Characterization and Composting of Municipal solid waste in Mahajanga (Madagascar)

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Abstract
This experiment aims to study the composting of municipal solid waste (MSW) in landfill site of Mahajanga city (Madagascar). The MSW was monitored in accordance by the French method XP X 30-408 and XP X30-466. The waste was composed of 9% of paper and paperboard, 10% of yard trimmings, 12% of food scraps, 11% of wood follows, 4% of rubber leather, and textiles and 22% of glass, plastic, metal and other inert wastes. The wastes without inert wastes were composted in clean area. Between March and September 2010, 29 compost heaps was monitored. The 12 mm sieved compost was about 26% of its initial humid weight, and contained a mean value of 144 g.kg⁻¹ of organic matter. The C/N ratio ranged around 10.7 and the C content was 54 g.kg⁻¹, N content 5 g.kg⁻¹, P 3 g.kg⁻¹ and K 4 g.kg⁻¹ DM.

Introduction
Municipal solid waste (MSW) landfills represent the dominant option for waste disposal in many parts of the world. In general, the comparatively high costs of treatment and disposal alternatives are a major reason for the reliance on MSW landfills, particularly in developing country [1]. The poorly maintained landfill sites are prone to groundwater contamination because of leaching and percolation. Further, there is a risk for explosion and bad odours. In order to identify a more sustainable waste management system for a city like Mahajanga (Madagascar), a characterization procedure was elaborated to determine composition of municipal solid waste (MSW) generated in households. The promotion of physical and chemical characterization of the MSW stream becomes one of the highest priorities in the waste management regulatory regime [2, 3]. According to data from the municipality of Mahajanga - Madagascar, annually 16000 ton of MSW were rejected to landfills [4]. MSW composting could resolve a part of this huge situation as it reduces the amount of deposits and offer organic inputs for agricultural systems. Composting MSW is seen as a method of organic waste material diversification from landfills while creating a product, at relatively low-cost, that is suitable for agricultural purposes [5]. In Mahajanga, the association Tananamadio with the support of Gevalor, French NGO; developed a composting process based on a reduced preparation of the initial composted matter. The objective of the present study was to characterize the MSW on the existing landfill site of Mahajanga city, and to assess the composting process and the produced compost.

Material and Methods

Site specification
Tananamadio, a Malagasy association, developed an experimental project of urban waste valorization in Mahajanga, the third biggest town of Madagascar, in order to contribute to the cleaning up of the city and its environmental protection by managing the local garbage dump and by recycling part of the urban waste into organic products of agricultural interest. Mahajanga, with a population near 280,000 inhabitants, is estimated to generate about 325,000 metric tons of garbage annually. However, the municipal administration estimated that the per capita generation of solid waste range from 130 to 250 kg/year, depending on the social and economic status of the community, but collected waste was only about 16 000 tons/year (in 2008) [4]. The study was conducted on the Mangatokana landfill site, 5 km from Mahajanga City (15° 42’ 07.42” S 46° 21’ 52.58” E). Sampling, sorting, and weighing of individual components of MSW were performed on September 2009 to August 2010.
**MSW characterization**

The municipal waste in Mahajanga was monitored in accordance by the French method XP X 30-408 (AFNOR, 1996) [7] and XP X30-466 [8]. The sample was collected at different truck dumper. The collected samples were physically segregated into different inorganic and organic components. Sample was weighed and spread onto clean area. Large and resistant elements were immediately weighed and removed from the sample. Collected samples were transferred to the laboratory on the day of sampling for the physicochemical analysis, then, samples were sieved to 100mm; 20mm and 8mm [8]. Sieved products were sorted by the following categories: a) wood and wood products, b) pulp, paper and cardboard, c) food, food waste, d) beverages and tobacco, e) textiles, f) garden, yard and park waste, g) glass, plastic, metal and other inert waste, h) fine.

**Composting tests**

Wastes without glass, plastic, metal, other large and resistant inert waste were composted on clean area. MSW were composted with slaughterhouse waste. Between March and September 2010, 29 heaps of composting was monitored. The moisture content of the mixture was adjusted to 50–60% by sprinkling water on the surface of the heap. Temperature was daily measured at different depth and different positions inside the pile. When the temperature either decreased or became constant for three consecutive days or the temperature rises above 70 ° C, the heap was returned. Finally, the compost was mature when the pile ceased reheating after turning. Heaps had a length of 4m with a width of 1.5 m and a height of 1.5 m. After composting, the products were sieved with a mesh size of 12mm; the screen overflow was mixed with new materials to form new windrows. The weight loss and the nutrient content at the end of the composting were assessed.

**Quality of compost**

Composts obtained were analyzed in laboratory. Organic matter (OM) content was quantified by calculating weight loss of oven-dried samples on ignition in a muffle furnace at 550°C. Ash was deduced from organic matter analysis. The dried material was analyzed to assess the total C content (Walkley-Black method), phosphorus content was determined after dry mineralization at 550 °C with a colorimetric assay method, potassium was determined by atomic absorption spectrometer, N content was determined by distillation after mineralization by the Kjeldahl method.

**Results and discussion**

**Characteristics of MSW**

The knowledge of MSW physical composition and evolution is crucial to planning methods and technologies to be applied as treatment. Fig. 1 shows a typical example representing the MSW physical composition in September 2009 to August 2010 in Mahajanga city. After the coarse sieving, initial material contained 35% of matter up to 100 mm diameter, 20% between 20 to 100mm, 13% between 8 and 20 mm and 32% less than 8 mm of dry material. The high content of fine part (<8mm) is a characteristic of MSW in developing country [9, 10, 11]. The MSW moisture is very different during monitoring period. During rainy season (December to April), the waste moisture rose to 53% but during the dry season it reached 33%. In the sieved product of 100-8mm, MSW was constituted to 42% of organic matter. So, with a fine sieved product, compostable part was 74% of MSW.

**Composting tests results**

The initial weight was considerably reduced in all windrows. The result was similar with a data of several authors [12, 13]; windrows have lost in average 65% of its initial mass. The sieved compost of 12mm is around 26±7% of its initial humid weight. Compost agronomic values were determined in laboratory. The nutrient contents of studied composts were comparable to those determined by [14, 15]. Compost had high N content (5±1% g.kg⁻¹ DM) but low organic matter content (144±21g.kg⁻¹ DM) and C content (54±12g.kg⁻¹ DM). Compost maturity is often assessed by the C/N ratio. It has been established that a C/N ratio between 10 and 15 corresponds to a mature compost [16]. The average C/N ratios determined in this study was 10.7 indicating that the composts would be mature. Compost contained 3±1g.kg⁻¹ P and 4±0.6g.kg⁻¹ K. Results of biochemical analyzes are shown in the figure 2. The studied MSW composts have nutrient acceptable levels and can be used as fertilizer.
Conclusion
MSW of Mahajanga contained a high proportion of degradable organic matter that it is in agreement to other observations in developing countries. Composting process limited the waste environment impact by reducing the quantity of the MSW in the landfill. Thus, MSW composts were mature and contained an available nutrient for plant. But, as no pretreatment process was performed before composting, it was suggested to study the concentration and behavior of heavy metal and organic pollutants potentially present within the MSW composts.

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Figure 1. Estimated components in the Mahajanga MSW (average at September 2009 to August 2010)

Figure 2 : Biochemical analyzes of composts, % OM (van Soest)
References