World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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Characterization, quantification and recovery prospects for organic waste from the town of Dolisie in the Republic of Congo

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World Journal of Advanced Research and Reviews, 2023, 20(02), 173–188

Publication history: Received on 22 September 2023; revised on 29 October 2023; accepted on 31 October 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.2.2224

Abstract

Developing countries are facing increasing urbanization accompanied by the production of large quantities of solid household waste, the management of which is a crucial problem. This study aims to characterize, quantify and promote the recovery of organic waste in Dolisie, Republic of Congo. More specifically, it aims to: (i) Determine the flow of solid household waste produced in Dolisie and (ii) Evaluate the physical properties of solid household waste with a view to predicting possible recovery routes for organic waste. Waste from 60 households of different socio-economic levels was collected, weighed, dried and classified daily for 60 days, during the wet (February 15 - May 15, 2021) and dry (July 12 - September 30, 2021) seasons. The results showed that the average daily production of solid household waste in the city of Dolisie was 0.82±0.23kg/capita/day in the wet season and 0.61±0.10kg/capita/day in the dry season. Daily per capita production correlates positively with family income and negatively with household size. The average density of waste produced was 355.71±92.99kg/m^3 and 308.02±74.15kg/m^3 respectively for the wet and dry seasons. The moisture content of the waste varies between 40-80% in both seasons. The waste stream collected is dominated by waste sizes between 100-20mm. The study revealed that the composition of solid household waste produced in Dolisie is dominated by biodegradable waste, which can be recycled in several sustainable ways: composting, biomass pyrolysis and biogas production.

Keywords: Household solid waste; Household solid waste production; Socio-economic factors; Waste moisture content; Dolisie; Republic of Congo

1. Introduction

Rapid economic growth correlated with increasing urbanization and improved living standards over recent decades have had a considerable impact on the production, consumption and disposal of household solid waste [1-3]. Global waste production is increasing every year, over the last century rising from 300,000 to 3 million tonnes per day [4]. In 2016, annual global waste production was around 2.1 billion tonnes [5]. In sub-Saharan Africa, solid waste production is expected to double or even triple by 2050 [5].

Solid waste includes solid materials derived from the residues of human activities, biodegradable plant or animal waste and non-biodegradable, combustible debris (wood, paper, cardboard, textiles, plastic, etc.) and non-combustibles

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(metals, glass, stone, etc.) [6]. This diversity of solid waste can also be observed in the metropolises of sub-Saharan Africa, where it represents a real problem for urban management.

For integrated and sustainable management, waste characterization is necessary. A waste management system depends primarily on planning, the proper design of theoretical tools and reliable data [7, 8], but also on a good estimate of the quantity of household solid waste produced, and the identification of the various sources that make up the solid waste stream [9-11]. In developing countries, municipal solid waste is often generated by several sources, including the population's overall activities. Some studies have mentioned that, municipal solid waste production in developing countries is dominated by household solid waste (55-80%), then waste assimilated to household solid waste (10-30%) finally industrial and institutional waste (7%) [12, 13]. The waste resulting from household activity is heterogeneous in nature and presents variable characteristics from the point of view of the waste categories of which it is composed [14-16]. The composition of household solid waste in numerous studies in sub-Saharan Africa is dominated by the fermentable fraction, which accounts for 40-70% of the total mass of waste generated [7, 17, 18]. In the same region, the characteristics presented by other studies reveal a decline in the fermentable fraction in favor of fine particles (30-70%) of the total mass of waste produced [14, 19, 20]. Indeed, household solid waste production in developing countries depends on people's standard of living, with average daily proportions of household solid waste between 0.5 and 1.1kg/capita/day [7, 18, 20]. However, in industrialized countries, they are generally between 0.1 and 0.4kg/capita/day [10]. Daily production of household solid waste is generally correlated with household size and/or socioeconomic level [21-23]. Higher-income households will produce more waste on the one hand, and larger households would produce less waste [7, 10, 15, 24]. Thus, waste production in developing countries is increasing over time, with densities that can reach 600kg/m^3 with a moisture content exceeding 50% [25-27].

In the Congo, waste management in large cities such as Brazzaville and Pointe-Noire, the political and economic capitals respectively, each populated by more than a million inhabitants [28] is a crucial problem for city managers. The presence of heaps of rubbish and uncontrolled dumps in the urban perimeter detracts from people's living environment and health. Although the city of Dolisie has legal authority over waste management, it faces major difficulties in managing its waste [29]. Annual solid waste production in this city is estimated at 17,550 tonnes [30]. This waste comes from households (10,100 t/year), small businesses (5,400 t/year) such as shopkeepers, craftsmen and small enterprises, and large businesses (2,050 t/year) such as hospitals, markets, railway stations, public administrations and economic operators [30]. With a low collection rate for the household waste collection tax (TEOM), the Dolisie town council relies on state subsidies to provide this service [31]. In this context, it is difficult for the Dolisie town council to set up a sustainable solid household waste management system, given that the said state subsidy is difficult to mobilize.

The general objective of this study is to characterize, quantify and promote the recovery of organic waste in Dolisie, Republic of Congo. Specifically, it will aim to: (i) Determine the flow of solid household waste produced in Dolisie and (ii) Evaluate the physical properties of solid household waste with a view to forecasting possible recovery routes for organic waste.

2. Materials and methods

2.1. Study area

This study was carried out in Dolisie in the Niari department (figure 1). The city extends over approximately 100km^2 with an estimated population of 114,840 inhabitants, spread over 2 arrondissements, 28 quartiers and 141 blocs [12].

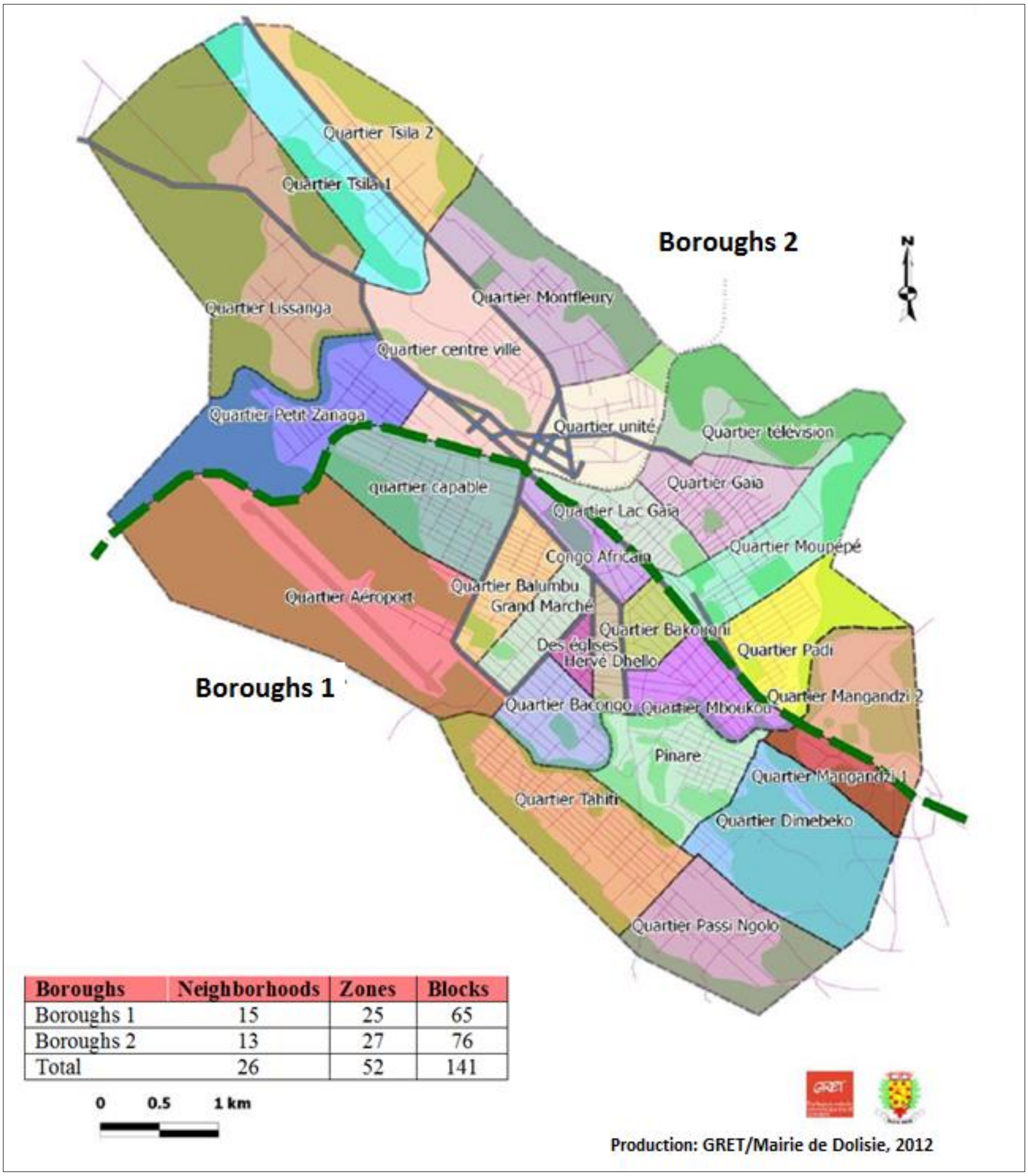

Figure 1 Map of the study area (GRET/Mairie de Dolisie, 2012)

2.2. Determining the flow of solid household waste generated in Dolisie

2.2.1. Household selection and sampling

Given the wide diversity of living standards and dietary habits among Dolisie's resident populations, the city is characterized by a plurality of dwellings built according to an architecture subdivided into three (03) living standards (standing). The first type of housing groups together farmers, who generally have a low standard of living. At the other end of the scale is the upper middle class, who live in modern architecture and generally live in the city center. These dwellings are referred to as high-standard. Between these two living standards lies the middle-class population with modest homes. This socio-economic subdivision of the population explains the choice of waste characterization based on living standards. Two data collection campaigns took place from February 15 to May 15, 2021 for the wet season, and from July 12 to September 30, 2021 for the dry season. To collect data from households, numbered, labeled garbage bags were deposited in each household with the help of the Dolisie town hall and private pre-collection operators present in the city. Bags containing household waste were collected every day for a period of 60 days and for each season. The collected garbage bags are transported by cart to the household waste transit areas (ATOM) for processing.

The target households are concentrated in the center of town and along asphalt arteries, making it easier for the collection vehicles to get through (figure 2).

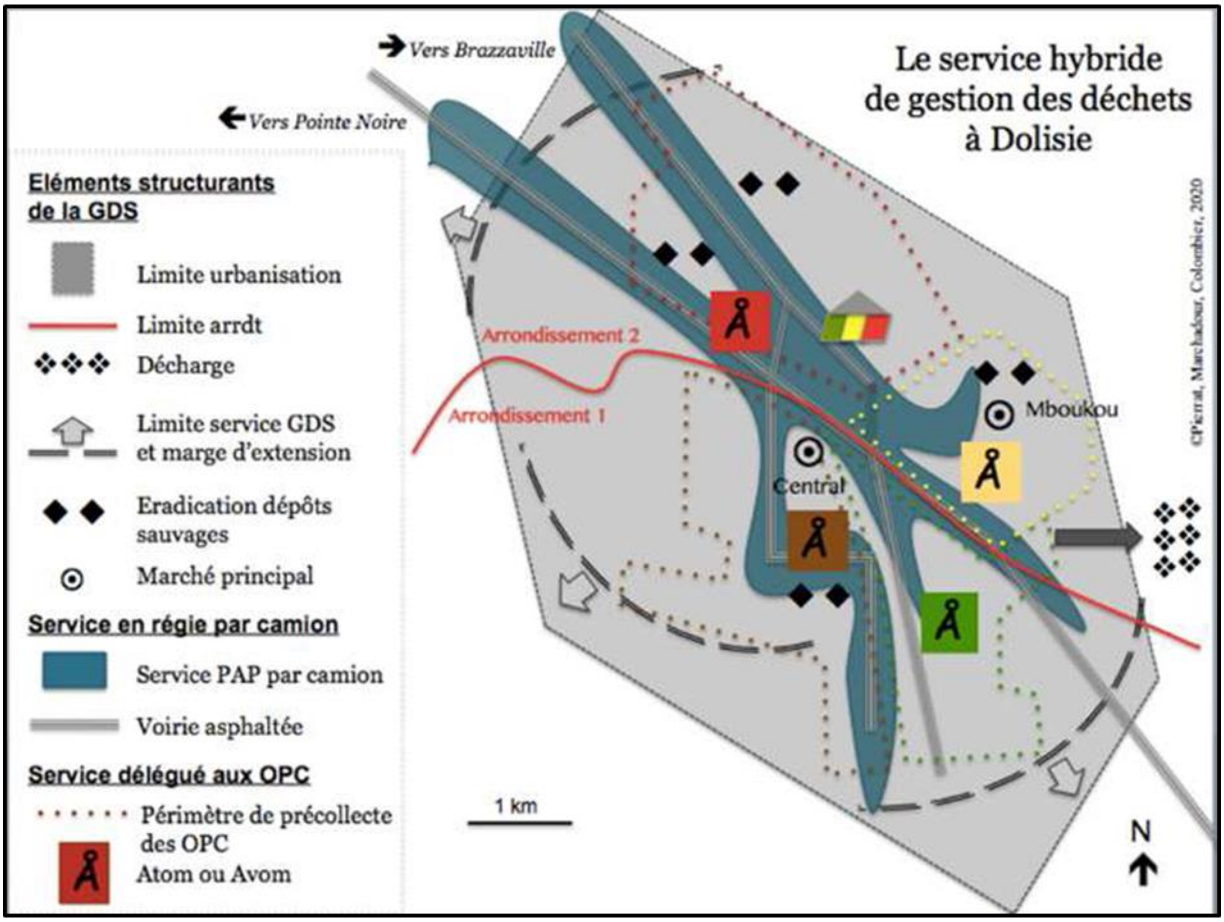

Figure 2 Solid waste collection scheme in the town of Dolisie [20].

2.2.2. Quantifying household solid waste

Collected garbage can bags are weighed according to household type. To estimate the quantity of waste produced per household in a day, a socio-economic survey was carried out to determine household size and standard of living. The daily quantity of waste produced per inhabitant was determined by relating the quantity of waste produced per day by the household to the size of the household [32-34].

$$Q = Q_i\,(kg)/P \qquad (01)$$

With :

Q: Average quantity of waste per day and per inhabitant,
Qi : Amount of waste produced per day,
P: Number of people in the household.

The socio-economic standard of living was determined according to the ratio between a household's monthly income and the total consumption units in a household [35].

$$UC = 1(AD) + 0.5(EY) + 0.33(EU) \qquad (02)$$

With :

UC: Consumption unit in a household,
AD: Number of adults in a household,
EY: Number of children aged 14 to 18,
EU: Number of children under 14.

NSE=RM/UC (03)

With :

NSE: socio-economic level,
RM: monthly household income,
CU: Household consumption unit,

The waste measured was air-dried, weighed and then the density of waste produced was calculated by the ratio between the mass of waste and the volume of the container [36]. A 60-liter bucket was used to estimate the density of waste produced by household type.

d= m /V (04)

With :

m: mass of waste (kg),
V: volume of container (m^3),
d: density of waste produced (kg/m^3)

Throughout the data collection period, samples of organic waste were taken to determine moisture content (H%). For this, 100 g of fresh sample was dried at 105°C in an oven until constant dry weight was obtained [27, 36-38].

$H(\%) = (m_1 - m_2)/m_2 \times 100$ (05)

With :

m_1 : mass of wet waste (g),
m_2 : mass of dry waste (g),
H : moisture content in %.

2.3. Characterization of solid household waste

Once the waste per household had been quantified, it was grouped according to standard of living. It was then subjected to a quartering operation to form a homogeneous sample of at least 500 kg [39]. A sorting table 2.5 m long by 1.5 m wide was used to separate the waste into the following sizes: coarse (> 100 mm), medium (100-20 mm) and fine (< 20 mm) [40]. The fines were separated into coarse fines (20-10 mm) and extrafine fines (< 10 mm). Waste > 20 mm in size was grouped together and classified into different categories: organic debris, paper/cardboard, textiles, sanitary textiles, plastics, glass, metals, unclassified combustibles (UCC), unclassified incombustibles (UCI), rubble and special waste.

2.4. Statistical analysis of the data

Statistical analysis of the data was carried out using R software version 4.1.3. Analysis of variance with a single classification criterion (type of season) was carried out to test the differences between household types (high standard, medium standard and low standard) and each variable measured (waste categories, waste sizes, daily quantity of waste, waste density and waste moisture content) for the two seasons (wet season and dry season). As the conditions of application (normality test) were not met, the non-parametric Kruskal Walis test and the Wilcoxon test were performed graphically. All differences were reported at P-value < 0.05.

To examine the relationships between the quantitative variables (daily waste production, household size and standard of living), simple linear regressions were performed between daily waste production and the size of each type of household as well as the socio-economic standard of living (family income). The coefficient of determination (R^2), which shows the variance explained (daily waste production) in relation to the explanatory variable (size of each type of household and socio-economic standard of living), and its statistical probability (P-value) were the main criteria for assessing the fit of the linear model.

3. Results

3.1. Size of different types of households studied

The household solid waste characterisation campaign covered a population of 431 in the wet season and 413 in the dry season (Table 1).

Table 1 Size of different types of households surveyed

seasons	Type of household and population			Total
	High standing	Medium standing	Low standing	
Wet	104	138	189	431
Dry	97	140	176	413

3.2. Daily production of solid household waste

The analysis of variance showed a statistically significant difference (p-value < 0.05) between seasons within households (Figure 3a) and between household types within each type of season (Figure 3b) in the daily production of household solid waste per capita. Average daily household solid waste production per capita was 0.84±0.23 kg/capita/day in the wet season and 0.62±0.10 kg/capita/day in the dry season.

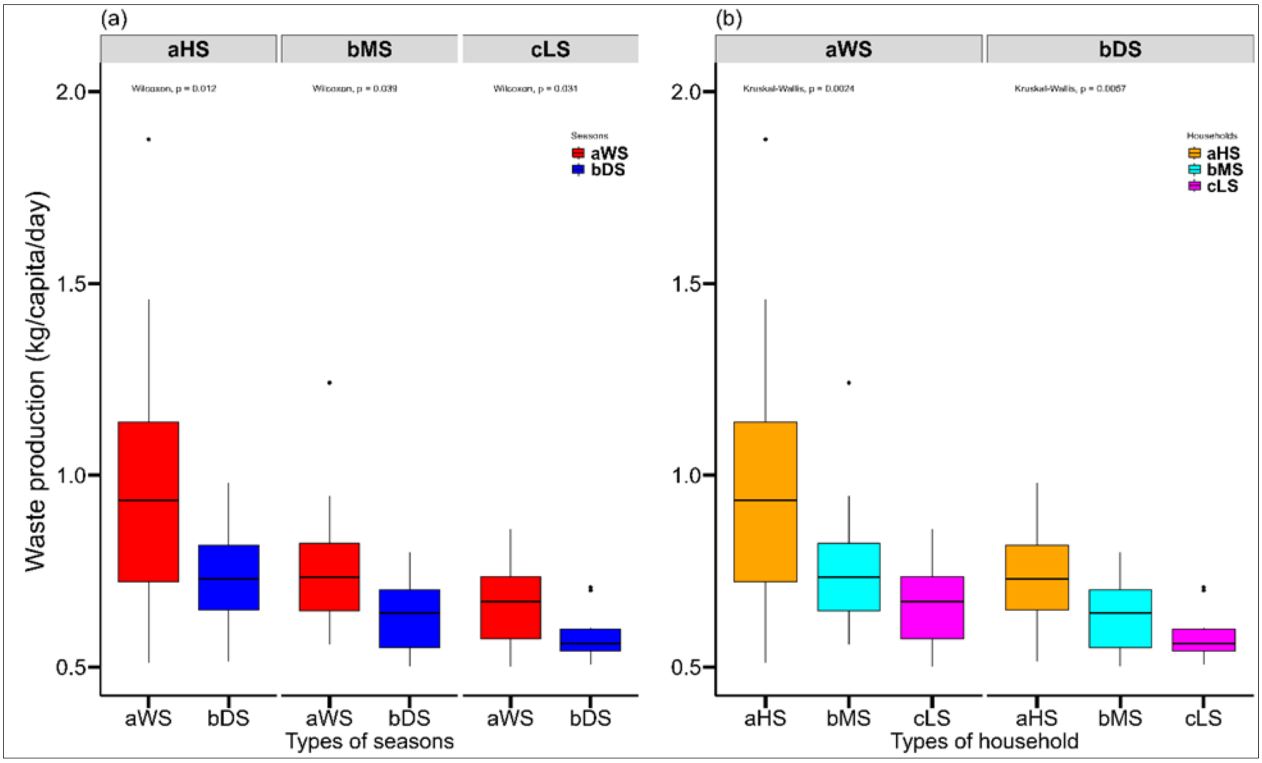

Figure 3 Daily production of household solid waste by household type (a) and by season (b). aHS: high standard household, bMS: medium standard household and cLS: low standard household, aWS: rainy season and bDS: dry season.

3.3. Effect of socio-economic factors on household solid waste production

There was a statistically significant difference (p-value < 0.05) between the socio-economic factors studied (income and household size) and daily per capita waste production in both seasons (wet and dry). The relationship between the daily quantity of solid household waste produced per capita was positively correlated with people's standard of living in both seasons (Figure 4). The poorer a household's financial situation, the less waste it produces. The better the household's financial situation, the more waste it produces. However, a negative correlation was observed between daily waste production per capita and household size in both types of season (Figure 5). The larger the household size, the lower the per capita production of solid household waste.

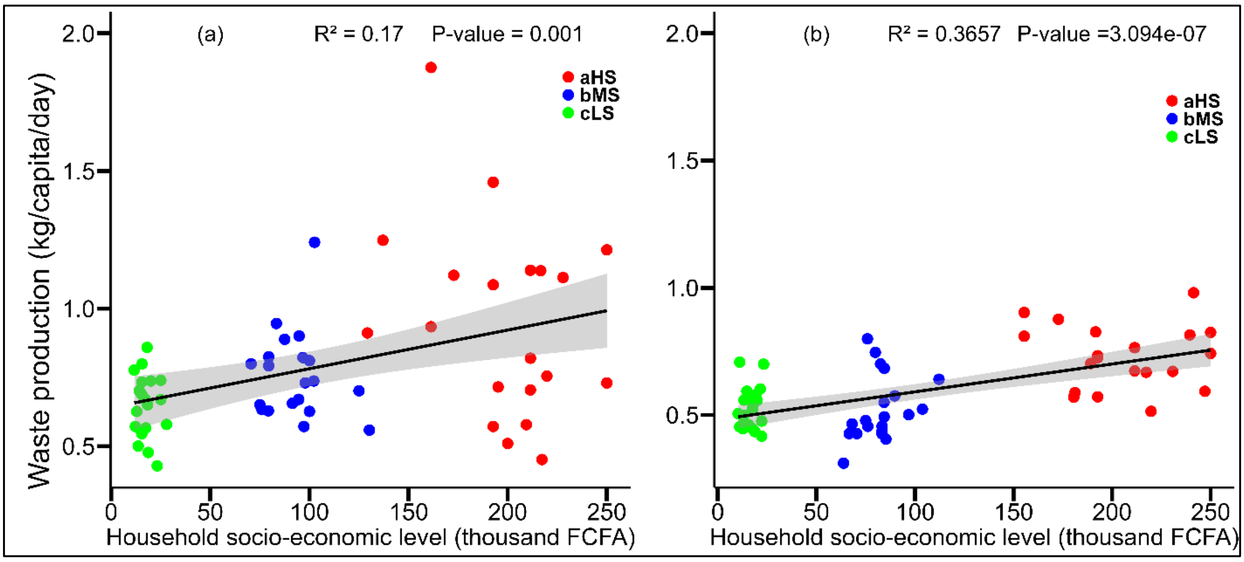

Figure 4 Relationship between daily household waste production and standard of living in the wet season (a) and dry season (b). aHS: high-status household, bMS: medium-status household and cLS: low-status household

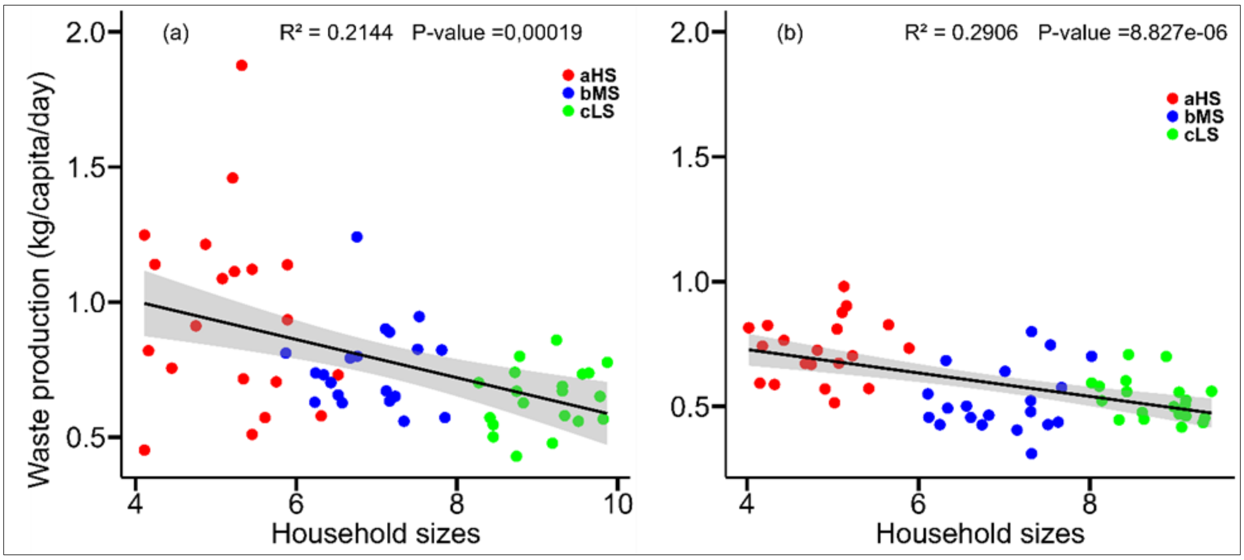

Figure 5 Relationship between daily household waste production and household size in the wet season (a) and dry season (b). aHS: high-status household, bMS: medium-status household and cLS: low-status household

3.4. Density of household waste produced

The density of solid household waste produced in households in the town of Dolisie is related to people's standard of living. Analysis of variance showed statistically significant differences (p-value < 0.05) between the different types of season within each household (Figure 6a) and between households within each type of season (Figure 6b) in the density of solid household waste produced. The average density of solid household waste produced was 355.71±92.99 kg/m^3 in the rainy season and 308.02±74.15 kg/m^3 in the dry season.

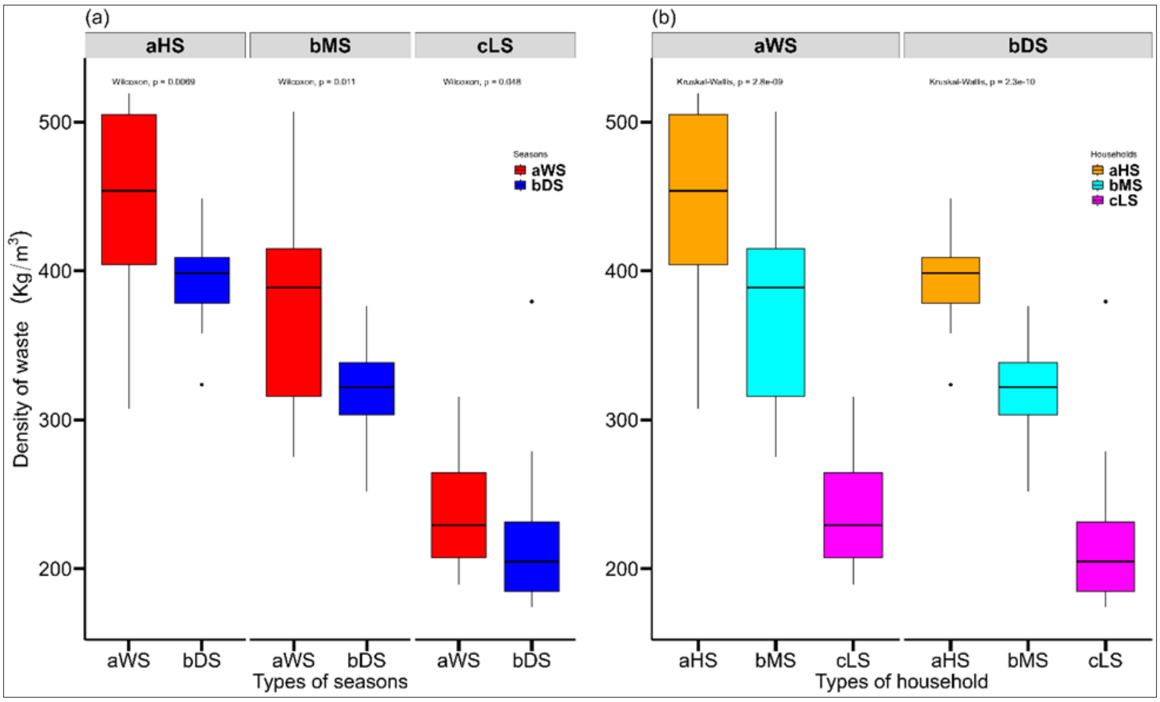

Figure 6 Density of solid household waste produced by household type (a) and by season (b). aHS: high-status household, bMS: medium-status household and cLS: low-status household, aWS: rainy season and bDS: dry season.

3.5. Seasonal moisture content of household solid waste

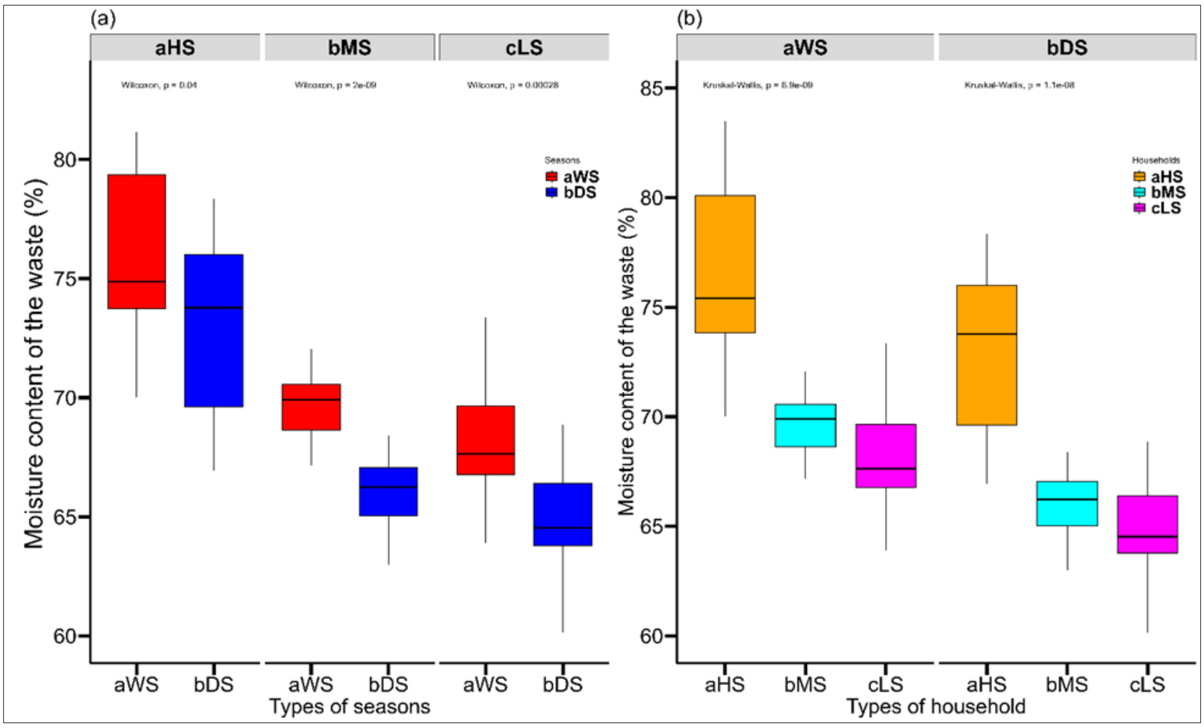

Figure 7 Moisture content of solid household waste produced by household type (a) and by season (b). aHS: high-status household, bMS: medium-status household and cLS: low-status household, aWS: rainy season and bDS: dry season

There are statistically significant differences (p-value < 0.05) between the types of season within households (Figure 7a) and between households within each type of season (Figure 7b) in the moisture content of household solid waste produced. The moisture content of solid household waste produced in households in the town of Dolisie is influenced by the season factor and the socio-economic level of households. High-Standing households produce household solid waste with an average moisture content in the rainy season (78.04±4%) and in the dry season (69.73±4.45%).

3.6. Seasonal characterisation of household solid waste by category

The characterisation of household solid waste in certain households in the town of Dolisie can be divided into three main groups: biodegradable, non-biodegradable and special waste. Analysis of variance showed no statistically significant difference (p-value > 0.05) between household solid waste categories and household types for the two seasons (rainy season and dry season) (Table 2). This showed similar production of different categories of household solid waste between these different household types. However, a statistically significant difference (p-value < 0.05) was observed between waste categories within each household type for both seasons (wet season and dry season) (Figure 8). Characterisation of household solid waste produced by household type in both seasons revealed eleven (11) waste categories (Table 3). Organic debris is the largest category in terms of proportion, whatever the type of household or season (Figure 8). This category represents almost half of the total quantity of solid household waste produced, with an average of 49.60±1.66% in the rainy season and 46.59±1.72% in the dry season. Special waste, on the other hand, represents the category with the lowest proportion of household solid waste, at 3.5±1.62% and 3.09±1.55% in the wet and dry seasons respectively.

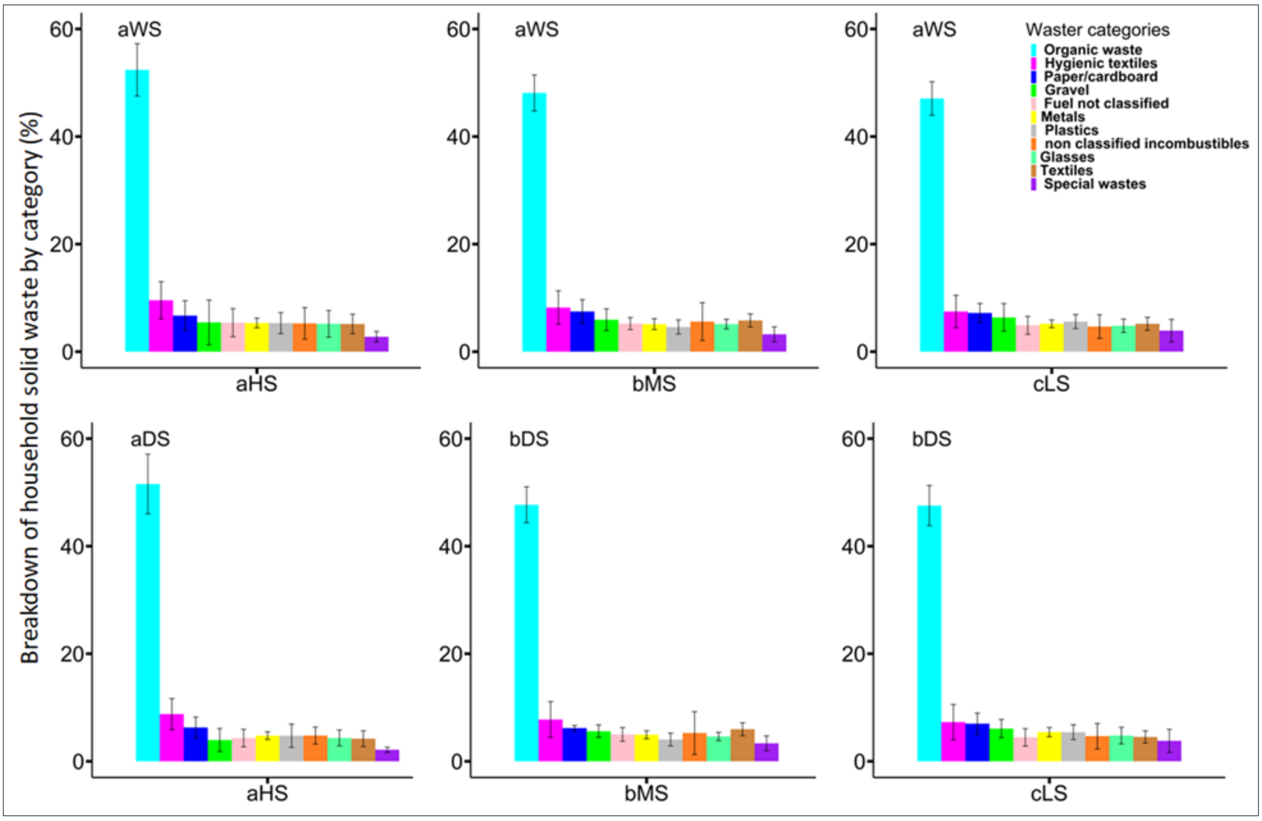

Figure 8 Characterisation by category of solid household waste produced by household type in both seasons. aHS: high-status household, bMS: medium-status household and cLS: low-status household, aWS: rainy season and bDS: dry season. Error bars represent sample standard deviation (n = 20).

Table 2 Analysis of variance between modalities (Categories and Households) and the physical characteristic of waste in the wet and dry seasons. DDL: degree of freedom. SCE: sum of squares of variance. CM: mean square. F: frequency. P-value: statistical probability

	DDL	SCE	CM	F	P-value
Wet season					
Categories : Households	20	121	6.0	0.860	0.6372
Residues	132	926	7.0		
Dry season					
Categories : Households	20	96	4.8	0.989	0.479
Residues	132	641	4.9		

Table 3 Characteristics of different categories of solid household waste produced in Dolisie

Groups	Waste categories	Waste sub-categories Groupes
Biodegradable	Organic waste	Food scraps, "chikwangue" packaging leaves, peelings, various leaves, branches, charcoal and others
	Paper and cardboard	Flat cardboard packaging, corrugated cardboard packaging, toilet paper, office paper and newspapers, magazines and journals.
Non-biodegradable	Plastics	- Plastic packaging: bottles, flasks, jars, etc. - Plastic bags and other plastics
	Glass and porcelain	- Glass packaging: bottles, flasks, jars, etc. - Other glass: broken glass and porcelain (shards)
	Metals	- Aluminium packaging: tins, cans and others, ferrous metals and others
	Textiles	Textiles Pieces of loincloth, shirts, towels, trousers...
	Sanitary textiles	Cottons, sanitary towels (pads), compresses, bandages, plasters, nappies, etc.
	CNC (Unclassified Fuels)	Leather, imitation leather, hair, cork, peanut bark.
	Gravel	- Stones: blocks, pebbles, etc. - Demolition materials (rubble)
	INC (Incombustible Non Class)	Unidentified fractions after coarse sorting and sieving
Special waste	Hazardous waste	- Batteries, telephone batteries, syringes, razor blades, etc. - Aerosols: insecticide and deodorant cans, tablet packs, condoms, etc.

3.7. Characterisation of household solid waste by particle size

The analysis of variance showed a statistically significant difference (p-value < 0.05) between the particle size of household solid waste between 100-20 mm and < 10 mm in both seasons, depending on the type of household (Table 4). Waste with a particle size between 10-20 mm showed a statistically significant difference (p-value < 0.05) between household types within the rainy season (Table 4). However, there was no statistically significant difference (p-value > 0.05) between the different household types on the particle size of household solid waste > 100 mm for both seasons and between 10-20 mm for the dry season (Table 4). On average, waste between 100-20 mm in size represented the highest proportion in the rainy season (57.00±4.8%) and the dry season (57.21±5.49%). Extra fines (< 10mm) represent on average solid household waste with the lowest proportion in the rainy season (4.17±1.56%) and in the dry season (5.19±2.18%).

Table 4 Breakdown of household solid waste by particle size. Signs (±) represent sample standard deviation (n = 20). Different letters on the means indicate a statistically significant difference at P < 0.05 according to the ANOVA test. *: statistically significant difference, **: statistically very significant difference and ns: no statistically significant difference.

Seasons	**Households**	**Size fraction of solid household waste (mm)**			
		100-20	20-10	> 100	< 10
Wet	High standing	66.28±4.88[a]	16.89±3.77[b]	11.56±2.56	3.07±0.35[a]
	Medium standing	52.81±4.56[b]	18.28±2.26[b]	16.65±3.84	4.6±0.73[b]
	Low standing	51.91±4.97[ab]	17.90±2.72[a]	17.43±2.84	6.45±0.84b[a]
Dry	High standing	64.48±5.82[a]	18.91±5.18	13.83±1.88	2.82±0.8a
	Medium standing	56.99±5.74[b]	17.22±5.18	15.83±4.43	5.16±1.28[b]
	Low standing	50.16±4.92[ab]	22.21±4.62	17.76±2.93	7.58±0.51[ab]
Wet season		*	**	ns	**
Dry season		**	ns	ns	**

4. Discussion

4.1. Quantification of household solid waste produced in Dolisie

Overall, daily per capita production of solid household waste is 0.79±0.19 kg/capita/day in the rainy season and 0.59±0.12 kg/capita/day in the dry season. Depending on the standard of living, high-status households produce greater quantities of waste (0.84 kg/capita/day) than medium-status households (0.64 kg/capita/day) and low-status households (0.58 kg/capita/day). The difference between these values is statistically significant (P-value < 0.05). This can be explained by the consumption of agricultural produce (various vegetables) and fruit (mangoes, saffron, figs, etc.) during the rainy season. These results differ from those found by Topanou [27] who showed that the daily ratio of solid household waste produced in the city of Abomey Calavi in Benin does not depend on climatic conditions even if slight fluctuations are observed. Indeed, the daily production of solid household waste is positively affected by dietary habits, population density in a household but also by seasonal variations during the year [14, 41]. In addition, the populations of some cities recover some of the useful matter from household waste for agricultural and/or livestock purposes, with the result that daily per capita production is reduced [2, 10, 42, 43]. However, they are similar to the work of Koledzi et al. [20] in Lomé, Togo, and Ngahane [26] in Bembéréké, Benin, towns with similar socio-economic levels to Dolisie in the Republic of Congo.

4.2. Effect of household socio-economic level on solid waste production in Dolisie

Waste production is influenced by local GDP, considered an important factor in daily waste production [43], as the socio-economic level of target populations has a positive correlation with daily household solid waste production [7, 44, 45]. Nevertheless, a household's monthly income is a very important parameter in determining the amount and types of household solid waste generated [46]. This provides a good orientation for household solid waste management policy. However, Trang et al. [47] showed a negative correlation between household income and household solid waste generation in the city of Thu Dau Mot, Vietnam. This shows that, high-income households produce less waste than low-income households. Moreover, production can be attributed to people's customs and culture [42].

4.3. Effect of household size on household solid waste production

There is a statistically significant difference between household size and daily household solid waste production. Indeed, the larger the household size, the lower the per capita household solid waste production [7, 10, 15, 24]. This trend can be explained by the fact that, in large and often poor households, purchases are made more by the head of household, which minimizes the amount of packaging and also waste produced compared to individual purchases. Thus, a negative correlation is observed between household size and daily household waste production per person. These results corroborate those found by Miezah et al. [15] in Ghana ; Qu et al. [10] in Beijing, China ; Thanh et al. [11] in Mekong Delta city, Vietnam ; Irwan et al. [48] in Putrajaya, Malaisia ; Kayode and Omode [49] in Ibadan, Nigeria ; Lozano Lazo et al. [22] in Santa Cruz de la Sierra, Bolivie all worked on solid household waste. However, previous studies Trang et al. [47] ; Khan et al. [50]; Noufal et al. [51]; Sankoh et al. [52] ; Senzige et al. [53] ; Guha et al. [21] have shown a positive relationship of household size on daily solid waste production, as the increase of one person in the household increases the amount of household solid waste produced per person. This increase in daily household solid waste production is a function of the increase in household consumption [50, 52]. Standard of living, household size and level of education are frequently cited as factors affecting solid waste production [54].

4.4. Household solid waste density

Household solid waste production differs from one country to another and from one city to another, depending on dietary behaviour, the socio-economic level of the population and the climate. The results of the present study show that, the density of solid household waste is influenced by climatic conditions, in line with the work of Koledzi [36] in Lomé, Togo which shows that the density of solid household waste is higher in the rainy season compared to the dry season. However, Ngahane [26], in Bembéréké, Benin, points out that the density of solid household waste is greater in the dry season than in the rainy season. This difference can be explained by the fact that there are more fine elements and rubble in the waste heaps in the dry season than in the rainy season. There was also a statistically significant difference between household solid waste density and household socio-economic level. This difference can be explained by differences in lifestyles and the socio-economic level of households. In cities in developing countries, for example, there are often areas with different habitats and socio-economic levels within the same neighbourhood in the same city [26], and increasing urbanisation and demographics play a very important role in the densification of household solid waste produced [55-57].

4.5. Moisture content of household solid waste

The moisture content of solid household waste produced in the town of Dolisie is strongly affected by seasonal variations throughout the year. There are statistically significant differences in the moisture content of MSW within seasons for each household type, and also between households in the wet and dry seasons. This difference can be explained by the nature of the household solid waste produced during the two seasons, in line with the work of Koledzi et al. [20] in Lomé, Togo. For Haro et al. [19], moisture content is seasonally sensitive. However, Aloueimine et al. [58] did not find any statistically significant difference depending on the season. This may be due to the fact that the inhabitants reuse certain types of waste in agriculture and animal husbandry. Guermoud and Addou [41] have shown that the moisture content of solid household waste depends on variations in climatic conditions and the elemental composition of fermentable waste, and that the moisture content is higher in the dry season than in the rainy season. Furthermore, De Guardia et al. [59] stress that the moisture content of solid household waste is really linked to a high proportion of organic matter produced by households. With regard to household type, Topanou [27] indicates that the moisture content of household solid waste does not reflect the socio-economic level of households. This can be explained by consumption patterns and the nature of organic waste. Thus, the moisture content of household solid waste is a very important parameter for operating a landfill, assessing the rate of waste degradation or predicting possible treatment methods for household solid waste [60-62].

4.6. Characterisation of household solid waste by category

The results of this study show that, whatever the season and social standard of living, the composition of household solid waste is dominated by the organic fraction. These results reflect the work of Topanou et al. [18] on the seasonal characterisation of household solid waste by social standard of living in Abomey Calavi (Benin). The average distribution of the organic fraction is 49.60±1.66% in the rainy season and 46.59±1.72% in the dry season. It is lower in Lomé in Togo [20] and in Brazzaville [16], while it is similar to the results found in the cities of Abuja, Lagos, Accra and Kumasi [17]. However, Haro et al. [19] pointed out that, regardless of the season of the year, household solid waste in the city of Ouagadougou (Burkina Faso) is dominated by fine particles. The presence of a high proportion of fine particles in household solid waste may be due to a change in feed and the start of degradation of household solid waste in transit centres into fine elements [20]. These variations in the proportion of organic waste in different African cities could be due to the difference in methodology, but also to the difference in the social standard of living of the populations [16]. The presence of a high proportion of biodegradable waste in the total waste treated gives rise to several avenues for waste recovery, such as composting [63].

4.7. Characterisation of household solid waste by particle size

When the season factor is taken into account, the characterisation of household solid waste by particle size is dominated by waste between 100 and 20 mm. This result can be explained by the immediate treatment of the waste collected. The proportions of waste between 100-20 mm in size, 57±7.01% and 58.21±7.34% respectively in the wet and dry seasons, are much higher than those found in Lomé in Togo [20] and Ouagadougou in Burkina Faso [19], and lower than the results found by Topanou et al. [18] in Abomey Calavi in Benin. Fine particles (10-20 mm) and extra fine particles (< 10 mm) represent an average of 10.31±5.78% in the rainy season and 12.37±7.17% in the dry season and consist mainly of coal debris, stones and sand. They are not produced directly by households but nevertheless end up in dustbins, bins and landfill sites and have a significant impact on the overall weight of waste produced. The proportions of fine particles differ from those found in Lomé, Togo (46% in the dry season and 56% in the wet season) by Koledzi et al. [20], as a result of the advanced degradation of household solid waste stored at the transit centre prior to evacuation to the final landfill. Characterisation of household solid waste by particle size provides necessary information that can be used as criteria for choosing the means of transporting the waste [64]. It can also be considered as a determining factor in the level of degradation of the organic matter contained in the waste stream [65].

5. Conclusion

The general aim of this study was to characterise, quantify and promote the recovery of organic waste in Dolisie in the Republic of Congo. The production of solid household waste in Dolisie among different types of households during the rainy and dry seasons was 0.79±0.19 kg/inhab/day and 0.59±0.12 kg/inhab/day respectively, which is characteristic of the average daily quantity of waste in sub-Saharan African countries.

Socio-economic level had a positive relationship with daily waste production, while household size had a negative relationship. The average density of all waste collected was 355.71±92.99kg/m^3 and 308.02±74.15kg/m^3 in the wet and dry seasons respectively.

The moisture content varies between 40-80%, typical of the moisture content of waste produced in developing countries. The household solid waste produced in Dolisie is generally between 100-20mm in size, making it easy to characterise. Household solid waste produced in Dolisie is divided into three groups (biodegradable, non-biodegradable and special waste), with biodegradable waste predominating whatever the season. The high content of organic matter suggested that the organic waste should be recycled by composting, given that market gardening is becoming increasingly popular in the town, resulting in a demand for organic matter, and by pyrolysis of the biomass (biochar) to combat deforestation of the surrounding forests through the manufacture of charcoal.

It would be advisable to determine the metallic trace elements both in the waste and in the products obtained after its recovery in order to decide on the hazardousness of this waste.

Compliance with ethical standards

Acknowledgments

The authors would like to thank the Marie de Dolisie, the Operateurs de Precollecte (OPC) and the heads of households who took part in the study.

Disclosure of conflict of interest

The authors declare that there are no conflicts of interest.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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