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ORIGINAL PAPER

Household solid waste sustainable management in the Khenifra region, Morocco

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Abstract
Khenifra region is facing a steady increase in household waste production in the last few years linked to population growth, consumption patterns, and living standard changes. This increase is making local authorities suffering in waste management when they are using traditional technics (collect and dumping in landfill). This study is aiming to characterize solid waste in this region for suitable management. Based on samples collected from trucks arriving to landfill site (4 km from Khenifra city), we used characterization method (MODECOM references) to distinguish between three fraction size particles (large, > 250 mm; medium, 250–80 mm; fine, < 80 mm) and 10 categories (organic materials, paper, cardboard, plastics …). This operation is repeated on 4 sectors in Khenifra region with a frequency of 2 campaigns in the season. A matter characterization has been done on the fine fraction (< 80 mm) to facilitate monitoring procedure and reducing environmental emissions. As results, during the two campaigns, the household waste is mainly composed by fermentable waste between 66 and 69%, and the rest is packaging waste (paper, paperboard, glass, textile, and plastic). The glass percentage is significantly varying on the two periods with a large difference between rural and urban sectors. The waste humidity is 67–85% successively in dry and wet season. The lower calorific value average is 408 kcal/kg caused by the humidity rate. Taking into consideration the biodegradable organic matter and moisture content, composting is the suitable solution for sustainable management, while the glass, paper, and plastics should be a part of recycling method.

Keywords Characterization · Household waste · Khenifra region · Composting

Introduction

Household solid waste (HSW) sustainable management is one of the major challenges that humanity faces today and in the future (El maguiri et al. 2014). With a large increase in world consumption, waste production is increasing in quantity and quality and generates huge health risks for the environment and populations (Van der Geer et al. 2000; Strunk and White 1979; Mettam and Adams 1999). This situation is much more serious in developing countries, due to lack of resources and the difficulty to solve the problem by adopting an approach tailored to their own context.

At the Morocco-wide, over 6 million tons are produced annually (Elkadi et al. 2016). However, the Khenifra province landfill, the object of this study, receives daily about 150 tons of various wastes, or more than 54,000 tons/year all of which are household and similar waste (Elhamdouni et al. 2017). This region has a strong contradiction between social, cultural, and economic factors, which is alarming a catastrophic waste management state in the Khenifra province. A recycling center and waste disposal are installed since the beginning of 2017 but the current state is still the same.

In the current context, the characterization of the HSW is essential to achieve the three strategic objectives of the national program for household and similar waste (NPHSW) (Elkadi et al. 2016) namely:

- Enhance HSW 20% in 2020, defines the NPHSW;
- Initiate the collection at the household or certain large producers and install sorting platforms in landfills

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(disposal centers and waste valuation), integrating scavengers in these projects,

- Financial support for development of recovery and recycling of the environmental tax by the resources.

The establishment of reliable data on waste characterization is a prerequisite for efficient management approach to these residues. The availability of this vital information primarily used to evaluate generated waste mass, to follow its evolution in planning and defining future strategies in the management and treatment. To assess the upside potential (composting, recycling metal, cardboard, etc.) and need for optimizing processing, a waste composition, and waste emissions, prediction of their impact has been studied.

Waste characterization is not universal because it depends on the conducted purpose. Therefore, characterization studies have already been carried out in some developing countries like Lome (Togo) (Koledzi 2011), Tunisia (Ben Ammar 2006; Zaïri et al. 2004), Algeria (Tahraoui et al. 2012; Youb et al. 2014), Nouakchott (Mauritania) (Sidi OuldAloueimine 2006), Dar Salam (Ouigmane et al. 2017), and Ghana (Kodwo et al. 2015). Their results showed that waste differs from one region to another, even within the same country.

In this context, this study concerns in particular the household solid waste characterization, their composition over two seasons, and their organic matter content and moisture. This physical and chemical characterization will help to decide which treatment is appropriate for solid residues in the Khenifra province in particular and in Morocco in general.

Materials and methods

Study area

The Khenifra province is located in the north of Beni Mellal-Khenifra region, one of the twelve regions created by territorial division as part of the advanced regionalization (Fig. 1). Administratively, the province is split into 22 municipalities including two in urban and twenty in the rural area. According to the censuses (inventories) dating September 2014, its population is estimated at 371,145 inhabitants (GCPH 2014). This province is characterized by highly reliefs and an altitude worsening from west to east. They vary from 306 m in the northwest and the south of the province to 2210 m in the southeast and the north. The climate of the province is continental Mediterranean type of mountains; it is characterized by a cold and rainy winter with periods of snow in the high mountains and a hot and dry summer with stormy periods (Elhamdouni et al. 2017).

The management of household waste in the study area is characterized by low rate of collection. Indeed, the resources are not adequate and sometimes absent in some areas. The impact is also becoming major in landfills, which have been in a critical situation since the 2000s. Waste is sent to these depots without any sorting at source. Due to social and environmental constraints, the state’s efforts in terms of solid waste management are not satisfactory.

Sampling and characterization of solid waste

The objective of the solid waste characterization study is to provide as much information and reference data that can help policy makers in decision-making, relatively management, and treatment of waste in the Khenifra region. Indeed, the availability of this tool will enable decision makers to be able to conduct periodic surveys to monitor changes and developments in the waste management situation; this will allow them to maximize choice in programs contributing to solve the problem of waste (recovery, recycling, treatment, etc.). On the other hand, achieving a qualitative waste characterization in the campaign of the Khenifra region remains a key element in order to provide a tool.

The segmentation of Khenifra’s region and the sample selection are based on a socio-economic study (Elhamdouni et al. 2018), to distinguish the different residential areas, commercial, administrative, rural, etc. The typology selected for the campaign is:

- Middle Standing Zone (MSZ)
- High Standing Zone (HSZ)
- Downtown Zone (ZD)
- Rural zone (ZR)

The sample represents the decisive step in the reliability of characterization results; this depends primarily on the objective of the study. The heterogeneity of waste deposits (categories, subcategories) and the change in target populations (neighborhoods, households) returning the more complex sampling (Wavrer et al. 2009). Studies recommend a sample weight ranging from 90 to 135 kg (Chandana et al. 2006). Other methods recommended the selection of 100 to 200 kg of waste after quartering (Tahraoui et al. 2012). The MODECOME (Method of Characterization of the household waste, the protocol recommended by ADEME in France) recommends a sampling of 500 kg after the quartering to reduce measurement errors (Tahraoui et al. 2012). But in this study, the waste of the Khenifra province contains no losses so we opted for a mass of 200 kg ± 10 to sample after quartering truck random during waste discharge. This operation was repeated for the four zones of the Khenifra region for two

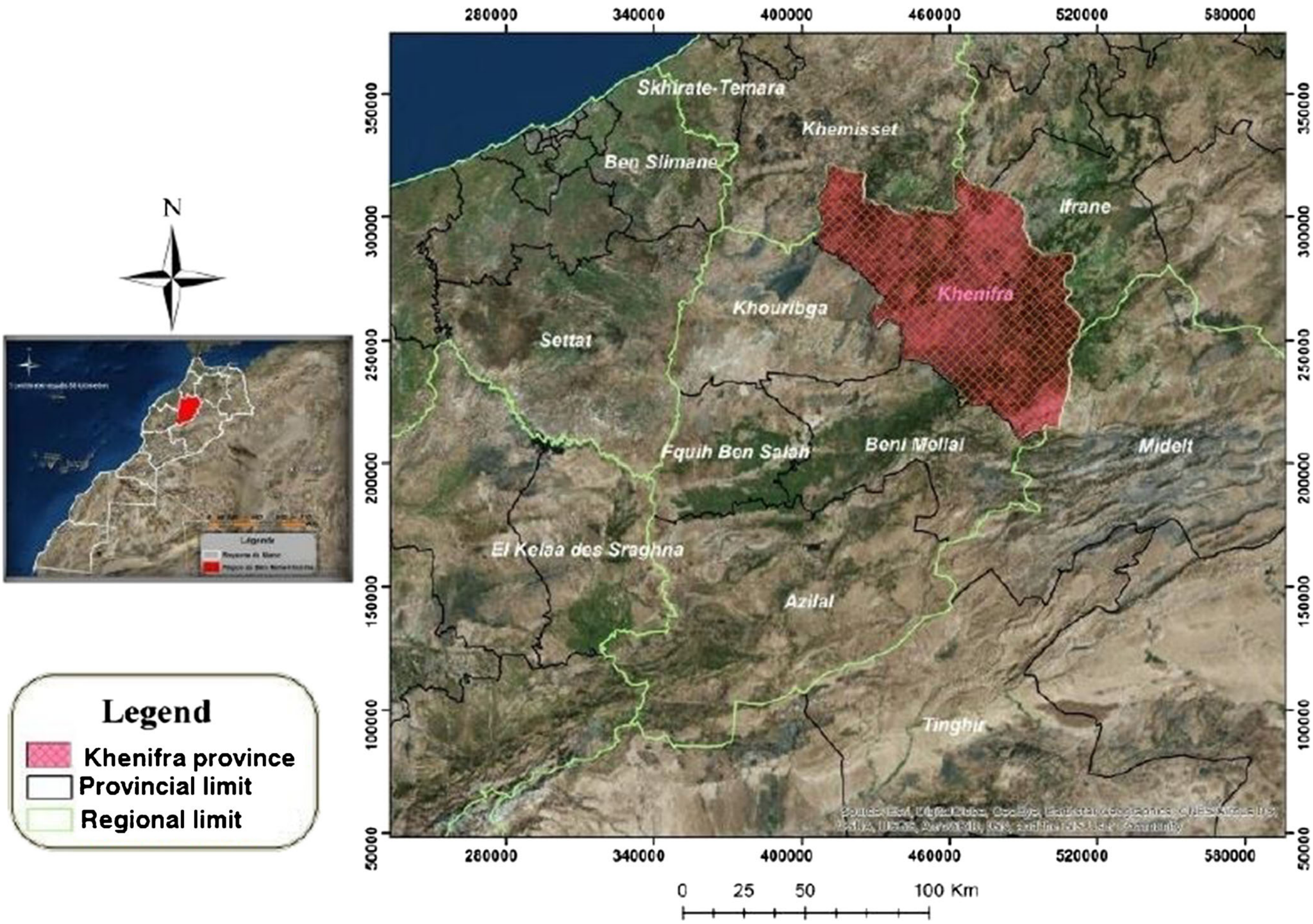

Fig. 1 Map of study area

periods (the dry period and wet period). Some amendments have been made to take account of local conditions.

Sampling took place in the truck dump area on the discharge, with the aid of a loader or excavator, and then, the sample is chosen to carry an equipped location. Thereafter, the waste is sorted with a sorting table (Fig. 2) which has achieved a separation into three sizes, namely fraction > 250 mm (G1), average fraction 250–80 mm (G2), and less than 80 mm fraction (G3). This is justified by the fact that the majority of small waste consists of organic materials (Ouigmane et al. 2017; Mechadi et al. 2016). The next step is to sort both fractions G1 and G2 into 10 categories and by MODECOM (ADEME 2007) putrescible (fermentable) paper and paperboard, textiles and medical textiles, plastics, glass, metals, unclassified fuel, demolition waste, and ceramics.

Moisture and dry matter contents were determined using the AFNOR method (French National Organization for Standardization), 1996. Using the drying at 105 °C until

Fig. 2 Particle size table (a). Particle size classification scheme (b)

a constant mass to determine the moisture and calcination, the material is dried at 550 °C for 2 h to determine the organic matter (Kelly 2002; Charnay 2005).

Measuring the density (specific gravity) of incoming waste at the site was obtained by using a vacuum seal 11 L weighed and then filled with a sample. Weighing is performed with an analytical balance ± 0.250 kg. The density of the waste is calculated according to the formula (Sidi OuldAloueimine 2006; Elkadi et al. 2016):

$$\rho = m/v \tag{1}$$

where ρ is the density in kg m^{-3}, m is the weight obtained in kg, and v is the volume of the bucket in m^3.

The determination of the lower calorific value (LCV) for wastes in Khenifra was made empirically based on the composition of waste by category according to certain models [23, 24, 25]; the choice of model depends mainly on the accuracy of results and technical means available. The LCV is determined according to the content of the following categories in the waste paper, cardboard, textiles total, unclassified fuels, fermentable, and plastics, according to the following model (Sidi OuldAloueimine 2006):

$$PCI = 40\,(P + T + B + F) + 90R - 46W \tag{2}$$

where W is the average humidity of waste; P, T, B, F, and R (%) are the contents (%) of paper fractions, textile, green waste, fermentable, and plastic, respectively.

The methodology used in the characterization is presented in Fig. 3.

Results and discussions

Daily production ratio of waste

Analysis of the results obtained from the daily ratio in the Khenifra region at the landfill site confirms the seasonal effect on the production of household waste, hence the significant increase in daily production during the summer season.

The results also show a difference in the daily ratio between the sectors studied; an increase was noted in urban compared with rural areas (Table 1). This increase is mainly due to population growth and the difference in lifestyles between the two backgrounds.

The average waste production ratio per day in the urban area is lower than in the Grand Casablanca and Mohammedia, 0.80 kg/hab./day (El maguiri et al. 2016). On the other hand, it is close to the average ratio of Morocco, estimated at 0.75 kg/hab./day in urban areas, and Algiers, estimated at 0.75 kg/hab./day (El maguiri et al. 2016). This can be explained by the high population density in this region (characterized by the verticality of its buildings), and collection is done at a high rate compared with other rural areas.

The results obtained during the dry season show an increase in the quantities generated on average of 10% over the wet period. This increase is greater in the urban area and has been about 15% over the wet season. This increase remains proportional for the main fractions. This may be due to changes in people's way of life, but especially to a change in their waste management practice.

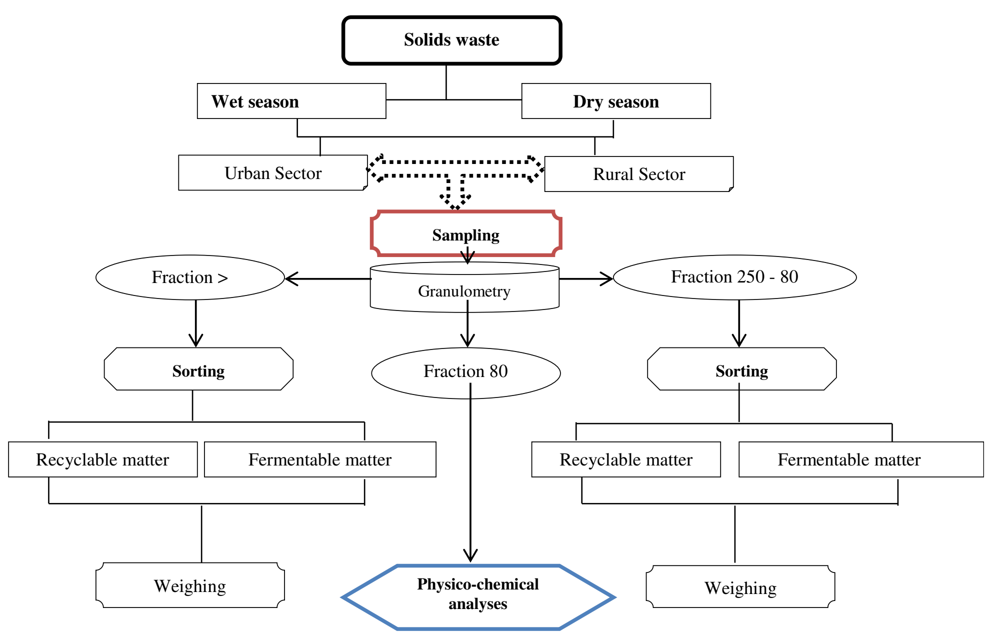

Fig. 3 Summary of the adopted method for the characterization of waste

Table1 Ratios by sector in the Khenifra region

	Urban zone	Rural zone	Khenifra region
	Wet season		
Population number	120,156	16,807	236,160
Quantity of waste (T/day)	83.84	8.83	150.35
Ratios (kg/hab./day)	0.70	0.53	0.62
	Dry season		
Population number	120,156	16,807	236,160
Quantity of waste (T/day)	99.01	10.5	180
Ratios (kg/hab./day)	0.82	0.62	0.73
Average ratios (kg/hab./day)	0.76	0.57	0.67

Physical characteristics

The sorting by size showed information about fractions proportions, that was previously described as G1 (> 250 mm), G2 (250 mm and > 80 mm), and G3 (80 mm). However, waste fraction below 80 mm has not been sorted as it consists mainly of biodegradable materials (Mechadi et al. 2016; Ouigmane et al. 2017).

The waste composition by category as mass sorted percentage and by season and area are represented in Tables 2 and 3. An analysis of its composition is essential to deduce disposal methods such as composting, metal recycling, and other recyclable materials: cardboard, paper, glass, plastics, and also to size processing sites.

The characterization campaign results clearly showed that HSW in the Khenifra region is mainly formed by fermentable waste (between 66% in wet season and 69% in dry one), packaging waste (paper, paperboard, glass, textile, and plastic) and thus unclassified fuels.

Size classification showed that the G3 fraction is mostly abundant with a fairly large temporal variation (66% in wet season and 69% in dry one), with a high rate of biodegradable materials. The G2 constituting 32% of the global waste samples with biodegradable materials and fuels as major constitutes (textiles, paperboard and paper, plastics, sanitary, and demolition waste). The G1 fraction is representing 2–4% depending on the season, with biodegradable material rate exceeding 30% and combustible part is 60% while the rest is a recyclable waste.

In both campaign's obtained results, they showed that the putrescible part is varying between 66 and 69% and a slight variation in packaging waste proportions (paper, paperboard, and unclassified fuels). The metal percent is very low.

The fermented proportions during dry season are very high compared with the wet period; it showed remarkable differences between Khenifra region's two sectors. This can be explained by lifestyle and living standard, by socio-economic character and population consumption which is based on vegetables and fruits during summer. Meaning that the study area factors (climate conditions) has a significant effect on food system.

The packaging waste temporal variation (paper, paperboard) during the two periods showed that there is no significant change, but spatially is remarkable between urban and rural sectors, linked to materials sources.

The results also showed that the percentage of glass varies significantly between the two periods, but there is

Table 2 Composition in percentage by category and under categories of the HSW (1st campaign)

Sectors	Urban			Rural			Khenifra region		
Granulometry	G1	G2	G3	G1	G2	G3	G1	G2	G3
Category	%	%	%	%	%	%	%	%	%
Plastics	1.25	3.01	-	-	1.1	-	0.6	2.05	-
PET	0.75	2.01			0.91		0.6	1.50	
HDPE	0.35	0.75			0.10			0.25	
PVC	0.11	0.13						0.23	
PP	0.04	0.12						0.07	
Glass	-	2.5	-	-	0.9	-	-	1.7	-
Carton	2.87	6.15	-	1.31	2.57	-	2.09	4.36	-
Paper	-	3.85	-	-	1.38	-	-	2.12	-
Metals	0.55	0.88	-	-	0.60	-	0.23	0.74	-
Textiles	3.62	5.25	-	1.87	3.91	-	2.75	4.58	-
Unclassified fuels	0.90	2.5	-	0.55	0.5	-	1.45	3.00	-
Hygienic waste	-	6.65	-	-	5.25	-	-	5.95	-
Brick and demolition waste	-	1.57	-	-	1.83	-	-	1.7	-
Putrescible	2.02	4.50	58.91	-	3.9	64.2	1.01	4.2	61.55

Table 3 Composition in percentage by category and under categories of the HSW (2nd campaign)

Sectors	Urban			Rural			Khenifra region		
Granulometry	G1	G2	G3	G1	G2	G3	G1	G2	G3
Category	%	%	%	%	%	%	%	%	%
Plastics	1.5	4.5	-	1.25	2.5	-	1.37	2.5	-
PET	0.5	2.51		1	0.75		0.88	1.12	
PEHD	0.75	1.02		0.25	0.26		0.22		
PVC	0.21	0.75		0	0.15		0.17	1.25	
PP	0.04			0	0.10		0.1	0.13	
Glass	-	3.5	-	-	1.2	-	-	2.35	-
Cardboards	1.5	5.2	-	0.55	1.88	-	1.03	3.55	-
Papers	-	3.85	-	-	1.55	-	-	2.7	-
Metals	-	0.99	-	-	0.75	-	-	0.9	-
Textiles	1.5	4.5	-	-	3.21	-	0.75	3.85	-
Unclassified fuels	1.9	4.23	-	-	2.55	-	0.90	3.39	-
Hygienic waste	-	6.5	-	-	5.25	-	-	5.80	-
Brick and demolition waste	-	2.5	-	-	1.05	-	-	1.75	-
Putrescible	1.70	3.50	64.55	-	2.00	66.61	0.85	2.75	65.58

a fairly large variation between the rural and urban sectors. This percentage being relatively small can be a fairly considerable saving because glass is the only recyclable material without losing its intrinsic qualities. Indeed, its burial is a loss of natural sources that must be protected.

In lifestyle view, hygiene textiles are increasingly used in both sectors and do not show any noticeable variation between the two periods. Plastic is found essentially in G2 fraction and a small amount in G1 fraction. In addition, it shows a significant variation between the two studied sectors and a slight variation of 1% by season. The high values in the urban plastic are explained by a petrochemical industry development in Morocco. On the other hand, PET is the subcategory of plastic that dominates 70–73%, followed by HDPE with 20–24%, compared with the rest (4%) for the other categories (PVC and PP). As a result, the rural sector produces less recyclable waste, due to household's lifestyle.

According to solid waste characterization in developing countries, Lome in Togo (Koledzi 2011), Tunis in Tunisia (Zaïri et al. 2004; Ben Ammar 2006), Nouakchott in Mauritania (Sidi OuldAloueimine 2006), Mohammedia (El maguiri et al. 2014), Beni Mellal in Morocco (Mechadi et al. 2016), and Algeria (Tahraoui et al. 2012) showed that there is a very large distance in each category, confirming the theory that the waste nature is linked to lifestyle way, the climate, and socio-economic characters of population. The waste variability categories and sub-categories clearly demonstrate the value of source sorting, which is an unavoidable necessity to avoid costly consequences.

Characterization matter

Moisture content

The humidity (moisture) of the thin granulometric fraction of our samples was determined after prior air dry, then the laboratory oven drying. Table 4 presents the results of humidity of the two campaigns.

It seems that the waste's humidity presents seasonal variations, but it records a slight variation between the studied sectors including the rural one. Low season's humidity varies from 80.4% to 85.3%; on the other hand, the high season's does not exceed 67%. This humidity is very important in the wet season than the dry season, due to the region climate. These values are a powerful plus in favor of treatment by compost than by methanization to avoid the generation of a large amount of leachate in the recovery centers. The moisture rate is higher than Mauritania (11%) (Aloueimine et al. 2005) and Tangier (43%) (Elkadi et al. 2016). However, it remains close to other studies carried out in Algiers (69%) (Ouigmane et al. 2017). The moisture (humidity) average of waste in Khenifra varies between 67.5 and 81.1% due to the large putrescible content.

Content in organic matter

Organic matter (volatile solids) was determined by calcination at 550 °C of dry matter (loss to the fire). Thus, the calcination is performed on fraction's reconstituted samples G3. The results obtained are summarized in the table below:

Table 4 Measured humidity (in %) by campaign

Sectors	Urban			Rural	Khenifra region
Zones	MSZ	HSZ	ZD	Rural zone	Average
Humidity	%	%	%	%	%
Campaign 1	84	82.5	80.4	85.3	84.3
Campaign 2	67.5	67.2	66.5	69.1	67.5
Average	75.75	74.84	73.45	77.2	75.9

The tests results, on samples replenished during different seasonal campaigns, do not show significant differences depending on the season. They show that the organic matter varies between 68 and 79%, representing an average of 75% of the dry weight of the waste (Table 5). This rate is comparable with the average of household garbage from other wastes in developing countries such as Mauritius 85% and Tanzania 80% (Tchobanoglous et al. 1993; Mbuligwe and Kassenga 2004), or some type of waste cited by Hossain (Hossain 2002) whose contents represent 78.6% of the dry mass of the waste. However, it remains relatively important to other wastes of the USA by Tchobanoglous (Tchobanoglous et al. 1993) which is 52% and varies from 40 to 60% according to the type of the waste. We believe that these results are in agreement with the geographical situation, climate, seasons, the standard of living of households, and food system. We noted that these factors favored high rates of putrescible waste whose moisture content is higher.

Density of HSW

Density is one of the important parameters in the choice and the design of the means of transport of urban waste (particularly in the developing countries) than in the stabilization of waste in landfills. It has been determined for the waste generated every day during the period of each campaign of characterization. Because of the heterogeneity of the waste, the measurements showed a great variation in the results (Table 6). However, despite the difference in constitution of the HSW by standing, we note that the average density values are similar, regardless of the living standard. This might be explained by the fact that the high rate of the fine fraction for low and medium standard levels, are compensated, in mass, by the fermentable waste in the high standing (the fermentable in the luxury). However, the measures have significant variations between seasons. The average density in the Khenifra region is between 272 and 350 kg m^{-3} according to the season. It remains in developing countries values ranges 250–500 (Cointreau Levine 1997).

Table 5 Organic matter in HSW (%)

Sectors	Urban			Rural	Khenifra region
Zones	MSZ	HSZ	ZD	Rural zone	Average
Organic matter	%	%	%	%	%
Campaign 1	77	73	68	78	74
Campaign 2	79	75	71	79	76
Average	78	74	69.5	78.5	75

Table 6 Density (kg m^{-3}) in HSW

Sectors	Urban			Rural	Khenifra region
Zones (kg m$^{-3)}$	MSZ	HSZ	DZ	Rural zone	Average
Campaign 2	290	230	310	255	271
Campaign 2	290	230	310	255	271
Average	320	275	365	282	310

Lower calorific value

The LCV determination for the HSW of Khenifra was made empirically based on waste composition by category according to the formula described above (Formula 2). The table below represents the results of the LCV based on sectors.

The LCV average is 408 kcal/kg. It is far lower than the average in many developing countries (1500–2700 kcal/kg) (Cointreau-Levine 1997). This low LCV is favored by the humidity rate (67%) and could be considerate as favoring parameter of composting treatment or Bio-methanization (Table 7).

Therefore, the recoverable fraction by recycling is interesting and could constitute the second segment of household waste management. However, organic matter, moisture content, and lower calorific value make the best biological treatments for an efficient and sustainable solid waste management in the Khenifra region. Given the climatic conditions (high sunshine rate, average annual temperatures) and enormous need for organic matter in our region's agricultural soils, as a result, composting remains the most appropriate method for a sustainable management of HSW. Regarding problematic concerning socio-economic aspects (Elhamdouni et al. 2018), we have been able to direct waste recovery towards the 3R approach (recycle, reuse, and reduce). As conclusion, selective sorting system is justified.

Table 7 Lower calorific value (LCV) in the second campaign

Sectors	Urban			Rural	Khenifra region
Zones	MSZ	HSZ	ZD	Rural zone	Average
LCV (kcal/kg)	357.7	464	463.20	350.2	408.8

Conclusion

The collected results allowed us to extract valuable information on the HSW physical and chemical aspect in the Khenifra region. It is clear that the quantity and composition of the HSW generated vary according to the season, status, and citizen's life style mode. The fermentable waste proportion suggests composting as the most promising management method rather than waste incineration. However, the recoverable fraction by recycling is interesting and could be the second segment of the HSW management.

To conclude, the waste in Khenifra region, taking into consideration their high organic matter content, the moisture rate influencing their low calorific value, can be valued through three possible ways: recycling, composting technique with good control, bio-methanization which is allowing the double gain in matter and energy. A combination of these methods will be ideal for field efficient exploitation in the Khenifra region.

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References

ADEME (MODECOM, 2007) Method of characterization of household waste. ADEME Editions. 1993

Aloueimine S, Matejka G, Zurbrugg C and Sidi Mohamed ME (2005) Caractérisation des Ordures Ménagers à Nouakchott: Partie II : Résultats en Saison Sèche et en Saison Humide, article en Presse, 8 pages.

Ben Ammar S (2006) Les enjeux de la caractérisation des déchets ménagers pour le choix des traitements adaptés dans les pays en développement: résultats de la caractérisation dans le grand Tunis: mise au point d'un méthode adaptée.Diss. Vandoeuvre-les-Nancy, INPL.

Chandana KV, Yuen STS, Pilapitiya S (2006) Municipal solid waste management in the Southern Province of Sri Lanka: problems, issues and challenges. Waste Manag 26(2006):920–930

Charnay F (2005) Composting of the urban waste in the PED: elaboration of a methodological initiative for a long-lasting production of compost. Doctoral thesis N 56. University of Limoges.

Cointreau-Levine S (1997) Occupational and environmental health issues of solid waste management. Int Occup Environ Med. St. Louis, 25 pages.

El Maguiri A, Fawaz N, Souabi S, Idrissi L, Taleb A, Vincent R (2014) The physical characterization of household waste in the city of Mohammedia- Morocco-and the evaluation of the financial impact of its current management. Int J Eng Innov Technol 3(12):100–106

Elhamdouni D, Ariou A, Karaoui I, Aba B, Ait Ouhamchi K (2018) Sustainable management of household garbage-status of citizens behavior and participation. A case study of Khenifra region (Morocco). Eur Sci J 14(20):61–78

Elhamdouni D, Arioua A, Aba B, Elhmaidi A (2017) Geomatics tools and AHP method use for a suitable communal landfill site: case study of Khenifra region (Morocco). J Mater Environ Sci 8(10): 3612–3624

Elkadi A, Maatouk M, Raissouni M, Chafiki T (2016) Characterization of household and assimilated waste in the city of Tangier. Int J Innov Appl Stud 18(2):512–528

GCPH (2014) Note on the first results of the General Census of the Population and the Habitat 2014, High Commissariat of Plans. Khenifra province, 30 pages.

Hossain MDS (2002) Mechanics of compressibility and strength of solid waste in bioreactor landfills. Thesis, Faculty of North Carolina State university at Raleigh, Department of Civil Engineering, 199 pages.

Kelly RJ (2002) Solid waste biodegradation enhancements and the evaluation of analytical methods used to predict waste stability. Thesis in Environmental Science and Engineering, Faculty of Virginia Polytechnic Institute and State University, 65 pages.

Kodwo M, Kwasi O, Zsófia K, Bernard F, Moses YM (2015) Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana, Waste Manag, 46 (2015), 15-27.

Koledzi E (2011) Valuation of the urban waste in the districts of Lomé (Togo): methodological approach for a sustainable production of compost. Diss. Limoges.

Mbuligwe SE, Kassenga GR (2004) Feasibility and strategies for anaerobic digestion of solid waste for energy production in Dar Es Salaam city, Tanzania, Resources. Conserv Recy 42(2004):183–203

Mechadi M, Mbarki M, Chamsi Z (2016) Characterization of the recyclable fraction of solid waste of the Beni Mellal-Morocco-Villa Zone Territorial Commune. Eur Sci J 12(23):253–269

Mettam GR, Adams LB (1999) How to prepare an electronic version of your article. In: Jones BS, Smith RZ (eds) Introduction to the electronic age. E-Publishing Inc, New York, pp 281–304

Ouigmane A, Boudouch O, Hasib A, Berkani M (2017) The size effect in the distribution of combustible components in the municipal solid waste produced in the summertime. Case of the city of Beni Mellal-Morocco. J Mater Environ Sci 8(8):2729–2737

Sidi OuldAloueimine (2006) Méthodologie de caractérisation des déchets ménagers à Nouakchott (Mauritanie) : contribution à la gestion des déchets et outils d'aide à la décision.Diss. Limoges, 195 pages.

Strunk W Jr, White EB (1979) The elements of style, 3rd edn. Macmillan, New York

Tahraoui Douma N, Matejka G, Chambon S, Touil D (2012) Composition of Municipal Solid Waste (MSW) generated by the city of Chlef (Algeria). EnergyProcedia 18:762–771

Tchobanoglous G, Theisen H and Vigil Samuel A (1993) Integrated solid waste management, engineering principles and management issues, McGraw-Hill International Editions, Civil Engineering Services, 978 pages.

Van der Geer J, Hanraads JAJ, Lupton RA (2000) The art of writing a scientific article. J Sci Commun 163:51–59

Wavrer P, Jourdan B, Courbet S (2009) Sampling and characterization of household waste: recent developments, Environment and technique, (FRA).nov. 2009.-pp. 28-32

Youb O, Youb A, Bouabdessalam H (2014) Municipal waste management in the Algerian High Plateaus. EnergyProcedia 50:662–669

Zaïri M, Ferchichi M, Ismaïl A, Jenayeh M, Hammami H (2004) Rehabilitation of Yahoudia dumping site, Tunisia. Waste Manag 24:1023–1034