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Analysis of waste management in a small town in sub-Saharan Africa, the case of Ouesso in the Republic of Congo

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Abstract

This study is being carried out in the town of Ouesso in the Republic of Congo. Its aim is to understand how waste generated by businesses is managed. The face-to-face, non-probabilistic, reasoned-choice survey involved 360 economic activities actors' owners in the town's two districts. The information collected included the type and method of waste collection, the method of transport and waste disposal practices, the nuisance caused by waste, monthly expenditure and willingness to pay for waste collection and disposal. The Sphinx software was used to draw up the survey forms and to analyze and process the data. The results show that packaging, plastic, paper and cardboard are more frequently cited than other types of waste. Most actors use bins to collect their waste. Waste is transported either by tricycle or on foot for disposal using methods that do not respect the environment. The most frequently cited nuisances are insect pests and rodents, which can pose health problems to the community. The vast majority of respondents already pay for the waste management service and are willing to pay a fee to improve the quality of the waste service.

Keywords: Waste Management; Economic Activities; Ouesso Town; Congo

1 Introduction

All human activity generates waste. The nature of waste and methods of disposal have evolved over time and space. Each era has had its own specific treatment methods and problems [1]. Today, the quantity and quality of waste produced continues to increase as a result of ever greater and more diversified consumption throughout the world. It stood at 1.3 billion in 2010 (6.842 billion inhabitants) and is expected to double in the next fifteen years to 2.2 billion tons per year in 2025, with a population that could reach 8 billion [2].

Assimilated waste from industrial, commercial, craft and other activities has the same polluting and hazardous characteristics as household waste (e.g. paper, glass, plastics, textiles, cardboard, wood, etc.) [3]. The management of this waste, and of household waste in general, has become a major challenge for cities throughout the world in recent years [4, 5, 6]. This challenge is more acute in developing countries, where the waste sector is faced with a multitude of problems, such as a lack of funding, materials and equipment, qualified staff, and misappropriation of funds allocated to the waste sector. In addition, cities in developing countries, especially those in sub-Saharan Africa, do not have adequate household waste management plans [7]. The problem of waste is therefore worrying, and should be a priority

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for public action by urban managers in Africa. Recent World Bank statistics on the production and management of waste in sub-Saharan Africa show that the situation of urban unhealthiness is tending to worsen. Only 44%, or less than half, of the waste produced is collected in the municipalities of these countries [8]. The absence or partial and inadequate management of waste can have harmful consequences for the environment and people's health [9].

One of the ways of solving the problems associated with unhealthy living conditions in sub-Saharan African towns is to carry out scientific studies on the subject of waste. This article assesses the way in which waste from commercial activities is managed in small towns in sub-Saharan Africa, in the case of the town of Ouesso in the Republic of Congo. The main topics are

- Find out about the nature of waste from economic activities and how it is collected,
- To assess waste disposal practices and the nuisance caused by waste in the human environment,
- To know the monthly expenditure on waste management and the willingness to pay for improving the quality of the waste management service.

2 Materials and methods

2.1 Presentation of the town of Ouesso

With a population of 7,595 inhabitants [10], spread over two districts (NZALANGOYE and MBINDJO), thirteen (13) neighborhoods, thirty-seven (37) zones and eighty-eight (88) blocks [11, 12], the town of Ouesso, capital of the Sangha department, is the most important town in terms of demography and attractiveness in the northern part of the Republic of Congo. Situated in the northern hemisphere (1°37 N and 16°03 E) on the border with the Republic of Cameroon and approximately 1,000 km from the capital Brazzaville, the town of Ouesso enjoys an equatorial climate [13], characterized by abundant and regular rainfall throughout the year. Annual rainfall is between 1,500 and 1,700 mm, and the average monthly temperature fluctuates between 23°7 and 25°4.

2.1.1 The following figure, shows the location of the town of Ouesso in the Republic of Congo and Congo in Africa.

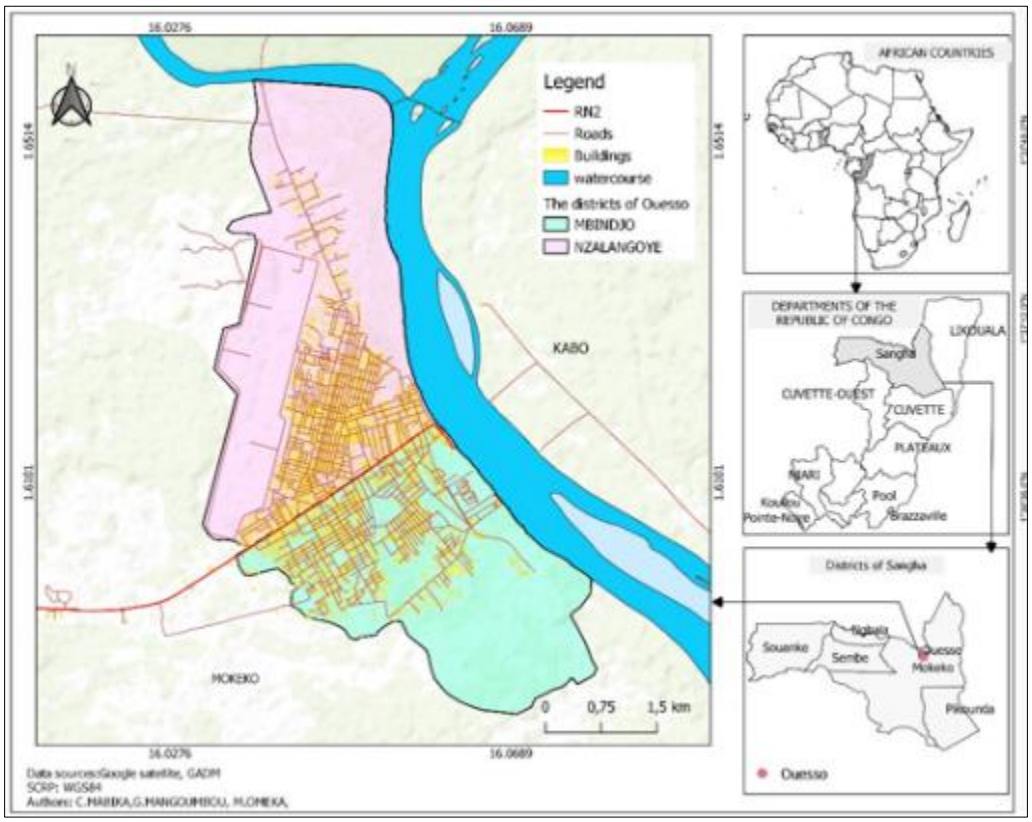

Figure 1 Location of the town of Ouesso

Ouesso's urban road network is very dense, with all the town's main and secondary roads asphalted. The town has benefited from the accelerated municipalization program, a policy of construction and modernization of the national urban fabric, initiated by the government of the Republic in the early 2000s.

Urban sanitation is provided by the town council, in accordance with law no. 31-2003 of 24 October 2003, which stipulates that the urban sanitation service is provided by the town council. Alongside the Town Hall, there are a number of private individuals involved in the collection and disposal of household and similar waste.

The following images show the quality of the urban roads and the waste collection equipment used by the *various players.*

Figure 2 Images showing the city of Ouesso and some waste collection equipment

2.2 Data collection

Given the nature of the information to be gathered, the preferred methodological approach was quantitative. In fact, assessing the way in which waste from economic activities is managed requires the application of an approach based on the use of data collection tools and techniques, in particular documentary research and surveys of the stakeholders concerned. As for the survey, a questionnaire developed using Sphinx was sent to the respondents, who had been systematically identified beforehand throughout the city. The questions, most of which were closed, concerned the nature of the economic activity, the type of waste generated, pre-collection/collection and waste disposal practices, perceptions of the nuisance caused by waste on the environment and people's well-being. The face-to-face survey was carried out with 360 stakeholders who agreed to receive the survey team. The type of survey used in this study was purposive probability sampling. The selection criteria were to be the owner or manager of the business, and the respondents were evenly distributed across the city's two districts.

2.3 Data Processing and Analysis

All the survey data were entered and processed using Sphinx 'Edition Lexica-version 5' and Excel. This processing consisted of drawing up graphs and pivot tables. The Chi-square test was used to rule out the hypothesis of independence. The 'hypotheses' consist of confronting H0: the variables are independent and H1: the variables are dependent. Chi-square tests can be used to determine whether there is a relationship between the variables, with a greater or lesser degree of certainty. However, it does not provide any information about the intensity of the relationship. Knowing, for a survey as a whole, which cross-tabulations of variables have the most interesting relationships is extremely useful, because it enables you to organize your work and validate or invalidate your initial hypotheses. To this end, the Cramer test was applied to determine the intensity of the relationships between the cross-tabulated variables. The closer Cramer's V is to 1, the stronger the relationship, and the closer V is to zero, the less dependent the variables studied are.

3 Results

3.1 Socio-demographic characteristics of respondents

Analysis of the table on economic activities that produce waste shows that shops, with a percentage of around 59%, and restaurants, with a percentage of 23.6%, are the most common economic activities in the town of Ouesso. Market vendors account for 5.6%, while hotels and public schools account for 6.7%. Other activities, such as secretariats, cyber cafés and bakeries, accounted for 5.3% of respondents. The other activities, which have waste similar to that of shops, are then considered as shops in the rest of this work.

The results of the survey show that 72% of economic activity managers are men, compared with 28% women. The majority of economic activities in the town of Ouesso are therefore undertaken by men.

Table 1 Characteristics of different categories of economic activities actors

Economic activities	Number of actors surveyed			Average age by sex		
	Feminine	Male	Sum	Feminine	Male	Mean
Hotel	6	7	**13**	36	33	**34**
Market	11	9	**20**	33	37	**35**
Others	8	11	**19**	29	33	**31**
Restaurant	45	40	**85**	31	36	**34**
School	4	7	**11**	43	40	**41**
Shop	26	186	**212**	32	35	**33**
Total	100	260	**360**	32	35	**34**

The results of the survey show that the average age is about 34 years. The average age of women is 32 years and that of men is 35 years. According to our results, economic activities in the town of Ouesso are undertaken by people who are active, i.e. young people.

3.2 Nature of waste and type of collection

3.2.1 Nature of waste

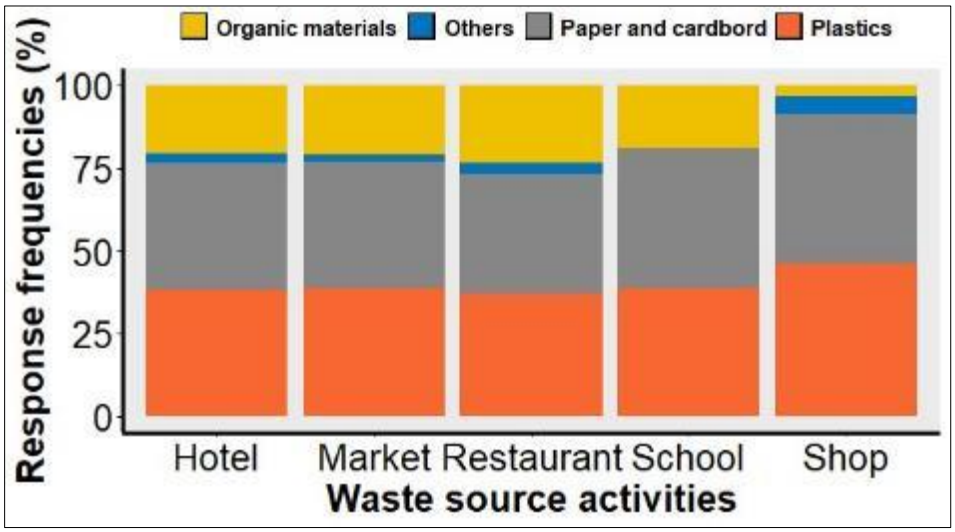

Figure 3 Nature of waste generated by respondents

The results on the nature of waste show that packaging waste made up of plastics and paper and cardboard is the most common type of waste produced by all economic activities. Most organic waste is produced in restaurants. Other wastes such as metals, glass and fabrics are not generated to any great extent. The dependence between the type of waste and the economic activity is highly significant. chi2 = 81.26, ddl = 12, 1-p = >99.99%. With a Cramer test of 27.43%, the strength of the relationship between the type of waste and economic activity is moderate.

3.2.2 Trash can

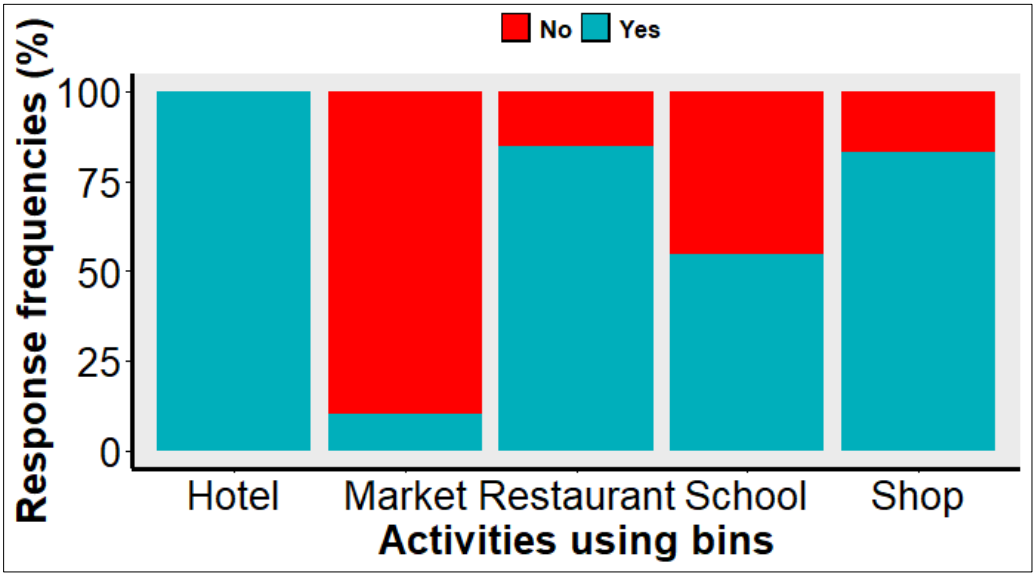

Figure 4 Economic activities and the use of bins

The results of the survey show that 79.2% of respondents have waste collection bins, compared with 20.8% who do not. All hotels and over 83% of restaurants and shops have bins. However, 90% of market vendors do not have bins. The dependence between waste bin use and economic activity is highly significant. chi2 = 69.24, ddl = 4, 1-p = >99.99%.the Cramer test being (Cramer's V): 43.86%, the strength of the relationship between economic activity and waste bin use is very strong.

3.2.3 Collectors

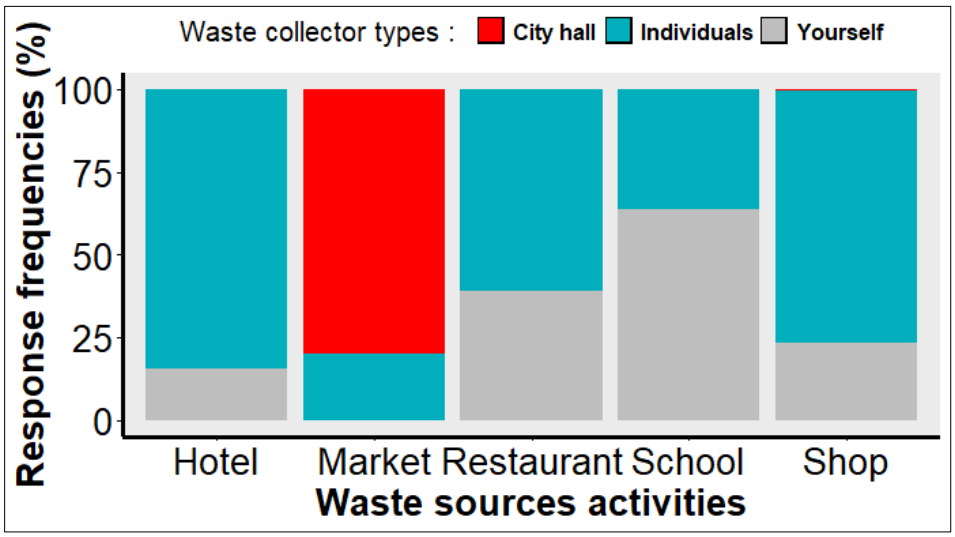

Figure 5 Nature of waste collectors

The results show that 68.5% of economic activities have their waste collected by individual informal waste collectors, 26.9% by the producers themselves and only 4.7% by the local council. Shops, restaurants and hotels make greater use of the services of individual informal waste collectors. Schools collect more waste themselves, while 80% of market waste is collected by the council's sanitation services. The dependence between collector and economic activity is highly significant. chi2 = 287.00, ddl = 8, 1-p = >99.99%. The Cramer test being (Cramer's V): 63.14%, the strength of the relationship between collector quality and economic activity is strong.

3.2.4 Method of transporting waste

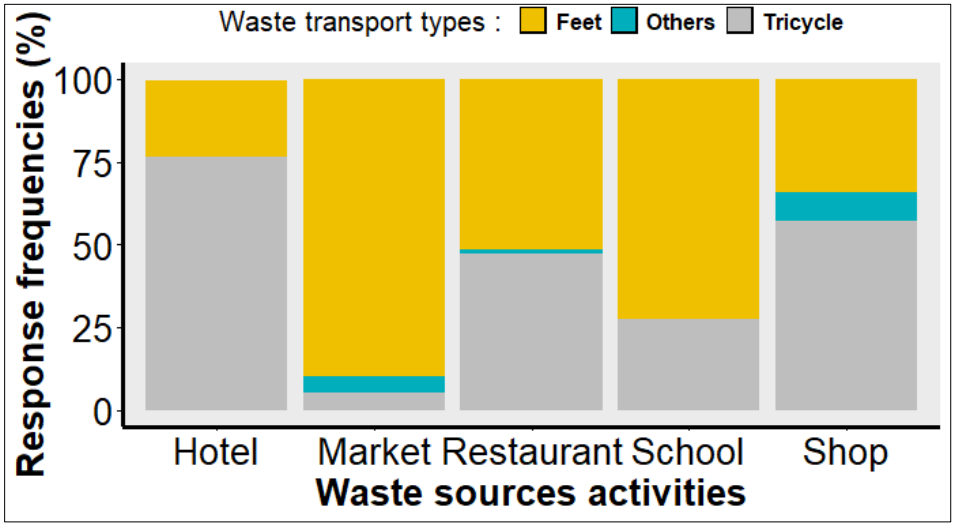

Figure 6 Type of waste transport

The results of the survey show that around 52% of the economic activities surveyed transport their waste using private collectors' tricycles (KavakiMotor), 42% transport it on foot in containers or with wheelbarrows, and only 6% use other means of transport such as cars or bicycles. Market waste is transported on foot in wheelbarrows. The majority of schools and restaurants carry their waste on foot in collection containers. However, shops and hotels pay for transport services using tricycles. The dependency between mode of transport and waste source activity is highly significant. chi2 = 40.06, ddl = 8, 1-p = >99.99%. Since the Cramer test is (Cramer's V): 23.59%, the relationship between the waste transport mode and the economic activities that generate the waste is moderate.

3.2.5 Collection Frequency

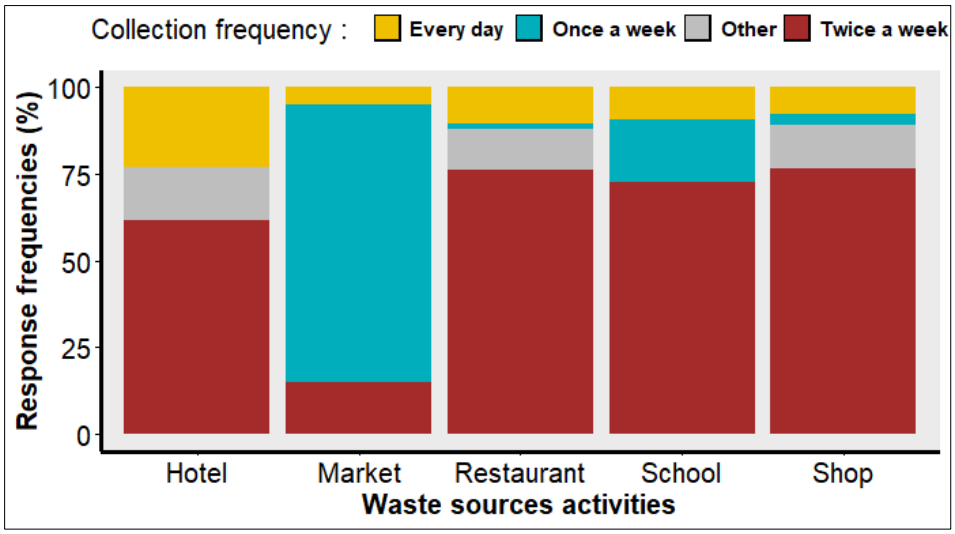

Figure 7 Frequency of waste collection

The results on the frequency of waste collection show that 72.5% of respondents have their waste collected twice a week, 7.2% once a week, 8.9% daily and 11.4% at other collection frequencies. Market waste is collected once a week, according to the schedule drawn up by Ouesso town hall. The dependence between collection frequency and economic activity is highly significant. chi2 = 177.30, ddl = 12, 1-p = >99.99%. With a Cramer test of (Cramer's V): 40.52%, the relationship between collection frequency and economic activity is strong. The nature of the economic activity explains the frequency of waste collection.

3.3 Waste disposal practices and nuisance caused

3.3.1 Waste disposal practices

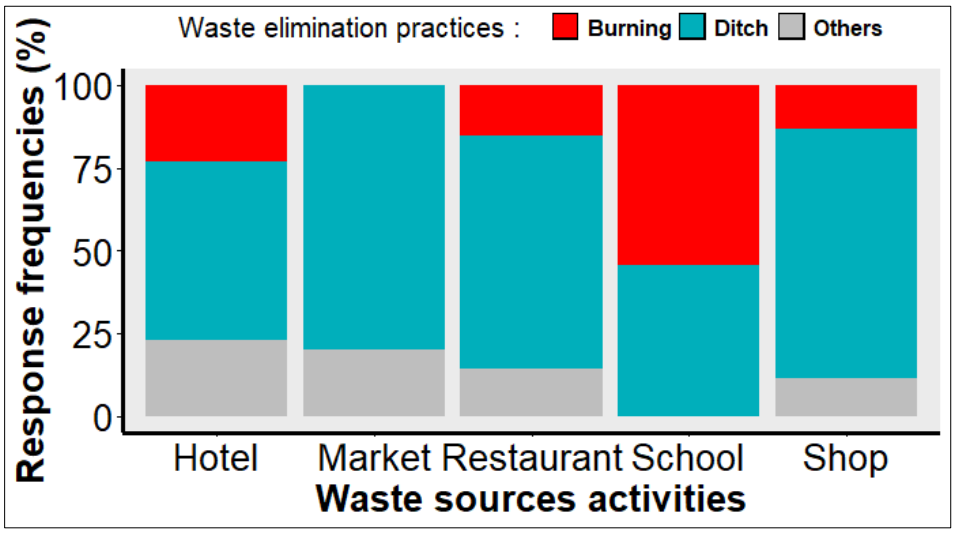

Figure 8 Type of waste disposal

The results of the survey show that 73% of business waste is disposed of by dumping in open pits, 14.6% by uncontrolled incineration and 12.5% by other means, such as uncontrolled dumping or dumping in the street. Uncontrolled incineration of waste is more common in schools. Market waste is not incinerated; in most cases it is dumped in pits. The dependence between waste disposal practices and the economic activity that generates waste is highly significant. chi2 = 22.05, ddl = 8, 1-p = 99.52%. With a Cramer test of (Cramer's V): 17.50%, the relationship between waste disposal practice and waste source activity is weak. Waste disposal practice does not depend on the quality of the waste source activity.

3.3.2 Waste nuisance

Table 2 Nuisances caused by waste

Waste nuisance	**Waste activities**						
	Hotel	**Market**	**Restaurant**	**School**	**Shop**	**Sum**	**%**
Harmful insects	13	15	82	9	228	**347**	**56**
Rodents	4	10	38	4	108	**164**	**26**
Microbes	4	1	20	2	33	**60**	**10**
Bad smells	1	8	29	0	16	**54**	**9**
Total	22	34	169	15	383	625	100

The results of the survey show that 56% of respondents recognized the nuisance caused by harmful insects such as mosquitoes and flies, 26% reported the presence of rodents such as mice, 10% feared the presence of microbes in their environment, 9% reported bad smells. Restaurants were the only activities to report a greater nuisance from unpleasant odors, while shops were less likely to recognize this nuisance. The dependency between the type of nuisance and the economic activity is highly significant. chi2 = 43.79, ddl = 12, 1-p = >99.99% The Cramer test is (Cramer's V): 20.14%, the relationship between economic activity and the type of nuisance experienced is moderate. The nuisance experienced does not necessarily depend on the quality of the economic activity.

3.4 Expenditure and willingness to pay in CFA francs (1 USD $ = 625.83 Franc CFA) for waste management

3.4.1 Monthly expenditure in CFA francs

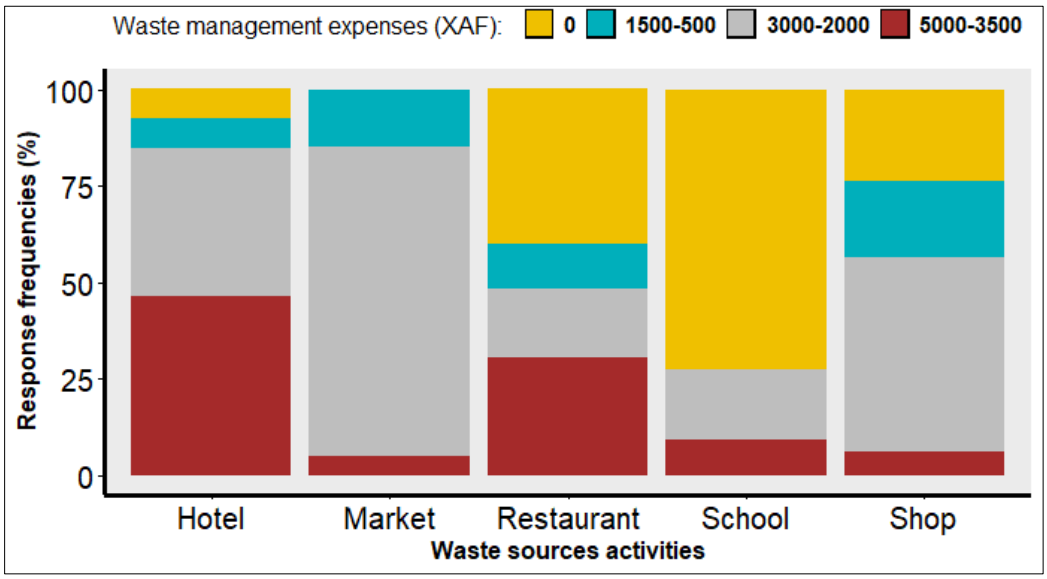

Figure 9 Waste management cost per month

The results of the survey show that around 43% of stakeholders spend between 3,000 and 2,000 CFA francs on waste management, 17% spend between 1,500 and 500 CFA francs, and only 13% spend between 5,000 and 3,500 CFA francs. However, 27% of respondents manage their waste themselves. Hotels and restaurants are the ones that pay a little more for waste management services than other activities. Schools pay almost nothing for waste management services, followed by some restaurants and shops. The dependency between monthly expenditure on waste management and the nature of the economic activity is highly significant. chi2 = 90.37, ddl = 12, 1-p = >99.99%. With a Cramer's V test of 28.93%, the strength of the relationship between expenditure on waste services and the nature of economic activity is moderate.

3.4.2 Monthly consent to pay for waste management

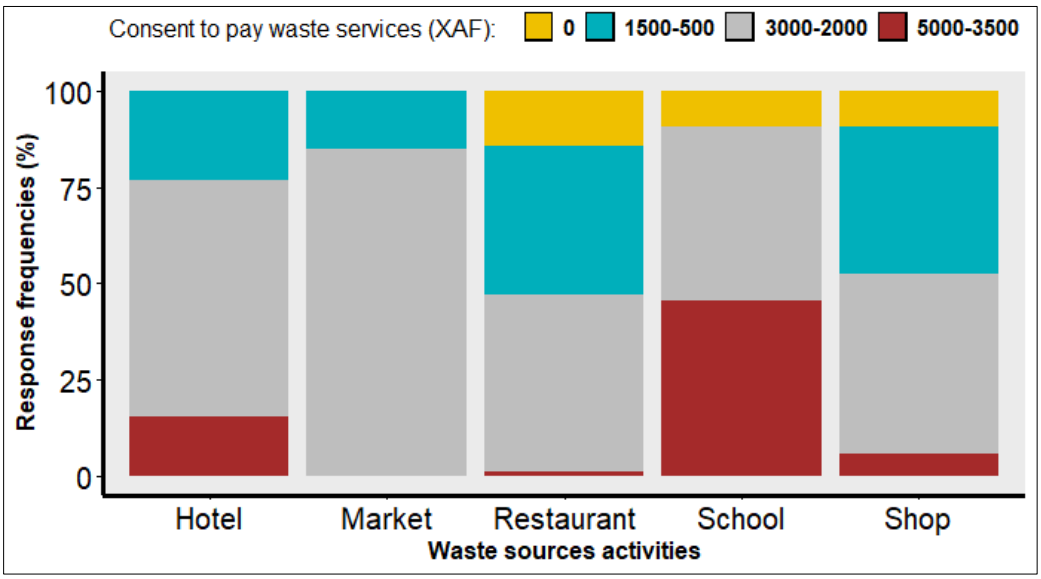

Figure 10 Willingness to pay for waste management services per month

Almost all respondents were in favor of paying for waste collection and management services, provided that the service offered was of good quality. 9% of respondents were not in favor of paying for the waste service. 49% of respondents

were in favor of paying between 3,000 and 2,000 CFA francs, 35.6% between 1,500 and 500 CFA francs and around 6% between 5,000 and 3,500 CFA francs. Schools are the activity most likely to pay between 5,000 and 3,500 CFA francs. However, the vast majority of market vendors are in favor of paying between 3,000 and 2,500 CFA francs. Markets and hotels are the only activities where stakeholders are totally in favor of paying for waste management services. The dependence between willingness to pay for waste management services and the nature of the economic activity is highly significant. chi2 = 54.90, ddl = 12, 1-p = >99.99%. With a Cramer's V test of 22.55%, the strength of the relationship between willingness to pay and economic activity is moderate.

4 Discussion

4.1 Nature and method of waste collection

4.1.1 Nature of waste produced

The results on the type of waste generated show that plastics, paper and cardboard predominate. This waste comes from retail packaging. Organic materials are more common in restaurants than in other activities. Other types of waste, such as glass, metals, fabrics, etc., are rare. The chi2 test reveals a highly significant dependence of the nature of waste produced on economic activities. Cramer's V indicates a medium intensity relationship between these two variables. Our results are similar to those of MERNIZ et al, 2021 in the town of M'sila in Algeria, with more than 50% of packaging (cardboard, paper and plastic) [14]. MANIRAKIRA, 2023 obtained a different trend in households in the town of BUJUMBURA in Burundi, with a predominance of organic matter over other waste fractions [15].

4.1.2 Waste Collection Method

The results of the survey show that 79% of businesses use bins, compared with 21% that do not. Businesses such as shops, hotels and restaurants usually use bins. More than half of schools do not have bins. Almost all market vendors do not use bins. The chi2 and Cramer statistics strongly support the hypothesis that ownership of rubbish bins is dependent on the nature of the economic activity. Not all economic activities in Ouesso use bins. The study by MUKUKU, 2018 in the commune of Katuba in Lubumbashi (DRC) showed that 82.2% of households use dustbins compared with 17.8% who have no dustbins [16].

As far as waste collection is concerned, the results significantly show the presence of two main collection players, individual private players and the waste producers themselves. The chi2 and Cramer statistics significantly confirm the dependence between economic activity and the nature of the collector. The occupation of this sector by these two players shows the inefficiency of state services (Ouesso town hall) in fulfilling their legal obligations. The study by DIAYE et al, 2021 in the town of GRAND-YOFF in Senegal revealed that a large proportion of municipal waste in this town is collected by private individuals (carters) [17]. The authors claim that this is the most effective way of managing household and similar waste in towns where public waste services are ineffective, because private collectors (carters) go door-to-door to collect waste, unlike lorries. With this type of collection, households make less effort to dispose of their household waste.

In terms of waste transport, around 94% of respondents cited tricycles (kavakis) and walking as the most common modes of transport. Chi-square and Cramer statistics show a very significant, medium-intensity dependency between the type of transport and economic activities. The type of waste transported to final disposal sites depends on the nature of the economic activity. Schools, markets and restaurants tend to transport waste on foot, while hotels and shops use tricycles to transport their waste. The type of commercial waste transport encountered in the town of Ouesso is similar to that described by MUKUKU et al, 2018, in the commune of Katuba in Lubumbashi (DRC), with 94.1% of households using rickshaws as a means of waste transport [16].

Most businesses in Ouesso collect waste twice a week. Some businesses have their waste collected every day or once a week, or even at various frequencies. The Chi-square and Cramer statistics show a highly significant dependency between these variables. The economic activities in Ouesso do not collect their waste at the same frequency.

4.2 Disposal practices and nuisances encountered

4.2.1 Waste disposal practices

Waste from economic activities in the town of Ouesso is largely disposed of in uncontrolled pits. These pits are gullies or ravines in the town. The practice of uncontrolled incineration is the second most common way of disposing of waste. Other practices, such as dumping in the street, on uninhabited plots of land and on the banks of watercourses, are also

common. The Chi2 statistic revealed a significant dependency between waste disposal practices and the nature of the economic activity. However, the Cramer test indicated a low intensity between these two variables. Those involved in the disposal of waste produced by economic activities in the town of Ouesso use more or less the same waste disposal practices.

Commercial waste disposal practices in the town of Ouesso are similar to those described by KAZA (2018), who showed that in low-income countries, more than 90% of the waste generated is burnt or dumped in uncontrolled waste dumps [18]. The study by DJEMACI et al, 2011 showed that in Algeria, 87% of household and similar waste is disposed of by dumping in uncontrolled landfills. Such waste disposal practices are responsible for 5% of total GHG emissions worldwide (WB 2018 in CHEN et al, 2020) [19]. Inappropriate disposal of municipal waste also contributes to epidemics of diseases such as cholera-dysenteric diarrhea and to land degradation [20].

4.2.2 Nuisances encountered

The economic operators surveyed almost all acknowledged the nuisance caused by the presence of harmful insects in their environment. These insects are mainly mosquitoes and flies. Alongside this dominant nuisance, there are other types such as the presence of rodents, bad smells and pathogenic microbes in their living environments. The Chi2 and Cramer tests showed a moderately significant dependency between the nature of the nuisances declared and economic activity. The nuisances caused by waste management practices in economic activities in the town of Ouesso differ from one economic activity to another. Our results corroborate those found by MBIADJEU et al, 2021 in the town of Bangangté, Cameroon, with a predominance of unpleasant odors, the presence of harmful insects (flies, mosquitoes) and rodents (grey and black rats) [21]. Work by MANGOUMBOU et al, 2023 in university halls of residence in Brazzaville also showed a nuisance profile dominated by unpleasant odors, harmful insects and microbes [22].

4.3 Expenditure and willingness to pay for waste management

4.3.1 Monthly expenditure on waste management

Overall, 72.8% of respondents pay for waste management services, compared with 27.2% who do not. Of those who do pay, 42.8%, including 80% of market vendors, spend between 3,000 and 2,000 CFA francs a month, 16.7% between 1,500 and 500 CFA francs and 13.3% between 5,000 and 3,500 CFA francs. Market vendors pay a refuse collection tax to the town hall. This tax is compulsory and the amount is the same for all vendors. Specifically, 72.7% of schools do not pay for a waste management service. They dispose of their waste themselves, and believe that the waste disposal practices established by the players in the waste sector in the town of Ouesso are not respectful of the environment. 40% of restaurants also do not pay for waste management services. These are probably low-standard restaurants located far from the town center. Some restaurants, undoubtedly of medium standing and close to the town center, as well as hotels, make up the group of businesses that pay dearly for waste management services. These are well-organized, solvent businesses, often located close to the main avenues and not far from the city center. Given their location and the quality of their activities, it is not possible for them to manage their waste themselves. The Chi2 test shows a significant dependency between monthly expenditure on waste management and the nature of the economic activity. The Cramer test (Cramer's V) indicates a moderately strong relationship between the two variables. Monthly expenditure on waste management varies moderately from one economic activity to another. The monthly collection prices paid by businesses in Ouesso are much lower than those paid by households in the town of GRAND-YOFF in Senegal, which vary between 25,000F and 40,000F CFA [17].

4.3.2 Willingness to pay monthly for waste management

Overall, 91% of respondents were in favor of paying for waste collection, transport and disposal services, compared to 9% who were not. Of those in favor, almost half agreed to pay between 3,000 and 2,000 CFA francs per month, 35.6% agreed to pay between 1,500 and 500 CFA francs per month and only 5.8% agreed to pay slightly more, between 5,000 and 3,500 CFA francs per month. Almost all school managers are prepared to pay between 5000F and 2000F CFA for waste collection and disposal services from a reliable player whose practices are environmentally sustainable. For market players, no one is willing to pay a monthly amount higher than the 3,000F CFA monthly sweeping tax that they already pay to the town hall. These amounts can be used as a reference for political decision-makers to establish or re-evaluate the amount of the TEOM [5].

5 Conclusion

At the end of this study which assessed the waste management methods used by businesses in the town of Ouesso, it appears that shops and restaurants are the most common commercial activities. The type of waste is dominated by

plastic, paper and cardboard from the packaging of items on sale. Waste management is precarious, because although it is collected, it is disposed of using practices that do not respect the environment. The most frequently cited nuisances are the presence of insects that are harmful to human health, and rodents in the articles on sale. The majority of stakeholders pay for the waste collection service, which is run by informal collectors, and are also willing to pay for the services of a formal player, private or public, who would offer sustainable waste management services in the city.

Overall, similar waste generated by businesses in Ouesso is managed by informal players. The state, via the town hall, does not have a strong enough presence in the sector, and when it does, its influence is limited to the state-owned markets. The lack of effective state involvement is partly responsible for the inappropriate waste disposal practices encountered in Ouesso.

Compliance with ethical standards

Acknowledgments

The Authors sincerely thank Professor Alphonse Dorien MAKOSSO, an English-speaking teacher who corrected this article.

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest.

Statement of informed consent

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

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