

# State of Household Solid Waste Management in the Lukunga Health District: Challenges, Weaknesses and Opportunities

Francy Pembi Pembi<sup>1\*</sup>, Banza Cuné Kinégonde<sup>2</sup>, Emery Luzolo Kafinga<sup>1</sup>, Geneviève Nsenga Mboso<sup>2</sup>, Valentine Nzau Ngimbi<sup>2</sup>, Jeanne Mansanga Kiese<sup>2</sup>, Rose Shambu Mabintshi<sup>3</sup>

<sup>1</sup>Higher Institute of Medical Techniques of Kinshasa, ISTM-Kinshasa, Kinshasa, Democratic Republic of the Congo

<sup>2</sup>Higher Institute of Arts and Crafts of Kisantu, ISAM Kisantu, Inkisi, Democratic Republic of the Congo

<sup>3</sup>Higher Institute of Medical Techniques of Kisantu, ISTM-Kisantu, Inkisi, Democratic Republic of the Congo

Email: \*francypembi@gmail.com

**How to cite this paper:** Pembi, F. P., Kinégonde, B. C., Kafinga, E. L., Mboso, G. N., Ngimbi, V. N., Kiese, J. M., & Mabintshi, R. S. (2025). State of Household Solid Waste Management in the Lukunga Health District: Challenges, Weaknesses and Opportunities. *Journal of Geoscience and Environment Protection*, 13, 293-310.

<https://doi.org/10.4236/gep.2025.133016>

**Received:** January 21, 2025

**Accepted:** March 21, 2025

**Published:** March 24, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

---

## Abstract

Solid household waste management in Kinshasa, the capital of the Democratic Republic of the Congo, has become a significant problem due to its health, environmental, and economic impacts. The city generates several tons of waste daily, far beyond its management capacity. This study in Lukunga Health district aimed to define relevant, albeit local, strategies to improve waste management. A quantitative survey was conducted among 384 households. Socio-economic and geographical criteria were used for participant selection, and data were collected through a questionnaire. Data analysis revealed that the most common waste management method is uncontrolled dumping (62.2%) of cases. Reuse is practiced by 22.1%. Other challenges include lack or insufficiency of treatment infrastructure (16.4%) and inefficiency of municipal waste management services (15.4%). Statistics show that on average, 0.64 kg per person and 3.60 kg per household of waste are produced daily. Principal component analysis (PCA) indicated that raising awareness and educating the population, followed by strengthening sanctions against illegal dumping, are perceived as priorities for improving waste management. The results reveal poor waste management, exacerbated by socio-economic and infrastructural reasons. To reverse these trends, we must provide environmental education. To address these challenges, the study proposes a comprehensive solution based on awareness-raising and community engagement.

## Keywords

Solid Household Waste, Waste Management, Environmental Challenges,

---

## 1. Introduction

Municipal solid waste management in Kinshasa, the capital of the Democratic Republic of the Congo (DRC), represents a major urban challenge with health, environmental, and economic consequences. Kinshasa has an estimated population of over 17 million inhabitants, generating approximately 7000 tons of waste per day (World Population Review, 2024), which exerts intense pressure on outdated equipment and an unsustainable management plan for urbanization. This scenario has concerning consequences; among others, there is an increase in diseases associated with poor sanitation, pollution of rivers and groundwater, and degradation of the urban environment (Pembi et al., 2022). Organisms faced with non-ecological forms of waste disposal, such as throwing waste into ravines, burying it in plots, open-air burning, or dumping it in the street and gutters, maintain the living environment in a state of advanced fragility and precariousness (Balet, 2016). These practices, coupled with the lack of adequate systems to drain wastewater and rainwater, are the source of erosion phenomena, landslides, and floods, and maintain water stagnation in the streets, creating conditions conducive to the spread of disease vectors such as malaria and typhoid fever.

The Kinshasa Sanitation and Public Works Agency (RATPK), currently RASKIN, which is a technical service of the Ministry of Environment (Raymond, 2021), is among the service providers contributing to waste management in Kinshasa. While this agency has taken over instruments bequeathed by the Kinshasa Urban Rehabilitation and Sanitation Support Project (PARAU) funded by the European Union, its activity is severely hampered by limited financial resources and lack of equipment. Municipalities struggle to meet the challenges related to waste collection, transport, treatment, and disposal (Raymond, 2021). This situation is exacerbated by the absence or lack of follow-up of a clear regulatory framework and ineffective coordination between the various actors involved in waste management.

Moreover, the rapid population growth and unplanned urban expansion of Kinshasa (Diabagate & Konan, 2019) exert pressure on available infrastructure, making the task even more arduous. Waste treatment is hardly better in the Lukunga health district. The district produces far more waste than it can normally manage, leading to anarchic waste aggregates, degrading the living environment, threatening ecological resources, and endangering the population's health. This highlights significant structural and cultural problems, such as low levels of environmental awareness among residents.

Furthermore, many citizens are unaware of the implications associated with their non-ecological practices on public health and the local ecosystem (Ali et al., 2015), due to the effects, for example, of pollution on soil and waterways. The absence of a true waste management culture results in few or no community initiatives aimed at



province of Kinshasa, the capital of the DRC. This district is part of the decentralized health system of this city. Lukunga was one of the urban health districts established in Kinshasa in the context of Congolese health system reforms that were launched with the intention of decentralizing health services at the local level.

## 2.2. Population and Sampling

The study population included all residents of the Lukunga health district, including people of all socio-economic and demographic statuses, estimated at over 10,000, without any distinction. The survey unit was the residential plot, while the statistical unit was a household. We used a three-stage stratified random sampling (Voxco, 2022), combining purposive and random choice approaches to ensure representativeness of the studied population.

Stage 1: The study area was stratified into five geographical sectors according to urban and socio-economic criteria. Such stratification was designed to ensure adequate spatial coverage based on the characteristics of the assessed health district. Stage II involved the selection of twenty (20) avenues in these sectors proportionally to their size as a Probability Proportional to Size sampling method (Gavin, 2021). This approach ensures that some of the more densely populated areas have better chances of being selected, representing a more homogeneous distribution of the population. Sites were selected based on criteria such as population density, socio-economic level, accessibility, and variety of habitat types. This selection was validated by a panel of local urban planning experts to ensure its relevance and representativeness.

In the third stage, we applied Cochran's formula (Rahi, 2017) to identify the optimal sample size for an unknown population of over 10,000 inhabitants. The applied formula was:  $n = Z^2 * p * (1 - p) / e^2$  with a confidence level of 95% and a margin of error of 5% where:  $n = 1.96^2 \times 0.5 \times 0.5 / 0.05^2 = 384$ . To compensate for refusals/incomplete questionnaires, we increased the sample by 10%, bringing the number of households to contact to 422.

In each avenue, households were selected using a systematic sampling step with a random start. From there, the sampling step was estimated by dividing the estimated number of households per avenue by the number of households that needed to be drawn from it. We conducted in-depth analyses of non-respondent demographics, including follow-up interviews with a subsample of non-respondents for apparent biases. Data quality control was performed through interviewer training, field verification, and consistency analysis of the obtained data. Thus, a pilot study with a small sample (10% of the final size) was conducted to test and improve the adequacy and usefulness of the data collection instruments and sampling procedures employed.

Participants were informed of the study objectives, protocol implementation modalities, and their right to withdraw from the study at any time. All participants provided informed consent before inclusion in the study in accordance with ethical standards.

### 2.3. Measurement

In terms of measurement, average estimates of household solid waste quantities generated per day in the 384 surveyed households were made. For this, each house was provided with a plastic bag for waste. All they had to do was deposit all solid waste generated by the household during one day in this bag. Quantification was carried out for three consecutive days using a “Salter” brand scale (1000 mg). The study was conducted from September 25 to October 25, 2024.

### 2.4. Study Limitations

We wish to acknowledge certain limitations of this study. In fact, the study was limited to the Lukunga health district, which would tend to limit the generalization of results to the entire city of Kinshasa. Although the sample of 384 individuals is statistically significant, more information could have been obtained if the size had been larger. Interviews or focus groups, which could have included mapping, would have provided a greater richness of results.

## 3. Results

The results of this **Table 1** indicate that the 384 subjects were diverse in terms of sociodemographic characteristics. The sample shows a slight male predominance (54.7% men versus 45.3% women) and an age distribution evenly spread across the twenties, thirties, and beyond (each group representing about a quarter of the sample). 36.5% had a low level of education. Monthly incomes were mainly low to moderate, with 41.7% of respondents earning less than \$100 and 37.5% earning between \$100 and \$300. The largest socio-professional category was the general population (residents/households) (46.9%), followed by merchants (15.6%). Regarding housing, most (62.5%) were tenants, 31.2% owners. This gives a balanced overview of the studied population, which is mainly composed of low-income people and tenants, which can be beneficial for understanding behaviors or opinions based on these variable sociodemographic attributes. Household size was mainly composed of 6 or more people, 70.3%. These characteristics could be useful for guiding targeted interventions or policies towards this population.

As shown in **Table 2**, food waste, packaging, and papers had the largest share with 58.9%. For optimized waste management, this means that reducing or recycling this type of waste should be a priority. The second largest category, food waste and packaging, accounted for 15.1%. Papers came next with a contribution of 11.5%.

**Table 1.** Distribution according to participant profile.

| Variable | Categories | Number.<br>n = 384 | Percentage<br>(%) |
|----------|------------|--------------------|-------------------|
| Sex      | Male       | 210                | 54.7              |
|          | Female     | 174                | 45.3              |

**Continued**

|                              |   |     |      |
|------------------------------|---|-----|------|
|                              | Less than 25                            | 96  | 25.0 |
|                              | 25 to 30                                | 88  | 22.9 |
| Age                          | 31 to 36                                | 98  | 25.5 |
|                              | Over 36                                 | 102 | 26.6 |
|                              | Low (primary or illiterate)             | 140 | 36.5 |
| Education Level              | Secondary                               | 124 | 32.3 |
|                              | University or Higher                    | 120 | 31.2 |
|                              | Less than 100\$                         | 160 | 41.7 |
| Monthly income               | Between 100\$ and 300\$                 | 144 | 37.5 |
|                              | More than 300\$                         | 80  | 20.8 |
|                              | General population (resident/household) | 180 | 46.9 |
|                              | Merchant                                | 60  | 15.6 |
| Socioprofessional categories | Work at a NGO                           | 40  | 10.4 |
|                              | State agent                             | 36  | 9.4  |
|                              | Health worker                           | 28  | 7.3  |
|                              | Waste picker (informal sector)          | 40  | 10.4 |
|                              | Tenant                                  | 240 | 62.5 |
| Type of housing              | Landlord                                | 120 | 31.2 |
|                              | Other                                   | 24  | 6.3  |
|                              | Less than 3 persons                     | 26  | 6.8  |
| Household size               | 3 to 5 persons                          | 88  | 22.9 |
|                              | 6 and more                              | 270 | 70.3 |

**Table 2.** Distribution of waste types.

| Variable          | Categories                           | Number<br>n = 384 | Percentage |
|-------------------|--------------------------------------|-------------------|------------|
|                   | Food waste and packaging and paper   | 226               | 58.9       |
|                   | Food waste and packaging             | 58                | 15.1       |
|                   | Paper                                | 44                | 11.5       |
| Management method | Food or organic waste                | 20                | 5.2        |
|                   | Packaging (plastic, cardboard, etc.) | 20                | 5.2        |
|                   | Glass                                | 6                 | 1.6        |
|                   | Metal                                | 6                 | 1.6        |
|                   | Others                               | 4                 | 1.0        |

**Table 3** shows a diverse distribution of waste management methods. It reveals that the most used method was “Dumping garbage in nature”, representing 62.2% of cases, which constitutes a serious environmental problem. A less widespread practice, reuse, was practiced by only 22.1% of respondents, indicating some adoption of acceptable behaviors. Other options, such as sorting and recycling (1.3%), composting (0.5%), and energy recovery (1.0%) were barely mentioned.

**Table 3.** Distribution according to waste management methods.

| Variable             | Categories               | Number<br>n = 384 | Percentage |
|----------------------|--------------------------|-------------------|------------|
| Management<br>method | Sorting and Recycling    | 5                 | 1.3        |
|                      | Dumping in nature        | 239               | 62.2       |
|                      | Composting               | 2                 | 0.5        |
|                      | Landfilling              | 16                | 4.2        |
|                      | Sorting and incineration | 5                 | 1.3        |
|                      | Sanitary burial          | 7                 | 1.8        |
|                      | Energy recovery          | 4                 | 1.0        |
|                      | Reuse                    | 85                | 22.1       |
|                      | Source reduction         | 19                | 4.9        |
|                      | All these methods        | 2                 | 0.5        |

Statistics confirmed that management methods are used very unevenly: the average is 38.4 people per method (about 9.98%), but a significant standard deviation means that some practices are massively dominant. The median showed that only 6 people or fewer used 50% of the methods. This data shows a strong emphasis on a limited number of behaviors, particularly waste disposal in the natural environment. This is a manifestation of a lack of awareness or accessibility to sustainably conscious practices.

The results of **Table 4** can help assess the complexity (i.e., degree of connection, set of possible actions, associated resources, and their availability) of overall household waste management problems. The major issue raised was that there are no waste treatment facilities (16.4%). The most common challenges were inefficiency of municipal services in waste management (15.4%), presence of illegal dumps (15.1%), followed by an inefficient waste disposal system (14.4%). Infrastructure failures, administrative gaps, and citizen behaviors are interconnected, and these findings highlight this interdependence. Significant challenges also included waste collection problems, such as insufficient dumpsters and collection points (9.6%), inadequate collection services (9.4%), and poor landfill management (9.4%). Notably, the relatively low mention of challenges regarding correct waste sorting and recycling could suggest that these practices are not yet priorities in the studied community. The fragmentation of difficulties specific to each area

reinforces the need for comprehensive improvements in household waste management, including better infrastructure investments, improved municipal services, communication campaigns for awareness, and gradual implementation of sorting and treatment practices.

**Table 4.** Distribution according to the main challenges encountered in household waste management.

| Variable                          | Categories                                  | Number<br>n = 384 | Percent |
|-----------------------------------|---|-------------------|---------|
| <b>Challenges<br/>encountered</b> | Lack of information on waste sorting        | 6                 | 1.6     |
|                                   | Poor landfill management                    | 36                | 9.4     |
|                                   | Some of these challenges                    | 2                 | 0.5     |
|                                   | Insufficient recycling bins                 | 6                 | 1.6     |
|                                   | Irregular collection                        | 24                | 6.3     |
|                                   | Poor waste management by municipal services | 59                | 15.4    |
|                                   | Lack of awareness or education              | 57                | 14.8    |
|                                   | Lack of waste treatment infrastructure      | 63                | 16.4    |
|                                   | Presence of illegal dumps                   | 58                | 15.1    |
|                                   | Lack of adequate collection services        | 36                | 9.4     |
|                                   | Lack of garbage bins and collection points  | 37                | 9.6     |

The results of **Table 5** showed that most respondents (45.8%) suggested improving public awareness and education, emphasizing behavior change in favor of health and the environment. 38.0% of respondents recommended stricter sanctions for illegal dumping and aimed to reduce incentives for negligent actions. An improvement in waste collection frequency was highlighted by 9.9% of respondents as an area of dissatisfaction with current services.

**Table 5.** Distribution according to suggestions.

| Variable           | Categories                                      | Number<br>n = 384 | Percent |
|--------------------|---|-------------------|---------|
| <b>Suggestions</b> | More collection points for recyclables          | 6                 | 1.6     |
|                    | Better public awareness and education           | 176               | 45.8    |
|                    | Improved waste collection frequency             | 38                | 9.9     |
|                    | Installation of community composters            | 14                | 3.6     |
|                    | Strengthening sanctions against illegal dumping | 146               | 38.0    |
|                    | Other (to specify)...                           | 4                 | 1.0     |

The results show that respondents tend to prefer options aimed at changing individual and collective behaviors (education and sanctions) rather than approaches limited to infrastructure (which can be circumvented). This perception

indicates that the cornerstones of challenges associated with waste management are not rooted in the lack of infrastructure or services but rather in human practices.

**Table 6.** Estimation of waste production.

| Household size | Frequency | Percent (%) | Average production (kg/jour) | Total production (kg/jour) |
|----------------|-----------|-------------|------------------------------|----------------------------|
| Less than 3    | 26        | 6.8         | 16.64                        | 16.64                      |
| 3 to 5         | 88        | 22.9        | 56.32                        | 56.32                      |
| 6 and more     | 270       | 70.3        | 172.80                       | 172.80                     |
| Total          | 384       | 100.0       | 245.76                       | 245.76                     |

For **Table 6**:

1) Household distribution:

- The majority (70.3%) of the sample consisted of households of 6 people or more,
- 22.9% of the survey sample consisted of 3 to 5 people per household,
- Less than 3 people represented 6.8%.

2) Waste production:

- Households of 6 people or more produced the most waste (1123.20 kg/day): 81.3% of total production;
- 3 to 5 people produced 225.28 kg/day: 16.3% of total production;
- Less than 3 people produced 33.28 kg/day: 2.4%.

3) Average by household size:

- Households of 6 people or more had the highest average production (4.16 kg/day),
- Those of 3 to 5 people had an average of 2.56 kg/day,
- Those of less than 3 people had an average of 1.28 kg/day.

These results reflect a relationship between household size and waste production, with larger households producing more waste.

*Estimation of waste production per household:*

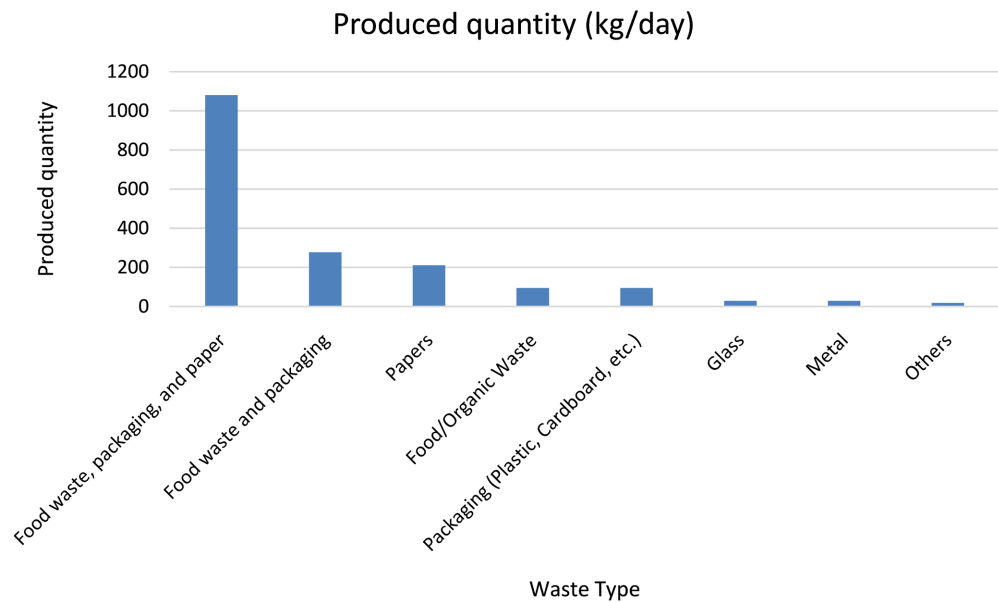
The average waste production per household was approximately 3.60 (kilograms/day). This number is calculated by obtaining the total waste production divided by the total number of households.

*Total population estimate:*

Using the following assumptions for household sizes:

- Less than 3 people: 2 people/household,
- 3 to 5: 4 members per home,
- 6 and more: 6.5 people per household on average,
- The total population is approximately 2160.

The average waste production per person is 0.64 kg/day. This is done by dividing the total waste generated (1381.76 kg/day) by the estimated total population of 2160 people. Total waste production (**Figure 2**) provides more information below.



**Figure 2.** Total waste production by type.

**Figure 2** shows that food waste, packaging, and papers are the largest category with 750 kg/day and the largest share of production. This includes food waste and packaging; the second has about 300 kg/day. Papers rank third with about 200 kg/day of waste produced.

The graph above highlights the importance of food waste combined with packaging and papers in waste management. Efforts to reduce or recycle this category should be prioritized to maximize environmental impact.

**Logistic Regression**

The results of this **Table 7** show that the variables sex, age, income, socio-professional category, and type of housing have a *p*-value < 0.05. Statistically, there is evidence of a significant influence on the development of large-scale municipal waste management problems. These findings highlight their importance as determinants requiring special attention in strategy formulation.

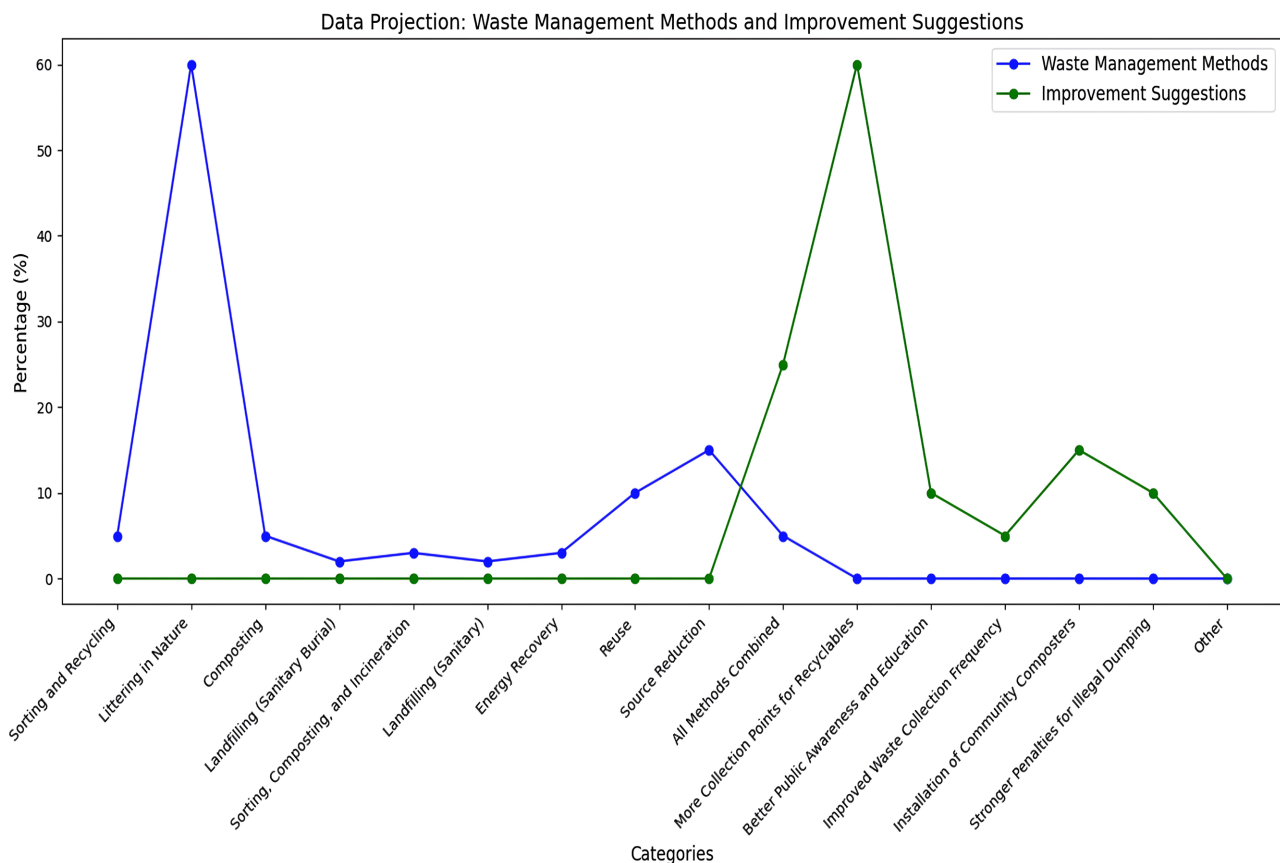
**Table 7.** Logistic regression between sociodemographic categories and challenges.

| Variable                 | Coefficient ( $\beta$ /beta) | <i>p</i> -value | Odds Ratio (OR) |
|--------------------------|------------------------------|-----------------|-----------------|
| Constant                 | -1.30                        | 0.05            | 0.27            |
| Sex (male)               | 0.75                         | 0.03            | 2.12            |
| Age (>36 years)          | 0.68                         | 0.01            | 1.98            |
| Education level (low)    | -0.45                        | 0.10            | 0.64            |
| Income (<100\$)          | 1.25                         | 0.001           | 3.52            |
| SP category (population) | 0.85                         | 0.02            | 2.34            |
| SP category (population) | 1.05                         | 0.001           | 2.85            |

Regarding the OR (Odds Ratio), the analysis results indicated that certain soci-

odemographic factors notably increase the likelihood of facing significant waste management difficulties:

- Low income (OR = 3.52): Low-income individuals are more likely to report difficulties, again showing a clear association between economic status and challenges encountered.
- Tenant (OR = 2.85): Management challenges are more encountered by tenants, which may indicate increased difficulty in accessing adequate infrastructure or services.
- Sex (OR = 2.12): Men respond more frequently, disproportionately showing problems associated with waste management, indicating potential gender differences in waste perception or management.
- General population (OR = 2.34): The general population is more exposed to challenges, indicating an overall vulnerability that requires inclusive and targeted solutions.
- High education level (OR = 0.64): Refers to a low probability of encountering major challenges related to waste management. In fact, the more educated a person is, the less they report problems with waste, suggesting that people with knowledge about environmental issues and good knowledge about waste are better able to cope with these challenges.



**Figure 3.** Data projection after principal component analysis (PCA).

Therefore, these results highlight the relevance of sociodemographic specificities in strategies and the significant role that education and awareness play in improving waste management practices. To complete the analysis comprehension (Figure 3), we tried to sort the principal components.

#### Principal Component Analysis (PCA)

Through Figure 3, the PCA allowed for dimensionality reduction to two principal components, providing insights that could help improve waste management:

Waste management methods (blue curve)

- The blue curve shows how nearly 80% of waste ends up being abandoned in nature. This is a very common practice, as evidenced by the high value of Component 1 (3.998516). From these goods and this predominant approach, increased effort must be made to orient behaviors towards more sustainable alternatives such as recycling, reuse, and composting.
- Reuse is the second most common technique with a positive value on Component 1 (0.928451).
- Other treatment methods (including sorting and recycling, composting, and energy recovery), along Component 1, show negative values, meaning they are used to a lesser extent.

Improvement suggestions (green curve)

- Regarding Component 1, better public awareness and education has the highest PCA value (<2.262219), which is consistent with it being the most frequently suggested improvement. Indeed, increasing public awareness of the negative effects of waste disposal in nature and the benefits of sustainability is important.
- The second is strengthening sanctions regarding illegal dumping, which comes with a high positive value on Component 1 (1.656580). Regulations must be clearly understood and respected.
- Other suggestions, such as more collection points for recycling and community composters, have negative values on Component 1, meaning they are not as common suggestions.

These two approaches (education and legislation) are highly complementary and serve to guide the population to change behaviors. Such integrated strategies that combine awareness, incentives, and penalties could help evolve current practices towards more environmentally friendly alternatives. The underlying logic of this approach is to address some of the main waste management challenges resulting from the PCA results, including improvements in waste production and management, while tackling behavioral changes at the individual level.

## 4. Discussion

This discussion of results highlights the complex realities and challenges associated with waste management in low-income country contexts. It draws on an analysis that integrates structural, behavioral, and socio-economic dimensions, as

well as strategic recommendations for rectification towards sustainable management.

#### 4.1. Sociodemographic Profile and Behaviors

As previously mentioned, the studied sample, composed mainly of low-income households and tenants, reflects trends introduced in the literature, notably by Wilson et al. and Guerrero et al. Due to their socio-economic vulnerability, these population groups are often more exposed to unregulated waste management practices (Guerrero et al., 2013). Furthermore, Kulkarni et al. confirm that income-related groups do not focus on waste sorting and demonstrate how economic status plays a vital role (Kulkarni, 2020). For Abarca Guerrero et al., these studies confirm that low-income households are the largest waste generators on average, as they lack the resources to reduce waste and tend to use more disposable items (Guerrero et al., 2013).

#### 4.2. Waste Management Methods

Waste disposal in nature (62.2%) also constitutes a major environmental problem in developing countries. This high rate confirms the findings of Guerrero et al. and Zurbrugg et al. on the environmental effects of informal waste disposal practices (Zurbrugg et al., 2012). Today, uncontrolled waste disposal is still common, occurring mainly due to a lack of collection services and awareness. This is particularly concerning in densely populated urban centers, where the amount of waste generated often exceeds waste management capacity. In Ghana, each day, out of a daily generation of 810 tons, only 27% is collected, resulting in 594 tons still untreated, thus becoming a significant environmental and public health risk (Zurbrugg et al., 2012).

Nie and Wadehra prove that an integrated approach encompassing not only access to adequate infrastructure but also awareness campaigns can radically change practices, even in low-income contexts like Bangladesh (Wadehra & Nie, s.d.). Their study revealed that with curbside collection of inorganic waste and information campaigns, household-level waste sorting could be clearly improved. Community members can also play a significant role in better waste management solutions through environmental education.

#### 4.3. Waste Management Challenges

A major challenge in solid waste management lies in a lack of infrastructure and awareness. Socio-economic aspects further complicate this problem, as observed in the study by Tsheleza et al., conducted in South Africa. Their research reveals that socio-economic status and household structure determine solid waste generation and management systems (Tsheleza et al., 2022).

These findings underscore the need for a systemic vision of the waste problem, where it is necessary to find a balance between these interconnected elements. In fact, daily waste-related problems still concern low-income communities, alt-

though the South African government has attempted to implement better waste management practices. This makes the pro-poor orientation of the solid waste management system critical. Moreover, Nie and Wadehra recently showed, through a study in Nepal, that a combination of information campaigns and construction of adequate infrastructure (e.g., curbside collection of inorganic waste) works. This approach has been particularly successful in promoting waste sorting at the household level, even in low-income contexts (Wadehra & Nie, s.d.).

Such observations justify the need for a holistic approach aimed at simultaneously addressing infrastructure, education, and socio-economic issues. This is why the development and extension of waste management infrastructure accessible to all, educational campaigns, and policies taking into account the socio-economic realities of local contexts become crucial to unleash our potential for sustainable waste management in urban and peri-urban communities.

#### 4.4. Measurement

The relationship between household size and waste production found in this study is consistent with general trends reported by other studies. However, the scale of this relationship seems to be more pronounced. For example, the 2011 EPIC survey mentioned in the research results indicated that waste generation increases with the number of people in a household, but generally at a decreasing rate. However, the current study showed a more linear increase per household, with those in the 6 people and above range producing an average of 4.16 kg/day, followed by households with 3 to 5 people with an average of 2.56 kg/day, and households with less than 3 people producing an average of 1.28 kg/day. The per person waste production estimated at 0.64 kg per day in this study is within the normal range observed on average in other urban contexts of developing countries. For instance, the specific production of household waste in Yaoundé (Cameroon), according to Ngambi, varies between 0.5 - 0.8 kg/person/day depending on housing standards and an average of 0.62 kg/person/day. However, Dieng et al. found that the average production of household solid waste was 3.60 kg per day/household, which, considering a similar household size in this study, would have given a comparable per person production (Dieng et al., 2018).

Since a large part of what we throw away consists of organic waste and packaging, there is much value in recycling or composting. Mbue et al. further affirm this observation with general recommendations to help improve waste management in African cities in their studies in Yaoundé (Zhang et al., 2024).

#### 4.5. Statistical Analysis and Impact of Sociodemographic Factors

The data show that education has a strong influence in decreasing existing waste management issues (OR = 0.64). This correlation is confirmed by research conducted by Tsheleza et al., emphasizing that awareness and community participation in recycling practices are the greatest contributors to reducing waste generation rates (Tsheleza et al., 2022). These results highlight the vital need for envi-

ronmental education in general, especially in low-income settings. Three steps progressively increase interest and understanding of waste-related issues (interest, understanding, action), and indeed, environmental education builds an understanding of waste through these three levels. This gradual method encourages the establishment of safe waste disposal routines such as sorting and recycling. Moreover, young people are particularly supported in this change when this sustainable lifestyle is taught at school, allowing this message to be part of not only their lives but also enabling children to share the message with their parents.

#### **4.6. Improvement Suggestions and Perceived Priorities**

The principal component analysis (PCA) shows that awareness, education, and more severe sanctions for illegal dumping are the most important factors in waste management. This ranking attempts to find the right balance between pedagogy and deterrence. The work presented by Nie and Wadehra in Nepal offers valuable evidence on the effectiveness of combined interventions (Wadehra & Nie, s.d.). Their research shows that the separation of inorganic waste at the household level is positively stimulated by the deployment of an information campaign aimed at targeting such behavior. Indeed, this pragmatic approach that combines awareness and logistical facilitation has proven particularly useful in the Nepalese context.

Furthermore, providing tangible solutions by providing appropriate bins and maintaining regular collection services produces a sustainable and measurable result. These types of interventions are more effective than isolated information campaigns, which underscores the need for a holistic approach to waste management. Zaman also supports these findings, reporting that environmental education and incentive policies are critical to achieving more sustainable waste management. His research shows that the mixture of these elements creates an environment that favors the adoption of environmentally friendly behaviors. This integrated effort, combining education, infrastructure, and incentives, is more effective than isolated interventions. It provides a framework for capturing the various aspects of waste management, from awareness to action through implementation through support systems. A comprehensive approach, as described above, is necessary to encourage a sustainable transformation of community waste management behaviors.

#### **4.7. Economic Opportunities and Social Inclusion**

The successful development of waste management systems can bring considerable economic opportunities. Recycling and waste-to-energy initiatives can create jobs, boost local industries, and contribute to fostering a green economy. As demonstrated by the example of SWaCH in India, integrating the informal sector with an existing formal waste management system can improve working conditions and income for marginalized workers while increasing the efficiency of waste collection (Saifi & Jha, 2024).

#### 4.8. Strategic Recommendations

To address these challenges, a multidimensional approach is essential, combining awareness, infrastructure, inclusion, and innovation:

- Propose educational programs tailored to local use that promote waste sorting at the household level; these will aim to educate households on the benefits of waste sorting (environmental and economic benefits).
- Facilitate easy collection and treatment, especially in low-income areas, to minimize informal practices.
- Adopt an inclusive and multi-stakeholder approach to achieve sustainability.
- Motivate residents to participate, particularly in local recycling and composting programs.
- Strengthen sanctions based on measures to reduce waste generation and promote recycling to deter prohibited behaviors.
- Channel appropriate technological solutions for waste collection and treatment.
- Increase fines for illegal dumping, the second most common suggestion.
- Improve and promote waste reuse as a management method, being the second most common positive management process after dumping in nature.

#### 4.9. Future Perspectives

A multidimensional approach would encompass education, adaptive infrastructure, and policies to reflect local socio-economic conditions. Future interventions should consider other practical, feasible, and culturally sensitive solutions, as well as strengthen environmental education through awareness and community engagement. Integrated and inclusive approaches can also foster progress towards sustainable waste management in low-income contexts.

### 5. Conclusion

Focused on the Lukunga health district, this analysis provides a detailed and multifaceted exploration of solid waste management challenges in low-income urban settings in Kinshasa. It highlights the structural, behavioral, and socio-economic gaps that constitute barriers to effective waste management, while suggesting strategic pathways for a sustainable and versatile model.

The results are alarming, indicating a critical lack of infrastructure, immense deficits in awareness and sensitization, and the persistence of informal and dangerous forms of management. On the other hand, the study also shows that integrated strategies combining education, community inclusion, and investments in accessible infrastructure can transform these challenges into opportunities.

Based on solid empirical data and citizen feedback, the study provides concrete and localized recommendations, with the aim of extending them to other districts of Kinshasa. Thus, this strategic framework targets policymakers, urban management, and civil society actors and equips them with the necessary tools and innovative solutions to effectively address solid waste management challenges in such

contexts. This study paves the way for a sustainable transformation of public health, a progression of urban environmental protection, and a decent quality of life for Kinshasa residents through a holistic, inclusive, and adaptable approach.

The implementation of the recommendations could make waste management in the Lukunga health district a showcase of waste management not only for other districts of Kinshasa but also for other African cities facing similar challenges. We believe that by linking education, adapted infrastructure, and community engagement, this approach can create sustainable change in waste management and ultimately guide the region towards the Sustainable Development Goals (SDGs).

## Conflicts of Interest

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

## References

- Ali, A. I., Bari, H. E., Belhadj, S., Karouach, F., Joute, Y., & Gradi, Y. (2015). Contribution à l'amélioration de la gestion des déchets ménagers aux Comores. *International Journal of Innovation and Applied Studies*, *12*, 786-800.
- Balet, J. M. (2016). *Gestion des déchets* (5e éd). Dunod.
- Diabagate, S., & Konan, K. (2019). Gestion des ordures ménagères dans la ville de Bouaké, sources d'inégalités socio-spatiales et environnementales. *Revue Espace, Territoires, Sociétés et Santé*, *1*, 126-142.
- Dieng, D., Diop, C., Sonko, E. h. M., Gning, J. B., Djitte, M., & Gassama, C. I. D. (2018). Gestion des déchets d'équipements électriques et électroniques (DEEE) au Sénégal: Acteurs et stratégie d'organisation de la filière. *International Journal of Biological and Chemical Sciences*, *11*, Article 2393. <https://doi.org/10.4314/ijbcs.v11i5.35>
- Gavin, T. (2021). *Stratified and Probability Proportional to Size Sampling*. <https://repositorio.cepal.org/server/api/core/bitstreams/667f6d59-21fb-4c0e-8be6-31f5a28766ca/content>
- Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid Waste Management Challenges for Cities in Developing Countries. *Waste Management*, *33*, 220-232. <https://doi.org/10.1016/j.wasman.2012.09.008>
- Holenu Mangenda, H., Mulaba, P., & Kiawutua, A. (2020). Gestion des déchets ménagers dans la ville de Kinshasa: Enquête sur la perception des habitants et propositions. *Environnement, Ingénierie & Développement*, *83*, Article 7723. <https://doi.org/10.4267/dechets-sciences-techniques.4272>
- Kang, Y. O., Yabar, H., Mizunoya, T., & Higano, Y. (2023). Environmental and Economic Performances of Municipal Solid Waste Management Strategies Based on LCA Method: A Case Study of Kinshasa. *Heliyon*, *9*, e14372. <https://doi.org/10.1016/j.heliyon.2023.e14372>
- Kaushika, N. D., Reddy, K. S., & Kaushik, K. (2016). *Sustainable Energy and the Environment: A Clean Technology Approach*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-29446-9>
- Kulkarni, B. N. (2020). Environmental Sustainability Assessment of Land Disposal of Municipal Solid Waste Generated in Indian Cities—A Review. *Environmental Development*, *33*, Article 100490. <https://doi.org/10.1016/j.envdev.2019.100490>
- Pembi, F., Thomas, K. P., & Baudouin, M. A. (2022). Congolese People Practices towards

- Insalubrity in the Mombele District. *Open Journal of Ecology*, 12, 133-148.  
<https://doi.org/10.4236/oje.2022.122008>
- Rahi, S. (2017). Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development. *International Journal of Economics & Management Sciences*, 6, Article 1000403.
- Raymond, P. L. (2021). *Etudes d'impact des activités de la RATPK sur l'environnement*.  
<https://www.morebooks.shop/shop-ui/shop/product/978-620-3-43186-5>
- Saifi, N., & Jha, B. (2024). An Overview of Solid Waste Management Practices in Pune, Maharashtra, India. *Nature Environment and Pollution Technology*, 23, 923-934.  
<https://doi.org/10.46488/nept.2024.v23i02.027>
- Tsheleza, V., Ndhleve, S., Kabiti, H. M., & Nakin, M. D. V. (2022). Household Solid Waste Quantification, Characterisation and Management Practices in Mthatha City, South Africa. *International Journal of Environment and Waste Management*, 29, Article 208.  
<https://doi.org/10.1504/ijewm.2022.121212>
- Voxco (2022). *Échantillonnage aléatoire stratifié: Définition, exemples et types*.  
<https://www.questionpro.com/blog/fr/echantillonnage-stratifie/>
- Wadehra, S., & Nie, Z. (s.d.). *Designing a Waste Management System Suitable for Developing Countries*. International Growth Center.
- World Population Review (2024). *Kinshasa, DR Congo Population 2024*.  
<https://worldpopulationreview.com/>
- Zhang, Z., Chen, Z., Zhang, J., Liu, Y., Chen, L., Yang, M. et al. (2024). Municipal Solid Waste Management Challenges in Developing Regions: A Comprehensive Review and Future Perspectives for Asia and Africa. *Science of The Total Environment*, 930, Article 172794. <https://doi.org/10.1016/j.scitotenv.2024.172794>
- Zurbrügg, C., Gfrerer, M., Ashadi, H., Brenner, W., & Küper, D. (2012). Determinants of Sustainability in Solid Waste Management—The Gianyar Waste Recovery Project in Indonesia. *Waste Management*, 32, 2126-2133.  
<https://doi.org/10.1016/j.wasman.2012.01.011>