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Comparative Study of Disposal or Recycling System of Waste Produced at Aspiro and Central Markets of Kisangani Town

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Abstract

Solid waste management remains a major challenge for towns in sub-Saharan Africa, particularly in Kisangani (DRC). A comparative study of waste pathways at two major commercial sites: The Kisangani Central market and the Aspiro market, was carried out. It employs a methodological approach combining the identification, classification, and quantification of waste streams, as well as the analysis of collection routes to recycling (recovery) or disposal sites. Results highlight the types of waste (biodegradable waste, plastic and paper/cardboard waste, and miscellaneous waste in both markets). The current linear management system showed high discharge at the river of 78.1% in the Aspiro market and a high open-air landfill at the central market (80%). Putative solutions such as composting, methanization, and manufacturing ecological paving stones based on plastic waste for a transition to a circular economy are suggested. This research opens up perspectives for intervention to improve public health and environmental sustainability in Tshopo province.

Keywords

Solid Waste, Sustainable Management, Circular Economy, Kisangani, Central

Market, Apiro, Tshopo

1. Introduction

1.1. Context, Problem Statement and Justification

Waste production is inevitable for all living beings, it is crucial to address the problem of its production and recycling. To date, the process of producing waste of all kinds remains largely linear in most developing countries. Indeed, through their work, production, and consumption activities, human beings constantly generate waste of all kinds, which is unfortunately often discarded, mismanaged, and neglected, even though it could represent an opportunity, a starting point, or a renewable raw material for the manufacture of new and useful products (Wilson et al., 2024; Degboe et al., 2026).

In Conakry, household waste management has become a major problem, a source of concern for both local authorities and residents. This situation stems from numerous shortcomings in the current collection and treatment system. The collection rate, estimated at 70% in 1997, has fallen sharply to around 20% today, even though waste production has increased considerably, rising from approximately 600 tons to over 1,500 tons between 1997 and 2015 (Marie, 2017).

In developing countries, waste management faces numerous challenges related to a lack of technical, financial, and organizational resources. These constraints result in inadequate infrastructure, unstable funding, underqualified personnel, and a lack of data and appropriate strategies (Koledzi et al., 2014).

Global assessments estimate that municipal solid waste production will increase significantly by mid-century, driven by population growth, urbanization and rising per capital consumption (Vergara & Tchobanoglous, 2012).

In many low- and middle-income countries (LMICs), organic waste (food and plant matter) constitutes the largest share of municipal solid waste (often 40% - 70% of the waste stream), but its management remains inadequate due to limited collection systems, a lack of treatment infrastructure, and competing development priorities (Zohoori & Ghani, 2017). The global increase in municipal solid waste production raises multiple interdependent environmental, economic, and public health challenges.

The population growth of African cities is accelerating at a rapid rate (3.5%) per year compared to other continents (UNEP, 2018, cited by Dagno et al., 2023), which has an impact on waste production with low collection and recycling rates.

In the Democratic Republic of Congo (DRC), and more specifically in the Kisangani region, rapid urban growth and limited municipal services have led to a chronic accumulation of organic waste (Kang et al., 2023; Kubanza et al., 2017).

As in other sub-Saharan African cities, sustainable waste management is one of the most pressing issues in Kisangani. Located in Central Africa, in the northeast of the Democratic Republic of Congo, in the Tshopo province, this city produces significant quantities of waste of all kinds daily. However, it suffers from a lack of

structured and environmentally sound management systems. Given this priority, we propose to contribute to the proper management of all types of waste produced at the Kisangani central market and the Aspiro waste treatment facility by identifying, classifying, and analyzing their journey from their sources to their recycling or disposal sites.

1.2. Research Questions

To do this, the following central question is addressed: how do the wastes produced in Kisangani circulate from their points of production to their final management?

This question raises two sub-questions:

- What types and volumes of waste are produced at the Kisangani central market and at the Aspiro waste management facility?
- What routes and management methods are adopted for the removal and treatment of this waste?

1.3. Objectives

To answer these questions, an overall objective was set: "to evaluate the routes of all types of waste produced at the Kisangani central market and at Aspiro, from their points of production to their final management."

Two secondary objectives follow from this:

- To identify and classify the types of waste produced in both markets, while estimating their volumes.
- Analyze the pathways and methods of disposal and treatment of this waste.

2. Materials and Methods

2.1. Study Location

The study was conducted at the Aspiro and Central Markets in Kisangani (**Figure 1**). Kisangani is the capital of Tshopo Province located in Central Africa, in the northeast of the DRC (**Figure 2**). It sits at an altitude of 366 meters above sea level. Its geographical coordinates are 0˚31' north latitude and 25˚11' east longitude. It lies in the equatorial zone crossed by the Congo River (Iungbi, 2023; Salumu et al., 2023).

2.2. Methodology

The method applied to this study is descriptive and based on observation and interviews. Four field missions were conducted at the central market and Apiro during opening hours (11:00 AM to 2:00 PM) to observe and interview users about the nature, classification, and analysis of waste pathways from their sources to their various recovery or disposal sites. Specifically, these four missions were carried out over a two-week period between October and November 2025 at these two markets. The objective was to identify, classify, and determine the proportions of by-products generated there. The survey involved 12 vendors, distributed as follows: 4 young men aged 20 to 45 years, 6 women aged 25 to 50 years, and 2 children under

18 years of age and sanitation services at these markets regarding their collection techniques and methods, as well as the waste transport routes to recycling or disposal sites. The collected data were analyzed using Excel and R software 4.5.2.

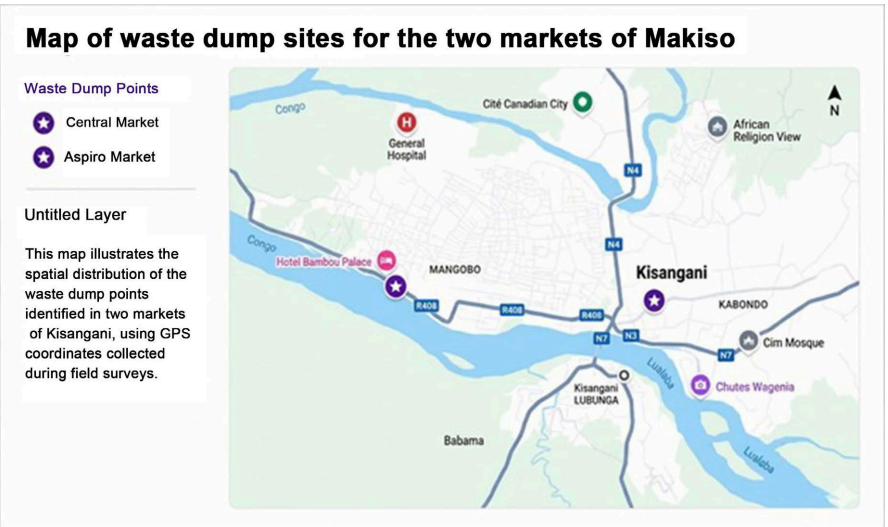

Figure 1. Study area, card made by Latémba DJIYERGOU using GPS geographical coordinate.

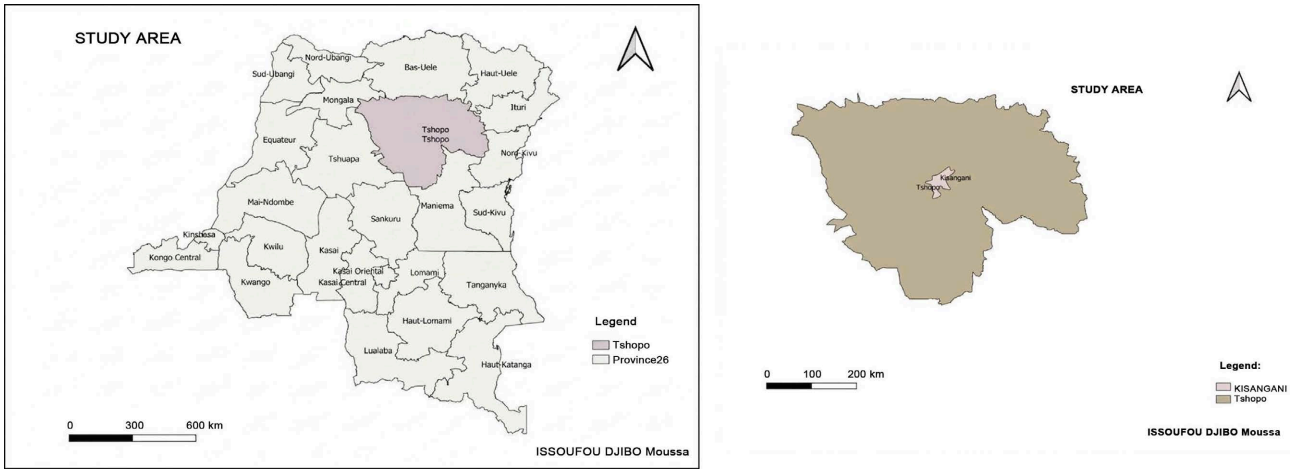

Figure 2. Map of the study area (Djibo, 2026).

3. Results and Discussion

3.1. Identification and Classification

The study revealed that these two markets (Figure 3 and Figure 4) mainly produce food waste, plant waste such as vegetable peelings, rotten fruit and tubers, plastic waste, paper, cardboard, electronic waste and liquid waste, classified into three main categories: bio-waste, plastic waste and miscellaneous waste.

The tables below illustrate the distribution of waste types produced in these markets.

❖ **Kisangani Central market**

Table 1 below illistrates the distribution of waste types produced in the Kisangani Central Market.

Table 1. Classification of waste types according to proportions.

Types of waste	%
Plastic waste	39
Biodegradable waste	43
Miscellaneous waste (paper/cardboard, electronic waste)	18

(a)

(b)

(c)

Figure 3. State of the Kisangani central market landfill.

❖ Aspiro market

Table 2 illistrates the distribution of waste types produced in the Aspiro Market.

Table 2. Comparative classification of waste types according to proportions.

Types of waste	%
Plastic waste	20
Biodegradable waste	70
Miscellaneous waste (paper/cardboard, electronic waste)	10

(a) (b)

Figure 4. State of the Apiro market landfill.

Comparative analysis shows that bio-waste constitutes the majority of waste on both sites, with particularly high proportions at the Apiro market (70%), reflecting a high level of activity related to food or perishable products.

The Central market also has a significant share of bio-waste (43%), but with a higher proportion of plastic waste (39%) compared to Apiro, which could indicate a significant use of plastic bags or packaging.

Paper, cardboard and other waste are present in moderate quantities at all sites, but are more prevalent at the Central market (18%) than at the Apiro market (13%).

3.2. Comparative Analysis of Waste Routes from Their Production Points to Their Final Management Methods

In these two markets in the city of Kisangani, the waste produced is poorly managed and the disposal or recycling system is failing.

❖ **Apiro market**

The results presented in Figure 5 below indicate that 78.1% of the waste produced is discharged directly into the Congo river. Meanwhile, 15% dumped in small landfills before incineration. An additional 1.9% first pass through gutters before discharge into the river, and the remaining 5% abandoned without any control.

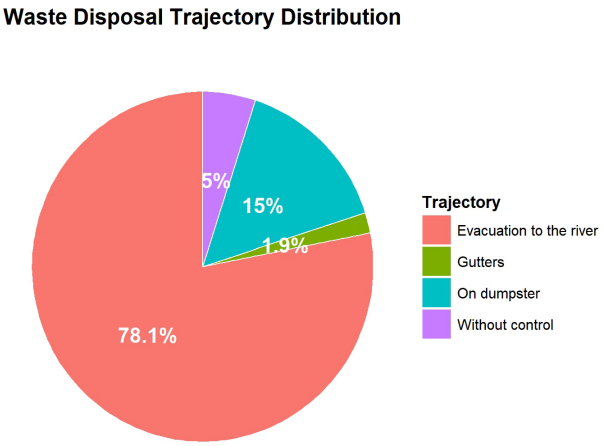

Figure 5. Analysis of waste trajectories in the Apiro market.

❖ **Kisangani Central market**

The results presented in Figure 6 indicate that at the Kisangani Central market, 80% of the waste produced is stored in the open air in the center of the market before transport by truck to an open-air landfill in Kabondo by the town waste management and sanitation service. An amount of 2.3% simply dumped elsewhere in the market without a disposal mechanism, 11.7% thrown into the gutters and the remaining 6% incinerated.

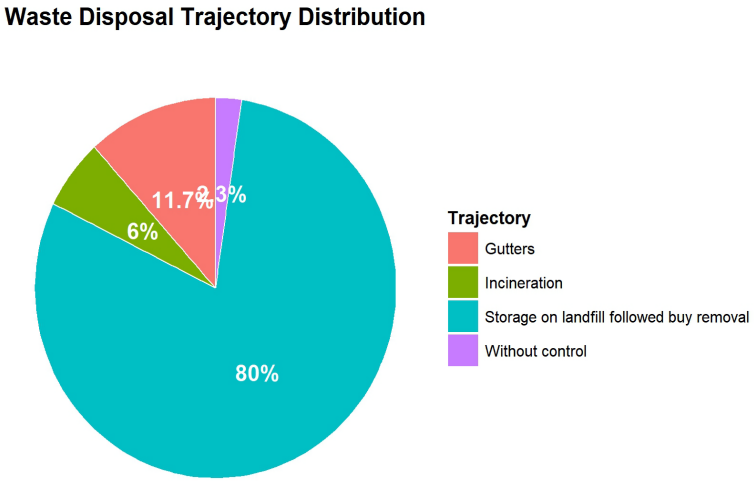

Figure 6. Analysis of the waste pathway at the Kisangani central market.

Table 3. Chi-square test results for differences in trajectory distributions between Central market and Aspiro site.

Study location	Kh-two (X^2) value	Degrees of freedom (df)	*p*-value
Central market	163.13	3	<0.001
Aspiro market	153.52	3	$<2.2*10^{-16}$

3.3. Discussion

All these results concerning the type, classification, and final management methods of waste are almost similar to those reported in the Matete district of Kinshasa, where a high proportion of organic waste (89.33%), food residues, paper, cardboard, glass, metals, and other materials was recorded, together with disposal practices such as dumping in gutters and incineration. Along University Avenue in the Mont Ngafula district, studies also reported the predominance of food waste (35%) and plastic waste (23%) (Alexis et al., 2022), as well as organic matter (80%), paper (12%), and plastics (7%) (Mola et al., 2024). However, some differences exist regarding waste management methods. Practices such as landfilling and waste collection by carts, commonly observed in Kinshasa (Vunir et al., 2022, cited by Kadilekoloko et al, 2023), are almost nonexistent in Kisangani, where waste management systems remain poorly developed.

The highly significant difference observed between waste disposal trajectories at the Central Market can mainly be explained by the geographical location of the

market in the city center and the presence of an organized sanitation service. The high proportion of waste stored at dumping sites before evacuation (80%) indicates that traders are encouraged or required to gather waste at collection points to facilitate transportation to the open-air landfill located in Kabondo. In contrast, the low proportions of incineration (6%) and uncontrolled disposal (2.3%) suggest a relatively better level of regulation and supervision of waste management practices in this market. Nevertheless, the disposal of waste into gutters (11.7%) demonstrates the persistence of inappropriate practices that may contribute to drainage obstruction, flooding, and urban sanitation problems.

For Aspiro market, the significant difference observed in waste disposal trajectories, characterized by a high proportion of waste discharged into the river (78.1%), low storage at dumping sites (15%), uncontrolled disposal (5%), and disposal into gutters (1.9%), can be explained by the market's location on the outskirts of the city, where sanitation services are insufficient or absent. Furthermore, the immediate proximity of the market to the river facilitates the direct dumping of waste into the watercourse. This situation reflects inadequate waste management infrastructure and highlights major environmental and public health risks associated with water pollution, including the spread of waterborne diseases and ecosystem degradation.

The chi-square test results confirmed that the differences observed between waste disposal trajectories were highly significant. For the Central market, the χ^2 value of 163.13 with 3 degrees of freedom and a p-value < 0.001 indicates that the distribution of waste management practices differs significantly and is not due to random variation (Table 3). Similarly, for Aspiro market, the χ^2 value of 153.52 with 3 degrees of freedom and a p-value < 2.2×10^{-16} also demonstrates a highly significant difference among the observed disposal trajectories. These findings confirm that waste management practices are strongly influenced by local environmental conditions, market location, and the availability of sanitation infrastructure.

4. Conclusion and Suggestions

Various field activities missions in the city of Kisangani, and more specifically to the Central market and the Apiro market, provided a precise overview of current waste management practices. The identification of waste types, existing and missing management methods, and the analysis of areas for improvement were carried out. The results obtained allowed for the suggestion of environmentally sound and compatible management methods.

For Apiro (where 78.1% of waste is dumped into the river), it is recommended to implement community collection and awareness campaigns to reduce direct discharges into the river, which are harmful to public health and the environment.

Although 80% of the waste produced at the central market is disposed of in a landfill, it is advisable to improve the organization and monitoring of this landfill in order to prevent the risks of health contamination and reduce environmental

impacts.

Indeed, these results suggest the need to adapt waste management strategies. Thus, there is a need to extract chemical compounds from the biowastes, characterize and test the compounds against crop pathogens for effective recommendations on management strategies

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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