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PRODUCTION AND TESTING OF MUNICIPAL SOLID WASTE CHARACTERIZATION IN N'DJAMENA, CHAD

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ABSTRACT

In Chad, the current solid waste management mechanism faces multiple socio-economic, technical, institutional, legislative and operational constraints. The lack of a reliable municipal solid waste collection service and the inadequacy of collection vehicles adapted to local conditions, have favored the anarchic creation of dumps at the feet of houses, on the edges of certain stagnations of water in the city, along the roads and in the drainage ditches.

For effective waste management, precise data on their generation and composition is required, which is important for making decisions about the appropriate waste management mode. Currently, there is no available data on the production and composition of municipal solid waste (MSW) collected in N'Djamena (Chad).

This article expresses an attempt to characterize municipal solid waste produced in the city of N'Djamena, the capital of Chad. An investigation into the conduct of housework was carried out. The determination of the characteristics of the municipal solid waste was made, based on the samples that were collected at the level of the "improvised dumping" of Lamadji (N'Djaména), during the two main seasons, dry and wet. After sorting into various components of the collected sample, the weight and volume of each component were measured and recorded. The average production of DSM is 0.48 kg / day / person by weight, of $1.536 \times 10^{-3} \text{ m}^3$ / day / person by volume with a density of 312.5 kg / m³.

The results show that the largest proportion of urban solid waste is composed of biodegradable and recyclable waste. For efficient management of waste streams, value-added processes such as composting, energy recovery and recycling must be practiced in the future. They could probably contribute to the considerable reduction of waste streams going to landfill.

Keywords: *characterization, composting, garbage dump, municipal solid waste, N'Djaména.*

I. INTRODUCTION

Nowadays, household waste management has become a major concern for local and regional authorities in developing countries[1].As urbanization and economic development have progressed, municipal solid waste generation has increased sharply worldwide, and their composition has undergone considerable change. These changes have a significant impact on human health, the environment, and the municipal solid waste management (MSW) system [2], [3]. This is due to the lack of information on the flow and composition of municipal solid waste, the quantities recovered, recycled and the location of solid waste disposal sites [4][5].

In general, rampant population growth and consumption patterns have favored the huge generation of waste streams in the developing country[6].The composition and characteristics of municipal solid waste are related to the topography of the area, the seasons, the food habits and the commercial situation of the city, etc. [7].In N'Djamena, the strong demographic pressure is characterized by a promiscuity of the populations in the East part of the city and poses real problems of solid waste management of the municipality. Its population is estimated at 1896,000 inhabitants[8], according to the General Census of Population and Housing (RGPH). Waste production increased from 450 tons per day in 2008 to 905 tons per day in 2019, a small portion of which (25 to 30%) is collected and transferred to landfill sites[9].The agglomeration has become unhealthy because of garbage, stagnant sewage, mosquito foci and flies, which contribute enormously to the degradation of the environment and human health.

A better characterization of solid waste requires knowledge of the sources of flow generated, the rate of generation, the composition of waste produced, to be able to control and promote the applied waste management systems. The near-efficient management of municipal solid waste requires the acquisition of these key elements, including waste collection, transfer and transportation, on-site production, handling and storage, processing and recycling, recovery and reuse, treatment and final disposal[10].

At present, there are no data on the composition and characteristics of solid wastes, which can be systematically collected in Chad. However, this solid waste characterization study is essential, and could contribute to improving the municipal waste management system, with the aim of reducing the frequent environmental impacts to the city of N'Djamena.

II. MATERIALS AND METHODS

Geographical location of the study area

N'Djamena the capital of Chad covers an area of about 8,000 hectares, or 3.1% of the country's area. The city is located 1000 km south of Lake Chad, at the confluence of the rivers "Chari and Logone". It is located between 12 ° and 13° latitude and 15° and 16° longitude. This city is the densest in Chad. The city does not have public landfills formalized and developed. On the other hand, occasional landfills are located on the periphery of the urban perimeter, among which, the landfill site of Lamadji is situated about 5 km from the city center, exploited since 2009.



Fig.1. Location of the city of N'Djamena (Source: Google MAP)

Calculation of the generation rate of household solid waste

As part of this study, waste collection and characterization was carried out at the Lamadji landfill, located on the outskirts of the N'Djamena urban area. The choice of the Lamadji dump is justified by the fact that it is the most frequently used by the municipal services, for solid waste management in N'Djamena. And besides, because of its proximity to the city, its environmental problems and its challenges. The study was started during the wet and dry seasons of 2019 and was conducted in three stages.

Step 1: Based on reports from the city's environment and property department (N'Djamena), articles and academic papers on municipal solid waste management.

Step 2: Update the information contained in some documents and recordings by interviewing officials responsible for municipal solid waste management and residents. Among them, the Project Coordination Unit at the Commune

level of N'Djamena, the head of the environment and cleanliness department of the city, the Director of the Waste Transfer Center, entrepreneurs, and ragpickers engaged in the management of municipal solid waste.

Step 3: A visit was made to the Lamadji dump for collection, sampling, separation and characterization. Manual collection was conducted randomly on municipal solid waste samples from the waste stream of the Lamadji landfill. As a result, the weight and volume of each component were measured and recorded. The total density was obtained by dividing the total weight by the total volume, which is equivalent to the average density of DSM.

For data production, the human resources and materials used at the landfill site were a sorting platform, an electronic scale, buckets for all sorting categories, gloves, a calculator and qualified assistants.

$$PCG = \frac{[Waste\ generated\ /day]}{Population} \quad (Kg/day/person) \quad (1)$$

Where, PCG is the per capita waste generation [11]

III. RESULTS AND DISCUSSION

Municipal solid waste production in N'djamena (Lamadji landfill)

The calculation of the generation rate was done on the basis of the daily quantity of waste dumped at the landfill and reported by the municipal authority in charge of waste management.

The value of the generation rate of municipal solid waste is estimated, based on the total weight of waste disposed of at the landfill per day, and the estimate of the population of the commune producing this waste.

According to information collected from the municipal waste management authority, the Lamadji landfill is home to 905 tonnes of waste per day. This waste comes from eight (8) boroughs. And each district is composed of several neighborhoods. The total population of the city of N'Djamena is 1896000 inhabitants [RGPH3] [8]. The results obtained from this study show that the rate of waste production in the municipality is 0.48 kg / day / person by weight and $1.536 \times 10^{-3} \text{ m}^3 / \text{day} / \text{person}$ by volume. The average density of DSM is $312.5 \text{ kg} / \text{m}^3$. In terms of comparison, this value is consistent with the generation rate determined in other developing countries.

On the other hand, according to the report of the development of the solid waste management strategy of N'Djamena, established in 2008 by the authorities in charge of the waste management [9], the production of household waste in N'Djamena was 0.39 kg / inhabitant / day. Indeed, this evolution could be explained by the increase in demography, the change of lifestyle of the population, as well as the economic progression, which has favored the increase of the urban solid waste production in Chad.

Composition and characterization of municipal solid waste

As part of this study, six different fractions of waste were classified. These include organic matter, paper / paperboard, glass, plastic, metals, fabrics / clothing and others. The others represent in this class, solid wastes that are not identifiable, or that do not fall into the six categories identified.

The composition percentage of each fraction was calculated by the following formula:[10]

$$= \frac{Weight\ of\ separated\ waste}{Total\ sampled\ mixed\ waste} \times 100 \quad (2)$$

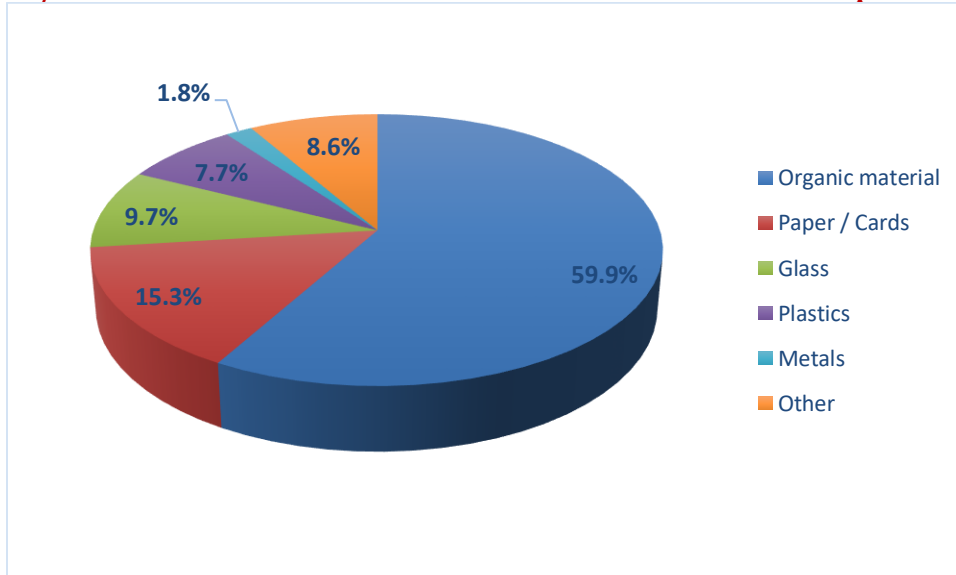


Fig.2: Percentage of municipal solid waste characterized at the Lamadji landfill site during the wet season of 2019

Table 1: Composition of municipal solid waste at the Lamadji landfill during the wet season 2019

Composition	Mass (Kg)	Percentage (%)
Organic material	19.3	59.9
Paper / Cards	5.2	15.3
Glass	3.3	9.7
Plastics	2.6	7.7
Metals	0.6	1.8
Textiles / clothing	-	-
Other	2.9	8.6
Total	33.9	100.0

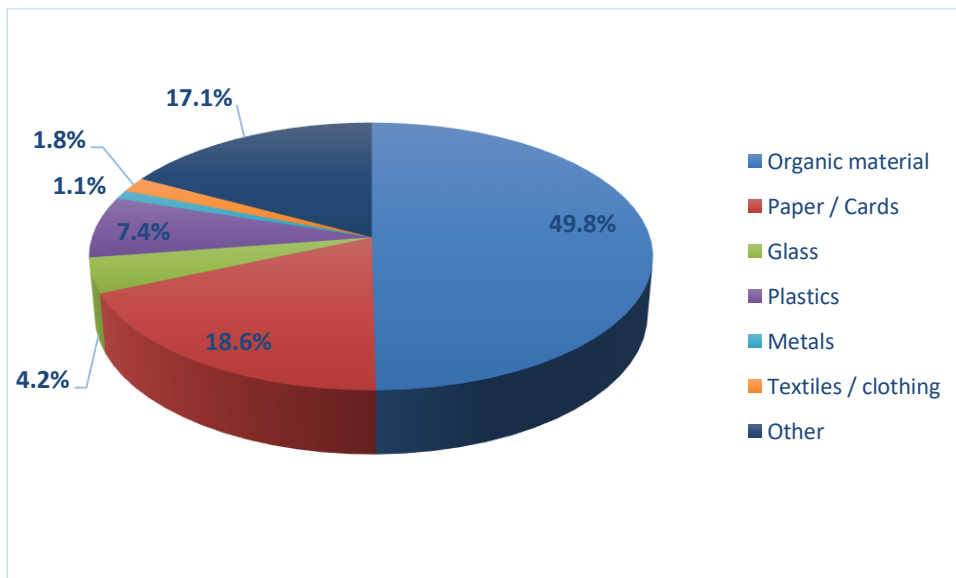


Fig.3: Percentage of household waste samples characterized at the Lamadji landfill

The results of the survey revealed considerable problems related to the municipality in charge of the waste management responsibility of N'Djamena, mainly the insufficiency of the financial resources, the inadequacy of the regulation, the absence of institutional framework, the lack of information on the quantity and composition of household waste and the lack of qualified agents.

Tables 1 and 2 present the results of the physical characterization study of solid wastes during both wet and dry seasons. Organic waste represents the largest portion, with 59.9% and 49.8% of the composition of household waste, during wet and dry seasons respectively. The other constituents are: paper / cardboard 15.3% and 18.6%; 9.7% and 4.2% glass; plastics 7.7% and 7.4%; metals 1.6% and 1.1%; fabrics / clothing 0% and 1.8% and other 8.6% and 17.1% [12], [13]

The results obtained show that food waste is the most dominant fraction in organic waste. They are especially composed of vegetable residues, food residues, leaves and rotting vegetables. Previous research has shown that most household waste in developing countries is food waste[14]. Based on the results of the study, it is very understandable that in Chad, the flow of food waste is produced by households and commercial establishments such as restaurants and hotels.

The large proportion of organic matter present in municipal solid waste leads to considerable environmental degradation. To mitigate environmental risks, we must valorize these biodegradable materials. The huge amount of leachate produced in the landfill is related to the abundance of the organic fraction released. The increase in the biochemical oxygen demand (BOD) of the leachate is proportional to the high volume of the organic fraction. The higher the organic matter content, the greater the amount of gas generated in a landfill. In fact, the most advantageous treatment for solid waste rich in organic matter is composting [6], [15]. The second most abundant waste category at the Lamadji landfill is paper/ paperboard, such as packaging, newspapers, books and magazines. The weights of this fraction recorded are 15.3% and 18.6% respectively during the wet and dry seasons.

Similar results were obtained at the Gosa (Abudja) landfill in Nigeria [16], [17]. The enormous production of paper and cardboard can be explained by different causes. Firstly, this is due to the existence of the practice of recovery of old paper and cardboard by rag pickers. Used paper flows are thrown directly into the trash, without being sorted or recycled for any valuation. Admittedly, there are a large number of young people who sometimes give up their studies, for particular reasons and go to the landfill to recover essential materials and easily sellable, in order to earn a small daily sum. On the other hand, there are other reclaimers who lead their lives practically thanks to this. However, they expose themselves daily to the landfill without being equipped with any protective equipment. It is a painful and dangerous practice for their health. In addition, in Chad, there are hardly any companies operating in the field of recycling paper and cardboard, yet a huge amount of goods coming from outside, which generates waste paper packaging and cardboard.

In addition, the percentages by weight of glass waste recorded during the two seasons are respectively 9.7% and 4.2%. These glasses are composed by juice containers, bottles of syrup, bottles of beverage etc.

Plastic waste comes in fourth position; the respective weight percentages of this category of waste assessed in the study are 7.7% during the wet season and 7.4% during the dry season. The composition of this plastic waste is diverse. Among others, plastic bags, plastic bottles, plastic vases. Often, the term "plastic mixture" is used to refer to any kind of plastic recover in the municipal waste stream. Other researchers in some African and Asian countries have achieved similar results; as in Nigeria, particularly in Abudja, the percentages of plastic waste are estimated at 7.9%; in Ghana 8%, in Malaysia 14%; 13% in Japan and 21.80% in Taiwan[3]–[5].

IV. CONCLUSION

In the city of N'Djamena, solid waste management has changed slightly from previous decades. For the spontaneous creation of sanitation committees by residents of certain neighborhoods has emerged. The purpose of these committees is to provide a pre-collection service to clean up their neighborhoods. However, the main phase that will

ensure effective waste management, is the knowledge of the composition of waste generated. This can be done by characterizing the waste. This makes it possible to develop appropriate collection, treatment, recovery and disposal strategies. The characterization study has shown that, the solid waste stream of the municipality of N'Djamena consists of compostable materials, and other major components, such as, paper / cardboard, glass, fabrics, plastics, metals and others.

What remains of fundamental is the development of the sectors of recovery, recycling and valorization of these products, in order to reduce their rejection at the level of the landfill.

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