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PHYSICOCHEMICAL CHARACTERIZATION AND PRELIMINARY ASSESSMENT OF THE COMPOSTING POTENTIAL OF MARKET BIOWASTE IN DIFFA, NIGER

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ABSTRACT

Urban solid waste management is a major environmental challenge, particularly in markets where commercial activities generate substantial quantities of organic and non-biodegradable waste. This study aimed to characterize market biowaste generated in the urban municipality of Diffa, Niger, and to preliminarily assess its suitability for composting. The study was conducted in the central, vegetable, and fish markets using a stratified sampling approach. Waste generation was monitored through daily weighing, while representative samples of 100 kg from each market were characterized according to waste category, particle-size distribution, apparent bulk density, moisture content, and volatile organic matter. The results showed substantial differences in waste generation among the three markets. The overall mean generation rate was 3.32 ± 2.37 kg/trader/day, with the highest mean rates recorded at the vegetable market (4.32 ± 3.43 kg/trader/day) and fish market (4.07 ± 3.59 kg/trader/day), whereas the central market recorded the lowest rate (1.57 ± 0.09 kg/trader/day). Organic waste was the dominant fraction in the vegetable and central markets, whereas plastic waste predominated in the fish market. The mean apparent bulk density was 260.03 ± 60 kg/m³, while mean moisture and Volatile organic matter contents were 36.33% and 43%, respectively. These physicochemical characteristics indicate that market biowaste in Diffa has potential for biological recovery, particularly composting, provided that non-biodegradable materials are removed through effective sorting. The study provides

baseline information for developing locally appropriate organic-waste recovery strategies and improving sustainable solid-waste management in Diffa.

Keywords: Market biowaste; Waste characterization; Composting potential; Organic waste valorization; Urban markets.

1 INTRODUCTION

Waste generation is an unavoidable consequence of human activities and constitutes a major environmental challenge worldwide. Urban solid waste management is particularly challenging in developing countries, where rapid population growth and urbanization place increasing pressure on waste-collection, treatment, and disposal systems. Inadequate waste management can result in environmental pollution, public-health risks, unpleasant odors, and the proliferation of disease vectors, particularly when biodegradable waste accumulates in uncontrolled disposal areas [1–3]. The increasing generation of municipal waste therefore highlights the need to develop appropriate management systems that integrate collection, treatment, recycling, and resource recovery. In this context, composting and other forms of organic-waste recovery have gained attention as potentially appropriate approaches for reducing the environmental burden associated with biodegradable waste [4,5].

Across sub-Saharan Africa, solid-waste management remains a major challenge because of rapid urban growth, limited municipal resources, inadequate collection systems, and insufficient treatment infrastructure [5,6]. At the same time, agricultural production is constrained in many areas by soils with low organic-matter content and a vulnerability to degradation. Insufficient restitution of organic matter to agricultural soils can contribute to declining soil fertility and reduced plant productivity [7,8]. The recycling of urban organic waste therefore represents a potential dual benefit: reducing the environmental burden associated with waste accumulation while returning organic matter to agricultural soils [9,10]. Composting is particularly attractive because it can transform biodegradable residues into a stabilized organic amendment that may contribute to soil fertility and provide an alternative pathway for recovering resources from urban waste streams.

Urban markets are particularly important sources of biodegradable waste because daily commercial activities involving fruits, vegetables, food products, and other agricultural commodities generate substantial quantities of organic residues. However, limited collection capacity, inadequate infrastructure, restricted municipal budgets, and insufficient waste-treatment facilities can prevent effective recovery of these materials and transform potentially valuable organic resources into environmental burdens [6,3]. Poorly managed market waste may contribute to local environmental degradation and public-health concerns through the accumulation and decomposition of organic residues. Characterizing market waste is therefore essential for distinguishing biodegradable materials from recyclable and other non-biodegradable fractions and for determining appropriate recovery and treatment options.

The urban municipality of Diffa, Niger, is also confronted with these challenges. The central, vegetable, and fish markets generate substantial quantities of organic and mixed waste, including fruit and vegetable residues, fish-related waste, paper and cardboard, plastics, and other commercial residues. According to the local development plan, biodegradable residues generated in market areas may be abandoned on the ground or disposed of around uncontrolled sites, creating potential environmental and sanitary concerns [11]. Composting could provide an accessible option for recovering an appropriate fraction of these biodegradable materials and converting them into an organic amendment potentially useful for local agricultural activities, consistent with experiences of organic-waste composting in Niger [12].

However, the development of such a circular approach requires reliable information on the quantity, composition, and physicochemical characteristics of the waste generated. In Diffa, updated scientific information on market biowaste generation and its potential for biological recovery remains limited. Waste generated by different markets can vary considerably in composition, particle-size distribution, moisture content, bulk density, and organic-matter content. These characteristics directly influence waste handling, sorting, treatment, and recovery options. Characterizing the waste stream is therefore an essential first step toward identifying appropriate biological-recovery pathways and informing locally adapted waste-management strategies. The overall objective of this study was to characterize market biowaste generated in the urban municipality of Diffa and to assess its preliminary suitability for composting. Specifically, the study aimed to (i) quantify biowaste generation in the main markets of Diffa, (ii) determine its physical and physicochemical characteristics, and (iii) assess its potential for biological recovery based on its composition, moisture content, bulk density, particle-size distribution, and volatile organic matter content.

2 MATERIALS AND METHODS

2.1 Study Area

The study was conducted in the urban municipality of Diffa, southeastern Niger, located between 13°18' and 13°22' N latitude and 12°36' and 12°40' W longitude. The area has a dry tropical Sahelian climate characterized by a long dry season and a relatively short rainy season. Average annual rainfall is generally between 300 and 450 mm, while the 1991–2022 climatic normal indicates an average annual rainfall of approximately 337.5 mm. The main economic activities of the local population are agriculture and livestock farming [13,14].

2.2 Materials

The materials used for waste collection, handling, sorting, and measurement included plastic bags, tarpaulins, shovels, an electronic weighing scale, sieves with mesh sizes of 100 and 20 mm, a calibrated 20-L container, personal protective equipment such as gloves, boots, and masks, pH indicator paper, and a drying oven (Thermosi SR 2000).

2.3 Sampling Design and Waste Quantification

The study covered three main markets in the urban municipality of Diffa: the vegetable market, the central market, and the fish market. The sampling design was based on stratification according to the type of commercial activity, with selected stalls distributed among the different trader categories. This approach was used to account for differences in the nature and quantity of waste generated by different market activities [15].

The selected facilities were distributed as follows: 291 facilities in the vegetable market, 1,100 in the central market, and 70 in the fish market. The corresponding sampling probabilities were 1/8, 1/20, and 1/2, respectively, resulting in 8, 20, and 2 strata. The average number of selected facilities per stratum was 36, 55, and 35, respectively, with a distribution of 2, 3, and 2 traders per stratum per day.

Waste produced by the selected traders was collected daily during the study period and then grouped to constitute representative samples from each market destined for the different analyses.

The distribution of sampled traders across the different market strata is presented in Table 1.

Table 1: Sampling distribution of traders by market stratum for waste collection

Market	Total facilities (N)	Probability (P1 × P2)	Number of strata	Average number/stratum (n)	Distribution/day (traders/stratum)
Vegetable	291	1/8	8	36	2
Central	1,100	1/20	20	55	3
Fish	70	1/2	2	35	2

2.4 Physical and Physicochemical Properties of Market Biowaste

2.4.1 Particle-Size Distribution

After quantification, the waste was subjected to manual sorting to separate waste categories and to determine particle-size distribution using 100 mm and 20 mm sieves. The particle-size classes were defined as fine (<20 mm), medium (20–100 mm), and coarse (>100 mm). For detailed characterization, a representative sample of 100 kg was constituted for each market, in accordance with the recommendations of SENES Consultants Limited [16], which indicate that such a mass is sufficient to characterize the main organic fractions of municipal waste when the organic fraction is dominant [18].

2.4.2 Bulk Density and pH

Bulk density was determined by placing the waste fractions in a calibrated 20-L container and recording their mass. Bulk density was calculated as the ratio of waste mass to occupied volume: Bulk density (kg/m³) = M/V, where M is the mass of waste (kg) and V is the occupied volume (m³). The pH was measured using pH indicator paper.

2.4.3 Moisture Content and Dry Matter

A 0.5-kg wet sample was collected for moisture determination. The sample was initially air-dried under sunlight and subsequently oven-dried at 105 °C until constant mass. Moisture content was calculated from the measured mass loss. Moisture content was calculated as:

$$\text{Moisture content (\%)} = [(M_w - M_d)/M_w] \times 100,$$

where M_w is the mass of the wet sample, and M_d is the mass of the dried sample. Dry matter content was calculated as $100 - \text{moisture content (\%)}$.

2.4.4 Volatile Organic Matter

Volatile organic matter (VOM) was estimated from the mass loss after combustion of pre-dried samples. The mass of the dry sample before combustion (M_1) and the mass of ash remaining after combustion (M_2) were recorded, and VOM was calculated as follows:

$$\text{VOM (\%)} = [(M_1 - M_2)/M_1] \times 100,$$

where M_1 is the mass of the dry sample before combustion, and M_2 is the mass of ash remaining after combustion.

The analysis focused on the biodegradable fraction and excluded inert and non-biodegradable materials such as glass, metals, and plastics.

2.5 Statistical Analysis

Descriptive statistics summarized waste generation rates and physicochemical characteristics. Results were expressed as means and standard deviations. Because the data did not necessarily meet the assumptions of parametric statistical tests, we used non-parametric procedures to compare waste generation rates among markets and commercial-activity strata. The Kruskal–Wallis test was applied to assess differences among groups, followed by Dunn’s multiple-comparison test where significant differences were detected. Relationships among waste characteristics were assessed using Pearson’s correlation coefficient. Statistical significance was considered at $p < 0.05$. All statistical analyses were performed using R statistical software, version 4.4.1.

Principal component analysis (PCA) was performed using R to investigate the relationships among the main waste characteristics. The first two principal components (Dim1 and Dim2) were retained for graphical representation, and their contributions to the total variance were expressed as percentages.

3 RESULTS AND DISCUSSION

3.1 Quantification of Waste Generated in the Markets

Waste production was monitored for 14 days in the three main markets of the urban municipality of Diffa. The total weekly average waste production was estimated at 1,505.92 kg, corresponding to approximately 1.5 tons per week. The vegetable market and the central market were the main contributors, generating 550.08 and 547.49 kg/week, respectively, while the fish market generated 408.35 kg/week. The mean waste generation rate varied among the markets, with the vegetable market showing the highest value, followed by the fish and central markets. The detailed generation rates, together with their minimum and maximum values, are presented in Table 2.

Table 2: Waste generation rate according to the study market

Study market	Mean ± SD (kg/trader/day)	Minimum	Maximum
Central market	1.57 ± 0.09	0.62	2.72
Vegetable market	4.32 ± 3.43	0.50	16.70
Fish market	4.07 ± 3.59	2.77	15.60
Overall	3.32 ± 2.37	0.50	16.70

The overall mean waste generation rate was 3.32 ± 2.37 kg/trader/day, ranging from 1.57 ± 0.09 kg/trader/day in the central market to 4.32 ± 3.43 kg/trader/day in the vegetable market. The fish market recorded an intermediate mean value of 4.07 ± 3.59 kg/trader/day. Across individual observations, the generation rate ranged from 0.50 to 16.70

kg/trader/day. The relatively high generation rates observed at the vegetable and fish markets may be associated with commercial activities involving fresh and highly perishable products. These values were higher than those reported by Adeniyi et al. [17], who found an average solid waste generation of 0.117 kg/person/day among stall operators in a developing-country institutional market.

The variation in waste generation among the different trader categories is presented in Table 3.

Table 3: Average waste generation by trader category

Market	Strata	N	Mean (Kg/stall/day)	CV (%)
Vegetable	vegetable v	14	11.00 ± 4.13	47.09
	Condiment v		4.38± 1.53	34.93
	Meat v		3.90 ± 1.29	64.01
	Others		1.64± 1.13	72.13
Central	Food products		1.75 ± 0.36	30.62
			1.64 ± 0.42	23.22
	Electronics v		1.61 ± 0.46	29.63
	Apparel v		1.54 ± 0.45	25.85
	OthersC		1.64 ± 0.41	45.58
Fish	Fresh Fv		9.35 ± 3.36	48.15
	Smoked Fv		4.02 ± 0.90	30.86

Kruskal-Wallis analysis highlights a significant difference in daily production between the three markets ($H = 87.07$; $p < 0.001$). Multiple comparisons (Dunn test) demonstrate that this difference is mainly due to specialized markets.

Within the vegetables market, strong variability is observed between strata ($H = 38.85$; $p < 0.001$), with fruit and vegetable sellers generating significantly more waste than other trader categories. A significant difference is also observed in the fish market ($H = 15.61$; $p < 0.001$), where fresh fish sellers produce more waste than smoked fish vendors. However, no significant difference is taking into account between the strata of the central market ($H = 2.61$; $p = 0.624$).

Table 4: Statistical comparison of waste generation among trader categories

Market	Strata	Medians	Mean-Std.Dev	P-value
Vegetable	vegetable v	11.01	11.00 ± 4.13 ^a	1.09e-08***
	Condiment v	3.89	4.38± 1.53 ^b	
	Meat v	3.43	3.90 ± 1.29 ^b	
	Others	1.30	1.64± 1.13 ^c	
Central	Food products	1.77	1.75 ± 0.36 ^c	0.624
		1.62	1.64 ± 0.42 ^c	
	Electronics v	1.71	1.61 ± 0.46 ^c	
	Apparel v	1.54	1.54 ± 0.45 ^c	
	OthersC	1.75	1.64 ± 0.41 ^c	
Fish	Fresh Fv	8.71	9.35 ± 3.36 ^a	1.56e-05***
	Smoked Fv	4.27	4.02 ± 0.90 ^b	

Finally, the overall analysis according to type of commercial activity confirms that the quantity of waste generated mainly depends on the nature of the products marketed ($H = 121.03$; $p < 0.001$). Activities related to fresh products (fruits, vegetables, and fresh fish) are responsible for the highest biowaste production.

Overall, these results show that biowaste production is strongly influenced by market specialization and by the type of products marketed, with activities that involve fresh products constituting the main sources of organic waste.

The statistical differences in waste generation among trader categories are summarized in Table 4.

3.2 Physical Characterization

3.2.1 Particle-Size Distribution

The granulometric composition of waste was assessed based on three size classes: >100 mm, 20–100 mm, and <20 mm. The results show that the medium fraction (20–100 mm) is predominant in the three markets, representing between 32% and 44% of the total waste mass. The coarse fraction (>100 mm) represents the second granulometric class, with proportions comprising between 31% and 36%, while the fine fraction (<20 mm) is the least represented (21–34%). These results are very close to those observed in the city of El Oued (Algeria) (medium fraction: 58.23%) [18], but different from those observed in Lomé (Togo), which indicate that the total fine fractions (fines (10–20 mm) and extra fines <10 mm) represent an important size share, 46–56% of the gross weight of waste on average [19]. This situation was justified by the sufficiently long residence time at transit sites for waste to begin to be degraded [19].

The differences are, however, observed between markets. The vegetable market represents the highest proportion of coarse waste, mainly linked to the presence of large plant residues. The central market has a relatively balanced distribution between coarse and fine fractions, reflecting the diversity of commercial activities and waste produced. Diversity of commercial activities and waste produced. Differently, the fish market is characterized by a predominance of the medium fraction, particularly attributable to the presence of plastic packaging and wet cardboard.

Overall, this granulometric distribution highlights a heterogeneity of wastes according to markets, by confirming the predominance of medium fractions, mainly made of organic matter. The non-negligible proportion of the coarse fraction, mainly composed of plastics and other non-biodegradable materials, underlines the need for prior sorting to improve the quality of biowaste destined for composting.

The particle-size distribution of market waste across the three study markets is shown in Figure 1.

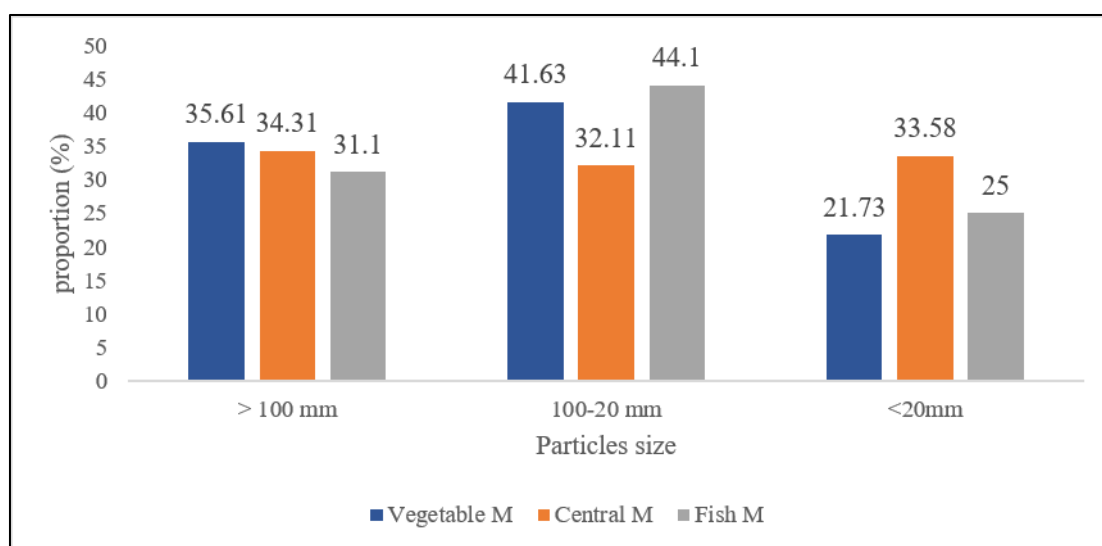


Figure 1: Particle-size distribution of market waste across the three study markets

Biowaste was sorted into two particle-size classes (>100 mm and 20–100 mm) and subsequently classified into waste categories to assess its suitability for integration into the waste-recovery value chain. The particle sorting below 20 mm was not carried out due to technical difficulties linked to very fine separating elements.

In this fraction, organic wastes constitute the dominant component of the vegetable and central markets, advocating the importance of plant residues from marketing activities. Conversely, the fish market is distinguished by a high proportion. The paper-cardboard category is also present in significant quantities, unlike the other categories (textiles, metals, glass, and inert waste) which remain poorly represented. These proportions are comparable to those reported for Niamey by Moumouni et al. [20], who found, after waste sorting, an organic fraction of 11.58%, plastics accounting for 7.69%, and paper and cardboard representing 4.29%. In contrast, the proportion of organic matter in the market waste from Diffa was lower than that reported for Mostaganem, Algeria, where organic matter accounted for 65.5% of

the waste, followed by paper and cardboard (13%), plastics (7%), metals (3.5%), glass (4%), textiles (3%), and other materials (4%) [23].

The distribution of waste categories within the >100 mm fraction is illustrated in Figure 2.

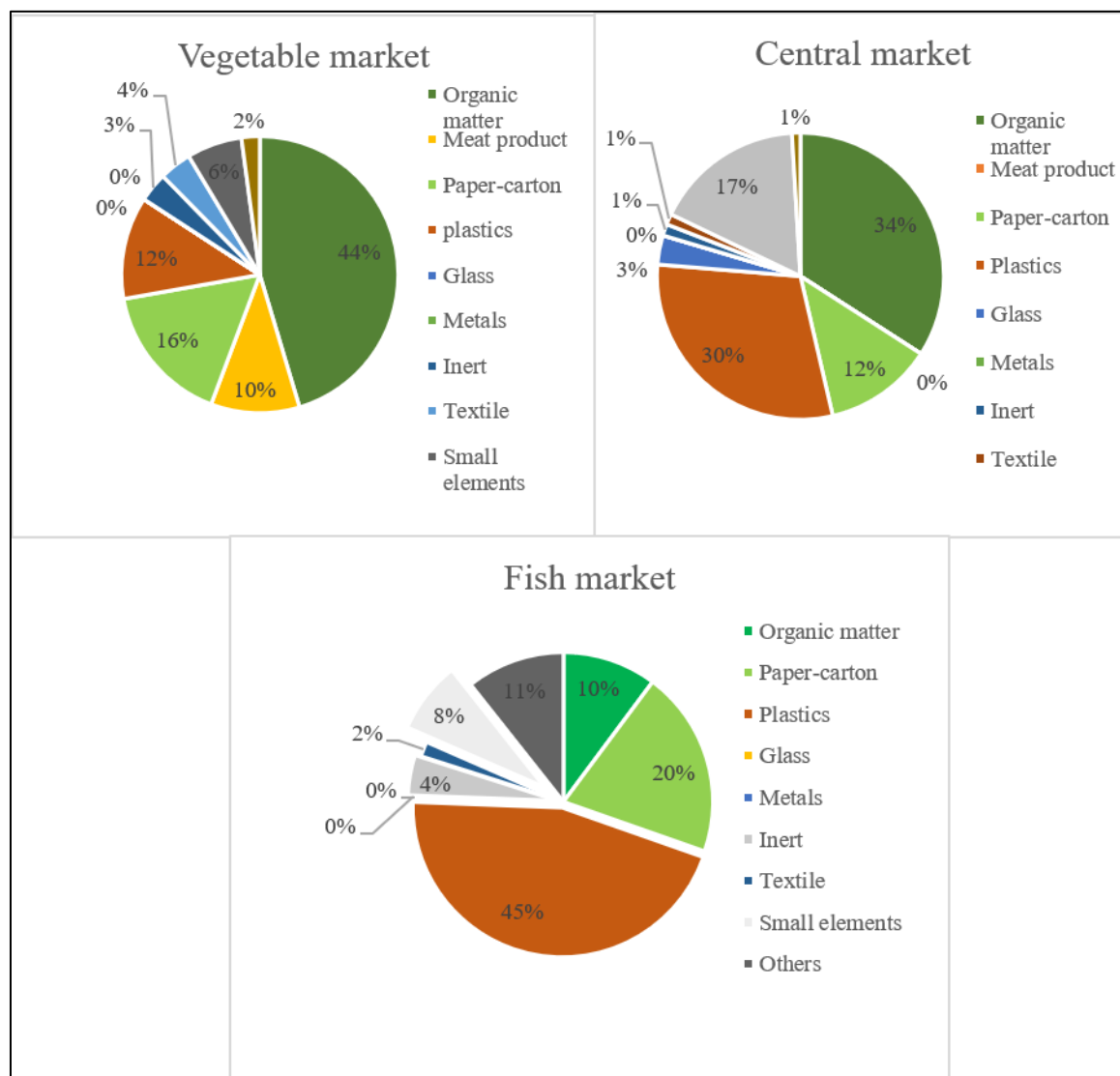


Figure 2: Distribution of waste categories in the >100 mm particle-size fraction across the study markets

The 20–100 mm fraction presents a generally similar composition. Organic waste remains predominant in the vegetable and central markets, while plastic waste remains prevalent in the fish market. This fraction also shows a higher proportion of fine elements, especially in the central and fish markets, and the presence of certain waste categories absent in the coarse fraction.

Overall, granulometric analysis highlights a predominance of the organic fraction in the central and vegetable markets, while the fish market shows a stronger presence of plastic waste. These results assert the biowaste potential for biological recovery, while underlining the need for prior sorting in order to limit contamination of organic matter by non-biodegradable waste.

The composition of waste by category across the study markets is presented in Figure 3.

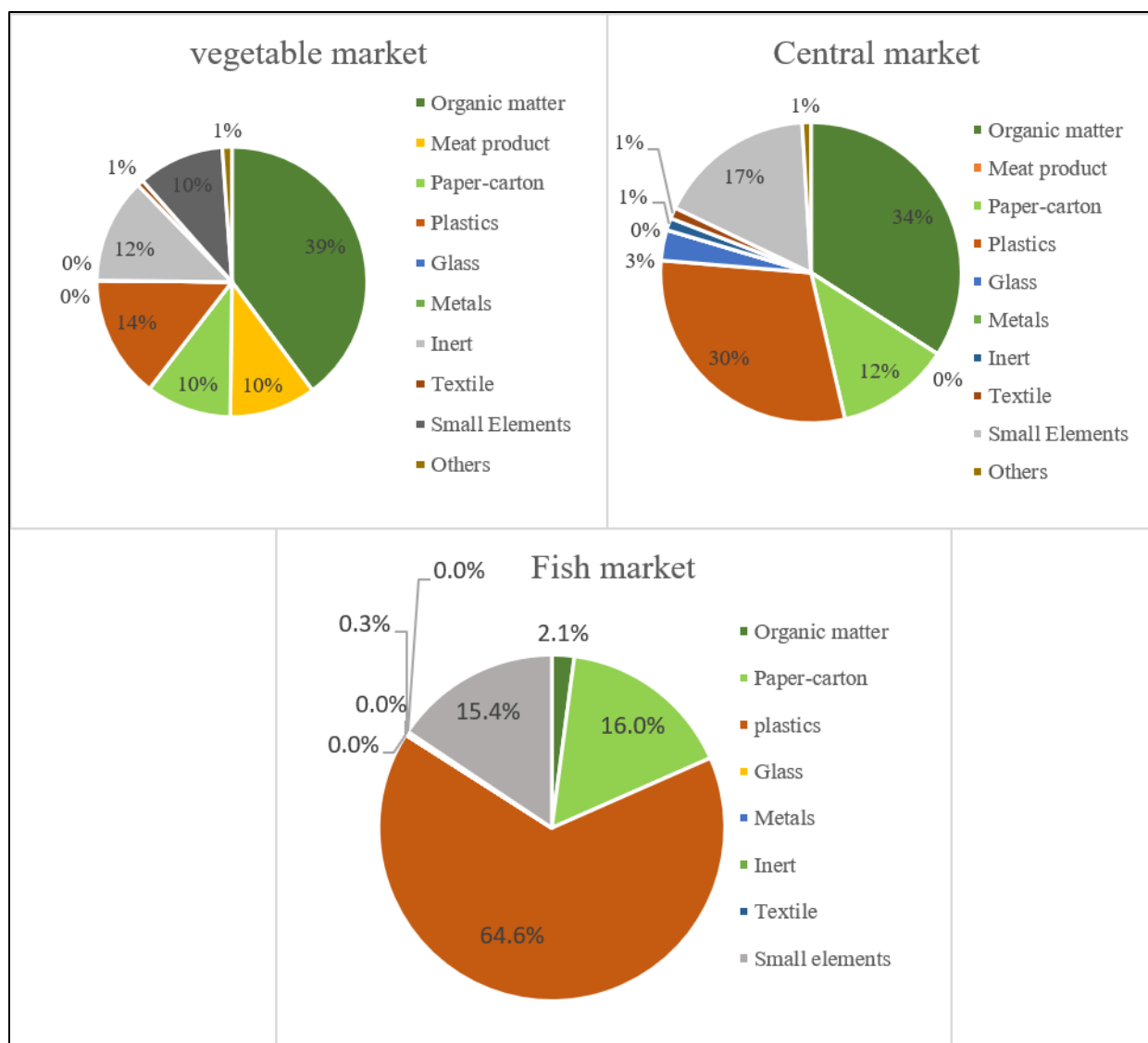


Figure 3: Distribution of waste categories in the 20–100 mm particle-size fraction across the study markets

3.2.2 Analysis of Apparent Density of Waste Streams

The apparent density of the main waste streams has been determined from the fractions whose mass and volume could be measured. Plastic waste has the lowest densities (approximately 120 kg/m^3) in the three markets, due to its low Apparent bulk density and its non-compactable nature. Differently, the fine elements fraction has the highest densities, reaching $863.9 \pm 108.0 \text{ kg/m}^3$ in the central market and 546.5 kg/m^3 in the fish market, reflecting strong compaction of low-granularity particles.

At the market level, biowaste from the vegetable market presents the highest average density ($332.3 \pm 39.5 \text{ kg/m}^3$), while the central and fish markets display the lowest average densities, between $222.3 \pm 68.3 \text{ kg/m}^3$ and $225.5 \pm 12.0 \text{ kg/m}^3$. In Togo, according to Koledzi [19], apparent waste density ranges between 540 kg/m^3 and 760 kg/m^3 . In Algeria, density ranges between 200 and 300 kg/m^3 [21].

The apparent density of the different waste categories across the three markets is presented in Table 5.

Table 5: Apparent bulk density of the main waste fractions across the three study markets

Market	Category	Density (kg/m ³)
Vegetable	Organic matter	370.93±0.61
	Paper-carton	251.25±0.01
	Plastics	120.94±0
	Small elements	-
	Total	332.29±39.52
Central	Organic matter	257.54±159.75
	Paper-carton	251.24±0
	Plastics	116.07±6.87
	Small elements	863.92±107.96
	Total	222.3±68.32
Fish	Organic matter	-
	Paper-carton	260.76±0.49
	Plastics	168.3±13.02
	Small elements	546.47±0
	Total	225.5±11.97

3.2.3 Moisture Content

Moisture content in the Different Waste Fractions varies according to particle size. The fine fraction (< 20mm) represents the highest values, between 47 and 55%, while the coarse fraction (> 100mm) records the lowest contents (30-40%). This difference is mainly related to the high proportion of organic matter in the fine fraction, which promotes water retention. The high humidity observed in the vegetable and central markets can also be attributed to the collection period, carried out during the rainy season. According to Guermoud and Abdou [22], moisture content varies from approximately 52 to 64% depending on the season for waste from the city of Mostaganem (Algeria). On the other hand, in the same country (El Oued region), Abdelbari and Doha [18] found a significantly lower result, with a moisture content of 18%. According to Norbert et al. [23] in the municipality of Kinama, Bujumbura, Burundi, waste has a volatile organic matter rate of 66.63%.

The variation in moisture content as a function of waste particle size is illustrated in Figure 4.

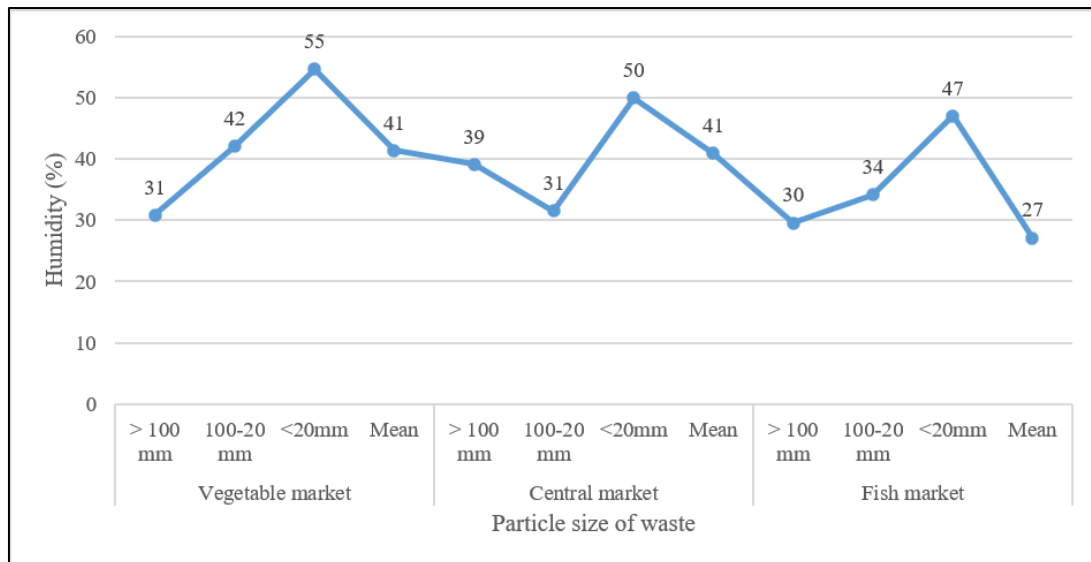


Figure 4: Variation in Moisture Content According to the Particle Size of Waste

3.2.4 Volatile Organic Matter

The Volatile Organic Matter (VOM) has been estimated by mass loss after the pre-dried samples' combustion. The outcomes show an increase in VOM as granulometry decreases, indicating a significant concentration of organic matter in fine fractions. The vegetable and central markets have the highest average contents (around 47%), while the fish market shows a lower average value (35%). In Togo, VOM is 24–25%, which is relatively low in comparison with that observed in this study [19]. In Algeria, these VOM rates vary from 67.75–85.2% depending on the period and region [21].

Overall, these physical properties show that biowaste produced in Diffa markets contains a high percentage of organic matter and relatively high moisture content. This makes it a candidate for recovery by composting, subject to a preliminary sorting operation to reduce the possible presence of non-biodegradable materials.

The variation in volatile organic matter content across particle-size classes and markets is shown in Figure 5.

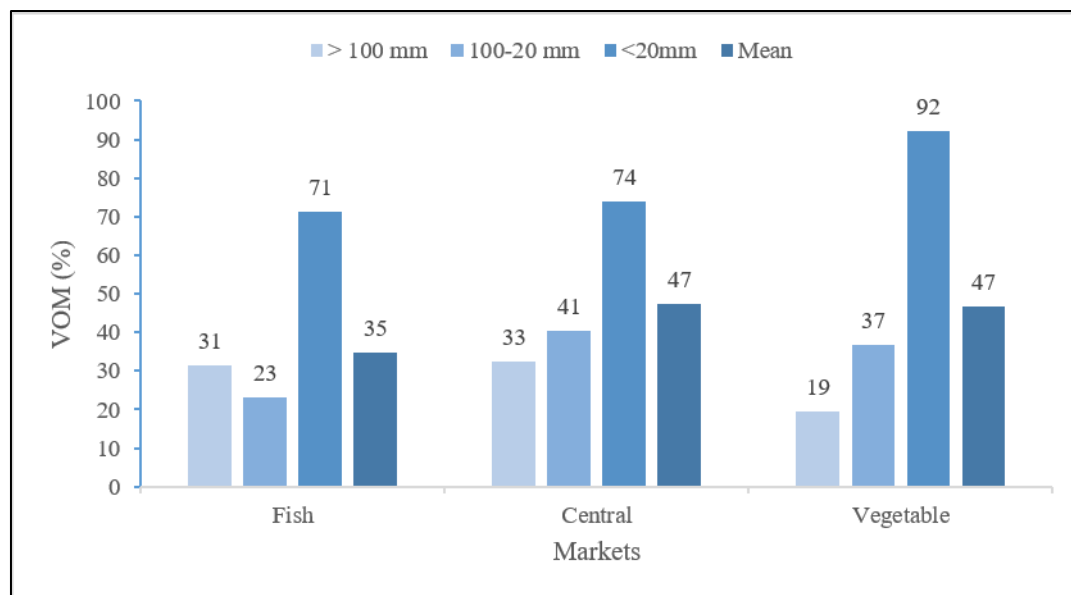


Figure 5: Variation in volatile organic matter (VOM) content according to particle-size class and study market

3.3 Correlation Analysis

The strong positive correlation between recyclable and combustible fractions indicates that these fractions tended to vary together in the sampled waste. However, correlation alone does not demonstrate energy-recovery potential and should not be interpreted as evidence of energy suitability without additional calorific-value and composition analyses.

The compostable fraction also presents a strong positive correlation with moisture content ($r=0.911$) and volatile organic matter ($r=0.927$). Furthermore, moisture content is almost perfectly correlated with volatile organic matter ($r=0.999$). These results indicate that waste with a high organic matter content also has a greater capacity to retain moisture, which may favor the composting process.

On the other hand, Apparent bulk density is strongly negatively correlated with recyclable fractions ($r=-0.990$) and combustible fractions ($r=-0.991$), as well as with pH ($r=-0.937$). This relationship reflects the low density of recyclable materials, mainly composed of plastics and packaging, which occupy a large volume for a relatively low mass.

In summary, these results indicate that the Diffa market waste presents characteristics suitable for biological valorization, in particular for composting, while recyclable fractions could be oriented toward the recycling field or energetic valorization.

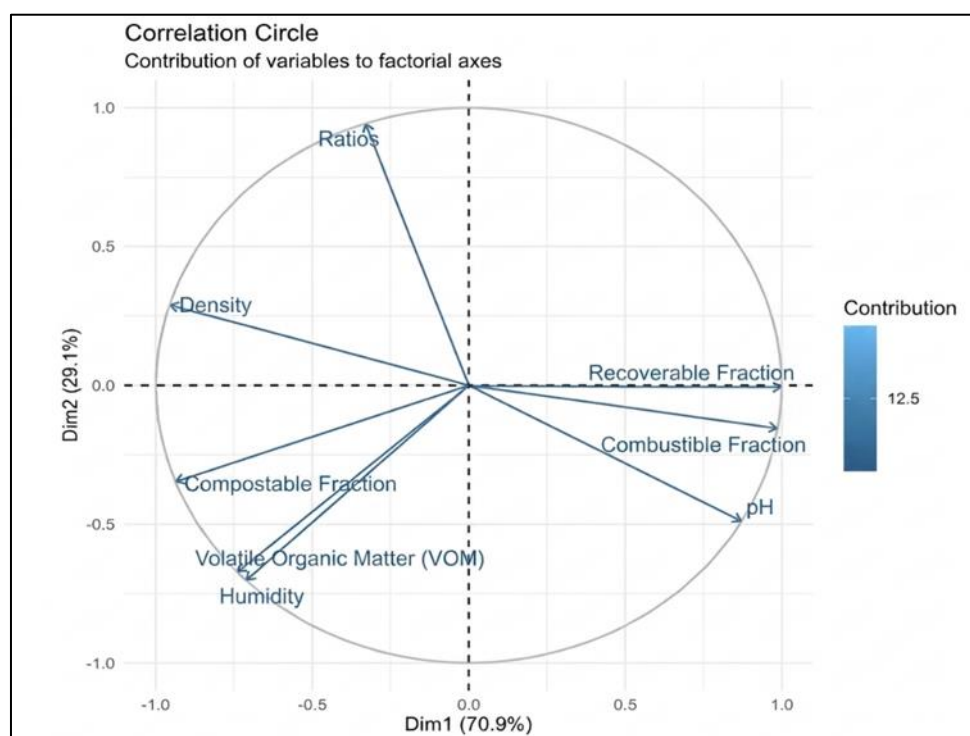
The Pearson correlation coefficients among waste fractions and physicochemical characteristics are presented in Table 6.

Table 6: Pearson correlation matrix among waste composition and physicochemical characteristics

Variables	Ratios	CF	RF	CbtF	PH	Dy	HL	VOM level
Ratios	1.000	-0.017	-0.472	-0.474	-0.750	0.590	-0.427	-0.390
CF	-0.017	1.000	-0.873	-0.872	-0.648	-0.991	0.911	0.927
RF	-0.472	-0.873	1.000	0.988	0.937	-0.990	-0.596	-0.628
FCbt	-0.474	-0.872	0.988	1.000	0.938	-0.991	-0.593	-0.625
PH	-0.750	-0.648	0.937	0.938	1.000	-0.937	-0.277	-0.316
Dy	0.590	0.797	-0.990	-0.991	-0.937	1.000	0.478	0.513
HL	-0.427	0.911	-0.596	-0.593	-0.277	0.478	1.000	0.999
VOC level	-0.390	0.927	-0.628	-0.625	-0.316	0.513	0.999	1.000

CF: compostable fraction; RF: recyclable fraction; CbtF: combustible fraction; Dy: apparent bulk density; HL: moisture content; VOM: volatile organic matter.

The relationships among waste fractions and physicochemical characteristics are visualized in the correlation circle shown in Figure 6.

**Figure 6: PCA correlation circle of waste characteristics and physicochemical variables**

The PCA showed that the first two principal components explained 100% of the total variance, with Dim1 and Dim2 accounting for 70.9% and 29.1%, respectively. The correlation circle (Figure 6) illustrates the relationships among the main waste characteristics and physicochemical variables.

4 CONCLUSION

The study provides useful baseline information for developing a local organic-waste recovery chain in Diffa. Nevertheless, the relatively short monitoring period and the absence of a comprehensive set of standardized chemical analyses limit the extent to which composting suitability can be fully assessed. Future studies should therefore include controlled composting trials and additional analyses of organic carbon, total nitrogen, C/N ratio, phosphorus, potassium, and microbiological quality to determine the quality, stability, and agronomic safety of the resulting compost.

The physicochemical characteristics of the waste, including particle-size distribution, bulk density, moisture content, and volatile organic matter, indicate a significant potential for biological recovery. However, the presence of plastics and other non-biodegradable materials highlights the need for effective source separation before composting.

This study characterized market biowaste generated in the urban municipality of Diffa, Niger, and provided a preliminary assessment of its suitability for composting. The three markets generated substantial quantities of waste, with fresh-product activities, particularly fruit and vegetable and fresh-fish trading, contributing substantially to waste generation. The waste was characterized by a predominance of biodegradable organic matter in the vegetable and central markets, whereas plastic waste was particularly important in the fish market.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

Statement of Informed consent

Informed consent was obtained from all participating traders before data collection. Participation was voluntary, and the information collected was used solely for research purposes.

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