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# The potential of wastes to improve nutrient levels in agricultural soils: A material flow analysis case study from Busia District, Uganda

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ABSTRACT

Like many other countries in Sub-Saharan Africa (SSA), Uganda faces a remarkable soil nutrient deficit in farmland soils. In order to cope with this deficit, many authors suggest increasing the recycling of hitherto unused nutrient sources from human excrement and urban municipal solid waste (MSW). However, a quantification of the potential of these nutrient sources to overcome soil nutrient deficits in Uganda has not been carried out so far. This research paper presents a case study calculating the soil nutrient balance for nitrogen (N), phosphorus (P), and potassium (K), as well as the potential of hitherto unused human excrement and urban MSW to decrease soil nutrient deficits in agricultural land by applying the method of material flow analysis (MFA) in Busia District (Uganda). Results show a high soil nutrient deficit of agricultural soils in the district, with values of $-33\,kg\,N\,ha^{-1}$, $-6\,kg\,P\,ha^{-1}$, and $-41\,kg\,K\,ha^{-1}$. The potential to reduce these negative balances is negligible for hitherto unused urban MSW (1–3%), but higher for human excrement (17–60%). The low potential of urban MSW as well as the hygienic problems associated with human excrement (particularly feces) means that other measures such as soil conservation and mineral fertilizer application should not be ignored in the effort to increase agricultural productivity. This is not only valid for Busia District, but also for other regions in SSA.

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## 1. Introduction

Contemporary societies in Sub-Saharan Africa (SSA) have the highest population growth rates in the world (World Bank, 2013). At the same time, agricultural soil nutrient deficits of nitrogen (N), phosphorus (P), and potassium (K) in many countries of the region impair their ability to feed their growing population (Sheldrick and Lingard, 2004). Among the countries in SSA, Uganda occupies a special position, having the third highest population growth (3.3% per year) together with high nutrient depletion in agricultural soils (Stoorvogel and Smaling, 1990; Sheldrick and Lingard, 2004; World Bank, 2013). This is also highlighted by local studies carried out in Uganda (Wortmann and Kaizzi, 1998; Bekunda and Manzi, 2003; Nkonya et al., 2005). However, Uganda is also one of the countries where a number of initiatives aim to reduce the soil nutrient deficit and thereby increase the crop yield by hitherto widely unused nutrient sources from organic municipal solid wastes (MSW) from urban areas or human excreta. For instance, the long-term ambitions on recycling human excrement by means of so-called ecological sanitation systems are internationally recognized (Tumwebaze et al., 2011; Dagerskog et al., 2013). Another activity that is seen to be a role model for other countries in SSA is the first country-wide small-scale composting program under the clean development mechanism (CDM) scheme, which not only aims to reduce greenhouse gas emissions through composting of organic MSW from 17 urban areas in Uganda, but also to increase the agricultural productivity through applying this compost on crop land (World Bank, 2008). Even though all these activities exist, in none of the soil nutrient balance studies from Uganda reviewed have researchers attempted to estimate the quantitative potential of recycling organic MSW from urban areas as well as human excrement. Thus, the general aim of this article is to determine the potential of these two nutrient sources in the case of Uganda.

To do so, not only must the soil nutrient balance be determined, but other nutrient containing materials flows, particularly solid wastes and human excrement, must be as well. However, the

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question arises for which area the nutrient balance, nutrient flows and stocks should be determined. One option is to consider an area that hosts (1) one of the 17 locations from the CDM composting program, and (2) human excreta recycling initiatives. Among the few areas that fulfill these criteria is Busia District in Eastern Uganda (Obernosterer, 2006; Lederer et al., 2012). Therefore, the detailed research questions in this article are:

1. What is the soil nutrient balance for the soils of agricultural land in the case study area of Busia District?
2. What is the quantitative potential of human excrement and hitherto unused MSW, particularly from urban areas as nutrient sources for agricultural soils in Busia District?

In order to answer these research questions, data from a research project carried out by the authors (Lederer et al., 2012) and from literature was used.

## 2. Methods and materials

After briefly describing the study area in Section 2.1, material flow analysis (MFA), which is a method that goes beyond soil nutrient balancing on a farm level and is thus suitable for answering the research question, is presented in Section 2.2. The data to carry out the MFA is shown in Sections 2.1 and 2.3. Some information is presented in the Supplementary materials, and the related tables and figures are indicated by an S (e.g., Table S1).

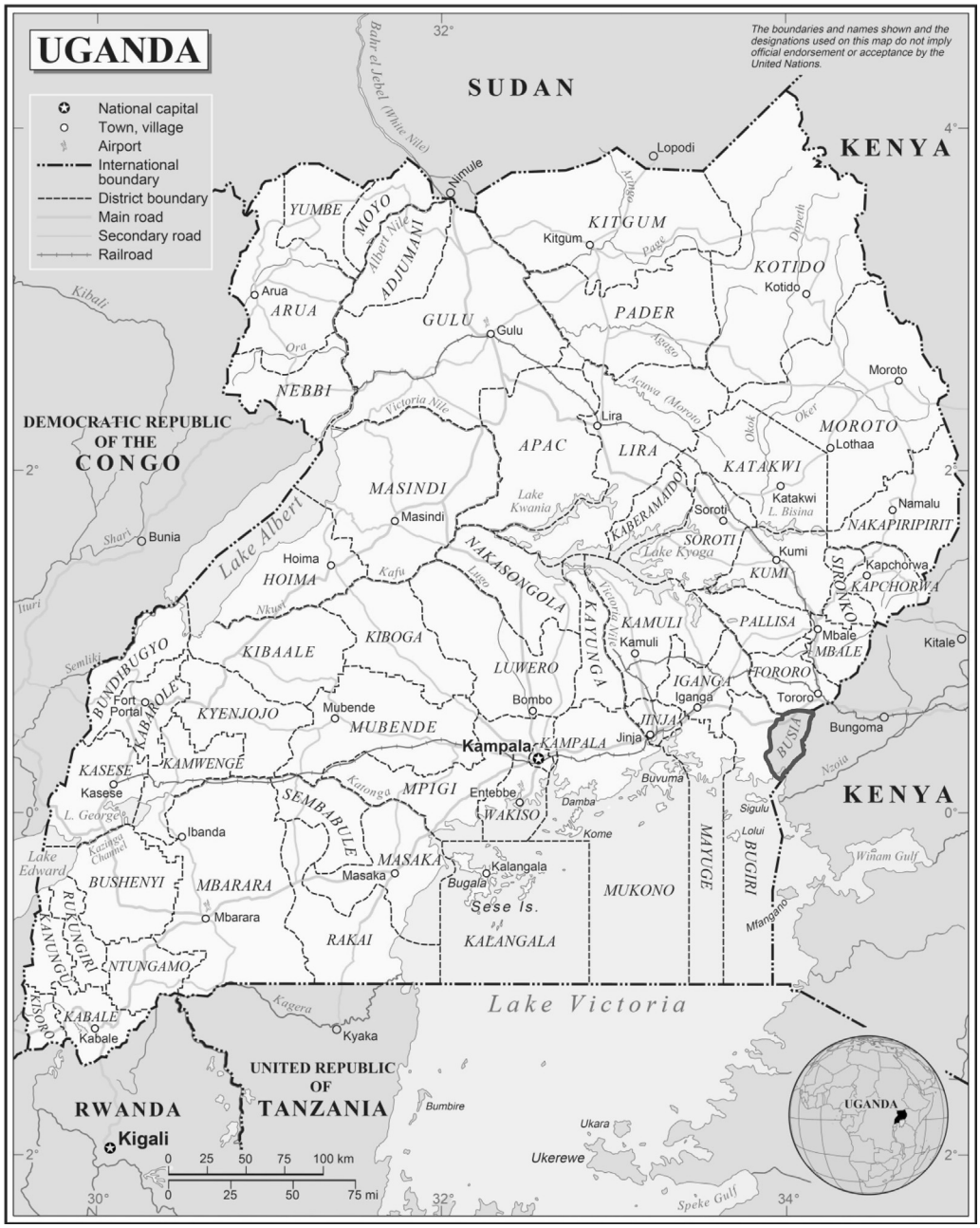


**Fig. 1.** Map of Uganda and situation of Busia District.

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