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How the origin of fresh household waste affects its ability to be biodegraded: An assessment using basic tools and its application to the city of Kara in Togo

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ABSTRACT

Waste biodegradation has been largely investigated in the literature by using conventional tests like the BMP test and the respirometric test, whereas only few studies deal with the use of leaching tests in combination with biological activity measurements. Consequently, this study used an improved leaching test to evaluate the biodegradability of two deposits of fresh household waste from the city of Kara in Togo. The first deposit came from households in neighborhoods located in the outskirts of the city and the second consisted of fresh waste, mainly composed of business waste and household waste, collected in the urban center and aimed at being deposited in the landfill. A physicochemical characterization of the two deposits completed the leaching test. The biological activity was monitored by measuring O_2 consumption and CO_2 production. pH, DOC/OM, VFA/DOC ratios and the SUVA index was measured in the leaching juice to assess both the state of degradation of the waste in the deposits and the ability of the organic matter to be mobilized quickly and to be easily assimilated by microorganisms. The biodegradability of waste from the city of Kara correlated with their origin even though the physical characteristics of the two deposits studied differed greatly.

1. Introduction

Municipal solid waste (MSW) management represents a great challenge for municipal authorities in developing countries. While in developed countries MSW collection and disposal is highly controlled, their collection and management in developing nations by urban centers and their disposal in optimal conditions are not usually mastered (Obersteiner et al., 2011). This greatly increases the health risks to which the local residents are exposed (Aina et al., 2009). The garbage dumps in nature and the uncontrolled landfills are often the final outlet for waste in which the storage conditions cannot guarantee that large amounts of water and soil remain contaminant free. The water infiltration through the waste mass generates a leachate with a high organic and mineral load depending on the natural biodegradation of the waste (Daskalopoulos et al., 1998; Perrodin et al., 2002). The biodegradation correlates with the physical characteristics of the waste, the dumping conditions and the variations in local weather (El-Fadel et al., 2002). In France, the characteristics of rural and urban households waste are not as different as in developing nations, like Togo (ADEME, 2009). The waste deposit in cities from developing countries can be classified into two main categories according to their origins: normal MSW consists in waste from households, services and commercial activities, and MSW from areas just outside the city limits where lifestyles are still similar to the ones of the countryside. The composition of the waste in each deposit greatly differs depending on their origin, thereby impacting on their natural evolution and degradation. A better understanding of the physical (particle size, category) and chemical characteristics of the waste in these deposits is therefore necessary (Soares et al., 2011) to evaluate their ability to transport pollutants. According to De Araujo Morais et al. (2005) and Parodi et al. (2011), leaching tests can be used and combined with the characterization of the deposits in order to evaluate the interaction between waste and the receiving environment. These tests, performed in water, allow hydrosoluble compounds to be released from the waste, leading to the production of a biogas and to the increase of the organic matter content in the leachate produced. The characteristics of this organic matter promote its deterioration at varying rates by microorganisms. This biodegradation could be assessed by the production of CO_2 and by characterizing the biodegradable portion in the leachate. Labanowski and Feuillade (2009), and Parodi et al. (2011) used parameters such as pH, conductivity, Chemical Oxygen Demand (COD), volatile fatty acids levels (VFAs), total nitrogen (N_T) and Dissolved Organic

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Carbon (DOC) and the Specific UV Absorbance measurement (SUVA index) to assess the state of stabilization of the waste.

This study was carried out in the city of Kara in Togo. Built on the catchment of the river Kara, the city of Kara does not provide adequate systems for collecting and disposing of household waste. As in other cities in developing nations, the residents in the city of Kara differ by their way of life: some live in the conditions of a modern city and other ones in districts on the outskirts of the city in semi-urban and semi-rural conditions. The household waste deposits from these two areas, therefore, present different characteristics, different biodegradable features and, therefore, different impacts on the receiving environments.

The objectives of this study were twofold. First, the physical characteristics of the household wastes from the city of Kara were compared to those of other cities in Africa and also in France. Second, the biodegradable characteristics were evaluated depending on the origin of fresh household wastes from the city of Kara.

2. Materials and methods

2.1. Study site

According to its activities, the city of Kara represents the second major city in Togo. It is located in the region of Kara (in northern Togo), in the catchment area of the river Kara. It extends about 8 km along this river. The climate is tropical with a long rainy season from May to September and a dry season during the Harmattan winds that blow across the north of the country from December to March. In 2009, the average precipitation was 1400 mm, according to the local meteorological station. During a given year, the temperature variations range from 18 to 38 °C. The population was recently estimated at 130,000 inhabitants, according to data from the general population and housing Census of 1992. The urban population is not equally distributed. The rural exodus promotes the rapid development of new districts on the outskirts of the city, which have a poor access to an almost nonexistent sanitation network. The lifestyle in these districts is semi-urban and semi-rural and waste management is very similar to that of rural areas.

2.2. Sampling method and physico-chemical characterization of the waste

Two fresh household waste deposits were studied. The first deposit, G1, consisted of household fresh waste coming from the outskirts of the city and the waste in the second deposit, G2, originated essentially from various activities (commerce, restaurants and hotels) and from households. The G2 sample was collected from the urban center on its way to the dump. These two deposits were chosen because of their origins and their significantly different management methods. The objective was to assess the impact of the origin and of the applied management methods (open air heaping in intermediary garbage pits, discharge into gutters, streams and the river) on the biodegradability of the waste.

Sample G1 was composed of waste from seven districts located on the outskirts of the city: Agamadè, Batascom, Adabawéré, Tchanadè, Kara-Sud, Agnarim and Tchitchinda (Fig. 1). It consisted of wastes from seventy households. The number of households selected per district was proportional to their population density. The households were selected randomly and only the ones which agreed to take part in the study were chosen. The mass of waste to be collected per district was determined by both the application of Bernoulli's law and the Student test in order to ensure that the sample size was representative. This mass allowed the number of collection days to be performed in each district to be estimated.

For deposit G2, in the absence of a national method, the sampling was performed according to the MODECOM (ADEME, 2009). A 500 kg mass from this deposit was therefore sampled.

The wastes were sorted on a sorting table to separate them into four different size fractions: coarse (>100 mm), middle (100–20 mm), fine (20–10 mm) and very fine (<10 mm). The coarse and the middle fractions were then classified into 10 categories according to MODECOM (ADEME, 1993): putrescibles, paper and cardboard, textiles and sanitary textiles, plastics, glass, metals, unclassified combustibles (UNCs), unclassified incombustibles (UNIs), composites and hazardous waste.

The humidity and the dry matter content were determined according to the AFNOR methods (1996). They were measured on the different amounts and particle sizes and on reconstituted waste after separation on the sorting table. The proportion of

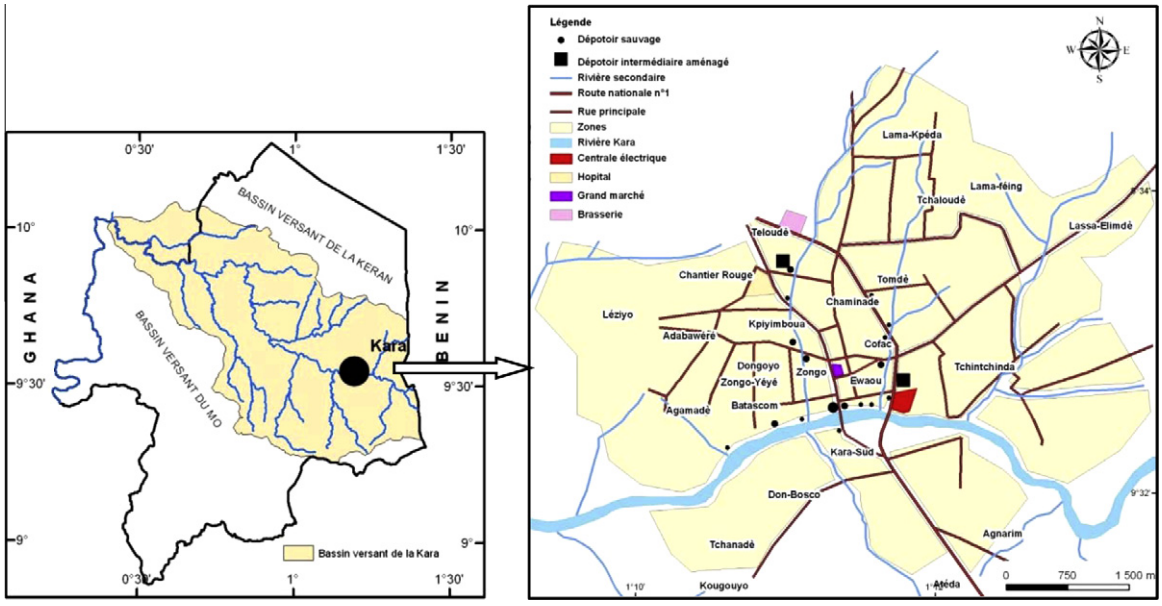

Fig. 1. Location of the districts chosen for the constitution of deposit G1.