K is favorably absorbed by plants resulting in lower Ca and Mg uptake (Marschner 2012; Pagel et al. 1982).

Sulphur (S) content displayed as elementary S is often neglected in corresponding literature resources. Co-composting seems to generally reduce the S content, indicating that FS is a resource for Sulphur enrichment.

Evaluation of Heavy Metal Content

Among the tested elements As and Cd were only detected in SL FS. Cd concentration exceeds threshold regarding EU organic certified fertiliser but is within limits for compost regulations of US and Canadian environmental standards for fertiliser (EPA 2000; CCME 2005; EU 2004). Regarding a safe usage, a detected value indicates that Cd contamination is possible and prompts a need for regular laboratory observations of feedstock materials for co-composting. Thresholds for As by US, Canada and EU allowing concentrations at least ten times higher than the detected values.

Traces of Lead (Pb) were detected in all treatments and Sri Lankan fecal sludge (SL FS 31,04 mg Pb/kg) seems to be the source for the comparably high values. However, all treatments are below of all quoted thresholds.

Table 1: Average concentrations in means of Pb Cd and As in g/kg dry matter (DM), Limit of Detection (LOD) 1,00 mg/kg DM, Standard Deviation (n=2) in parenthesis

Element [mg/kg DM]	*SL FS*	*SL FS+RH*	*SL FS-MSW*	*SL FS-MSW P*
Pb	31.04 (± 0.60)	13.11 (± 0.17)	22.82 (± 1.82)	20.91 (± 0.12)
Cd	1.67 (± 0.00)	< LOD	< LOD	< LOD
As	1.30 (± 0.10)	< LOD	< LOD	< LOD

Conclusions and Outlook

Waste recycling models like co-composting are an appropriate option to provide treatment and to reduce wastes and environmental pollution by recycling the organic fractions and reusing it as an agricultural resource. Standards set up by developed countries and institutions can be considered as guidelines for product quality, especially if exporting of agricultural products is targeted.
Fecal sludge can be regarded as a beneficial co-composting feedstock since it enriches municipal compost with plant nutritional elements and organic matter , although it bares the risk of contamination. Even if MSW is sorted out manually, it seems to entail inorganic particles like sand. For further product enhancement it will be important to reduce sand content in input materials before composting. This would lead to an increase of plant beneficial content in terms of organic matter as well as plant nutritional content.
Supplementary experiments and laboratory analysis are needed in order to develop the co-compost and its pelletised form as an agricultural resource. Regarding heavy metal pollution, it will be necessary to evaluate the impact of co-composts on accumulation in soil, plant availability and leaching.
Furthermore, it will be necessary to set up field and greenhouse trials to evaluate crop and soil responses and nutrient release of the co-compost on different soils and in different climate regimes to provide farmers and plantation managers with important information for enhanced production.

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