ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 7, Issue 4 , April 2020

Effects of human activities on solid waste composition in Tunisia

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ABSTRACT: The current situation of the organic solid waste in Tunisian cities drew attention to the need of an appropriate and updated waste management model allowing to overcome the environmental concerns. Indeed, the generation of solid waste (SW) is related to various features of urbanization and rapid growth of population rates. Thus, the amount and the type of wastes are not only influenced by the increase of the population rate but also by the human activities and the change of people's lifestyle. This work aims to elaborate an overview combining SW composition and the different sectors of activities to efficiently evaluate and predict variation in SW composition within regions and cities. Then, a brief perspective which intends to recommend a suitable process for recovery of the organic fraction of SW is provided.

KEYWORDS: Waste management; organic residues; biological treatment; waste valorisation, agricultural sector, touristic sector, industrial sector.

I.INTRODUCTION

Meaningful waste management strategies become nowadays a priority to comply with a worldwide challenge which aims to meet environmental and energetic concerns [1]. Then, several countries have recourses to a fundamental change in their waste management guidelines adopting the exploitation of different kind of residues to reduce the amounts of the disposed wastes and produce green energies simultaneously. A special interest has drawn attention to the worrying Tunisian situation in this matter [2]. Although the Tunisian experience in term of waste management policies has always been taken into consideration, the quantity of municipal solid waste has exponentially increased from 2.025 million tons/year in 2004 to attain 3.756 million tons/year in 2019 [3]. Therefore, the developing of an accessible data source aiming to help decision makers to execute appropriate waste management outlines is crucial which is then the target of this work.

II. SIGNIFICANCE OF THE SYSTEM

This manuscript mainly focuses on how a characterization of solid waste generated from different sectors helps decision makers to implant an appropriate waste management strategy aiming to reduce the streams of wastes and the environmental and energetic issues. This paper is divided into four parts, starting with an introduction (I), the Methodology is then explained in section III, followed by the section IV which covers the results of the study, and section V discusses the future study and Conclusion.

III. MATHERIALS AND METHODS

A. Study area

Tunisia is a small country located in the Maghreb region of North Africa and covering 162.155 km^2. Referring to [4], the population of Tunisia reached 11.722.038 million inhabitants in 2019. The country is divided into 24 provinces and regrouped to Northeast, Northwest, Mideast, Midwest, Southeast and Southwest (Figure 1) [5]. The used data in this work were gathered from a previous research achieved in 2009 and then an updating was ensured by the National Agency for Waste Management of Tunisia (ANGed) [6].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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Fig 1. Regional department of the study area [5].

B. Selection of SW indicators

Several influential actors such as population growth, urbanization rates and human activities create a considerable difference within regions and cities in term of waste materials[7]. Generally, solid wastes (SW) are classified as organic and inorganic flows to opt later for the conversion processes which should be adopted. However, a deeper classification entails to seven major categories of SW: organic fraction (food, agri-food and agricultural residues), paper and cardboard, plastic, metal, glass (broken bottles, beer or wine bottles), textile and diverse (various indivisible residues). Moreover, it should be noted that the selection of the study cities was not an arbitrary choice. Indeed, it was like a representative selection of different economic sectors in Tunisia. So, Greater Tunis, the valley of "la Medjerda" (Beja, Jendouba, Kef and Siliana), Sfax, Nabeul and Sousse were chosen as study areas. Data were gathered from a recent work *(realized by the author, but not published yet)*and a national project which were achieved by ANGed and the German consulting firm (KFW) [5;6].

IV.RESULTS AND DISCUSSION

A. SW per region activities

1. Business and citizens' services

Greater Tunis is the capital region of Tunisia. It covers a surface area of about 256.000 Ha and its population is about 3.002.093 inhabitants [4]. This region includes an intensive density of various business and citizens' services (ministries, companies, banks, universities, hospitals and clinics…) which makes clear the reason of its high population rate (around 25% of the inhabitants of Tunisia reside in the City of Tunis). However, such a development of urbanization in Tunis City will lead to a simultaneous increase of SW amounts in the coming years, then a better grasp of SW composition is needed to adopt an appropriate strategy aiming to overcome the environmental concerns generated. Figure 2 illustrates that the organic fraction was around 52%, followed by 16% and 11% of paper and plastic, respectively [10]. Moreover, organic and plastic waste are specific pollutant indices of residential living standards [11]. Indeed, the high number of hospitals, clinics, university refectories and canteens which marked Tunis City point out the relatively high fraction of organic matter and particularly the amount of food waste produced. A previous work highlighting the food waste quantities indicated that 2968, 177 and 1067 tons/year were generated by canteens, university refectories, hospitals and clinics throughout the Greater Tunis. Additionally, the Greater Tunis includes a wide range of wholesale markets and urban green spaces which produce later a huge amount of waste stream consisted mainly of vegetable waste (vegetable toppings, spoiled or expired vegetables) and gardening residues collected from green areas, respectively. Indeed, Tunis City generated around 5900 tons/year of wholesale markets residues (33% of

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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the total waste flow of Tunisia) and 260.000 tons/year of green wastes including lawns, fencing and alignment trees, shrubs, etc. So, those amounts deal with the proportion of the organic fraction shown in Figure 2. Furthermore, the significant number of universities (around 40% of the total number of universities is located in Tunis City), business and citizens' services (all the ministries, administrative headquarters, banks…) explains the significantly high rate of paper and carboards which achieved 16% of the total solid waste.

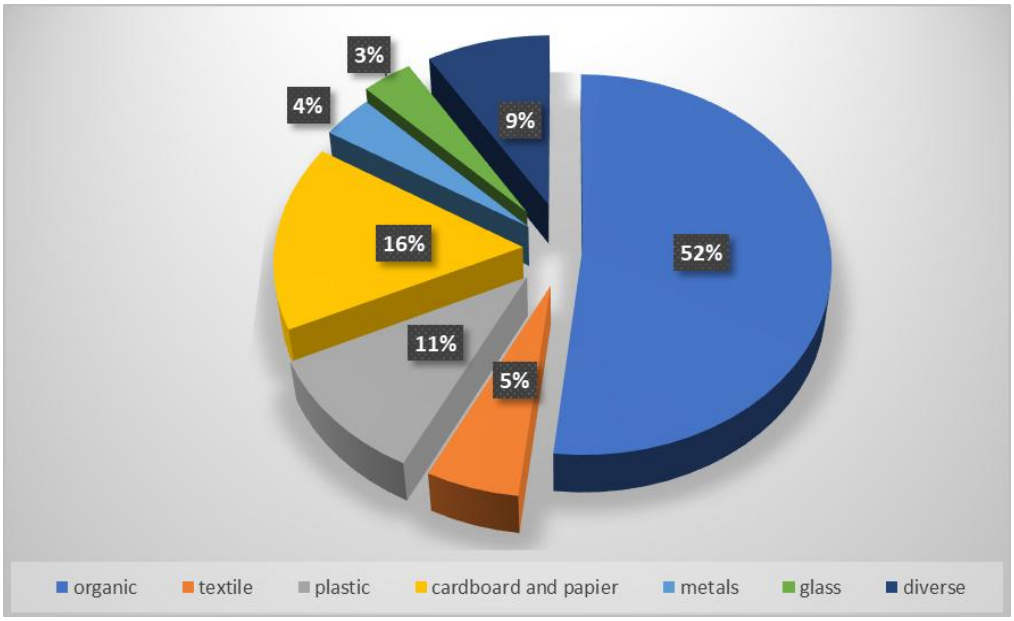

Figure 2.Characterization of solid waste generated from higher populated area.

2. Touristic sector

Regarding the touristic sector, Sousse was chosen as a study area where the waste management system looks not only after the wastes generated from the hotels but also from beaches. In term of solid waste quantity, it should be underlined that a tourist generates the double of the MSW amount produced by a local resident which gave rise to around 35 million tons of MSW per year [12]. As Tunisia welcomed over 9 million of tourists in 2019, an insertion of a pertinent SW management strategy is needed to guarantee the progress of touristic activities. For the current work, the governorate of Sousse seems to be the suitable study area, as it received around 1.3 million tourists in 2019, to well characterize the solid waste produced from the touristic sector [13]. Indeed, Figure 3 shows that hotels of Sousse produced different kind of waste which mainly consisted of a notable rate of organic waste reaching 78.2% [14]. In fact, the significant proportion of organic residues was resulted of green waste gathered from the gardening activity and kitchen waste collected before and after meals preparation. Indeed, the amount of kitchen waste acquired from the hotel industry of Sousse reached 11.441 tons/year which presented 27% of the overall SW generated from the hotels throughout the whole country.

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International Journal of Advanced Research in Science, Engineering and Technology
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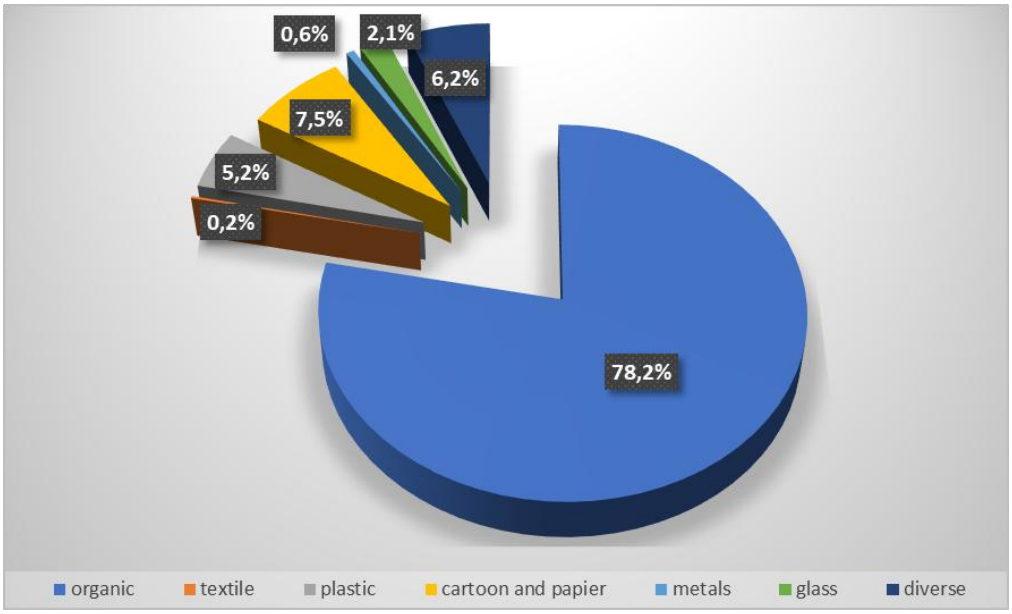

Figure 3.Characterization of solid waste generated from touristic sector.

3. Industrial and food-processing sector

Agro-food industries are the first largest manufacturing industry producing huge amounts of biodegradable residues. The main food processing streams (FWS) evaluated are fruit-and-vegetable wastes collected from cannery industries, grape wastes generated from winemaking industries, as well as wastes from poultry slaughterhouses. Indeed, changes in peoples' lifestyles lead to a higher consumption of canned food [7]. As Nabeul is known by the production of approximately 90% of the total canned tomatoes, it is chosen as a city area to quantify and qualify the food processing waste. Indeed, Nabeul yielded around 20.000 tons/year of tomatoes residues which presented 55% of the total FWS generated throughout Tunisia. Additionally, Nabeul is considered as the largest grape-growing region in Tunisia including 40 winery and grape juice industries and generated 8800 tons/year of winemaking wastes which counts around 87% of the total winemaking waste quantity. Moreover, the governorate produced 17.700 tons/year of poultry slaughterhouses residues which presented 37% of the cumulative amount in Tunisia. So, the eastern part of Tunisia is considered as the major producer of organic wastes gathered from industrial agri-food sector. Consequently, the sector activity has a direct impact on the characteristic of the SW generated by Nabeul. Figure 4 illustrates that 68% designate the organic proportion which may be due to the fruit and vegetables residues from the food canneries manufactories. In addition, higher rates of glass and metals comparing to further sectors are notable, reaching 4.5 and 5.8%, respectively. In fact, it is attributed to the by-products derived from winemaking industries (glass bottles) and food cannery business (metallic food cans).

As a part of the agricultural stream, the waste and by-products from olive mills activities are also highlighted. Indeed, the olive oil mills generate different kinds of wastes reaching 2.090.000 tons/year and categorized as liquid and solid wastes. Regarding the solid residues, the olive oil production industry produces around 650.000 tons/year of solid by-product which is the olive pomace-oil as well as olive leaves which are exploited as animal feedings and approximated to 70.000 tons/year. As the main olive processing industries are located in the Center-East of Tunisia, Sfax is selected as the second study area which represents the agricultural field. Therefore, Sfax is known as one of the most important producers of olive oil in Tunisia generating around 620.000 tons/year as a total flow including wastewater, leaves and olive pomace-oil. The seasonal amount of olive mill waste influences the composition of the total waste generated from the municipality of Sfax and then the organic fraction achieved 68% of the solid residues.

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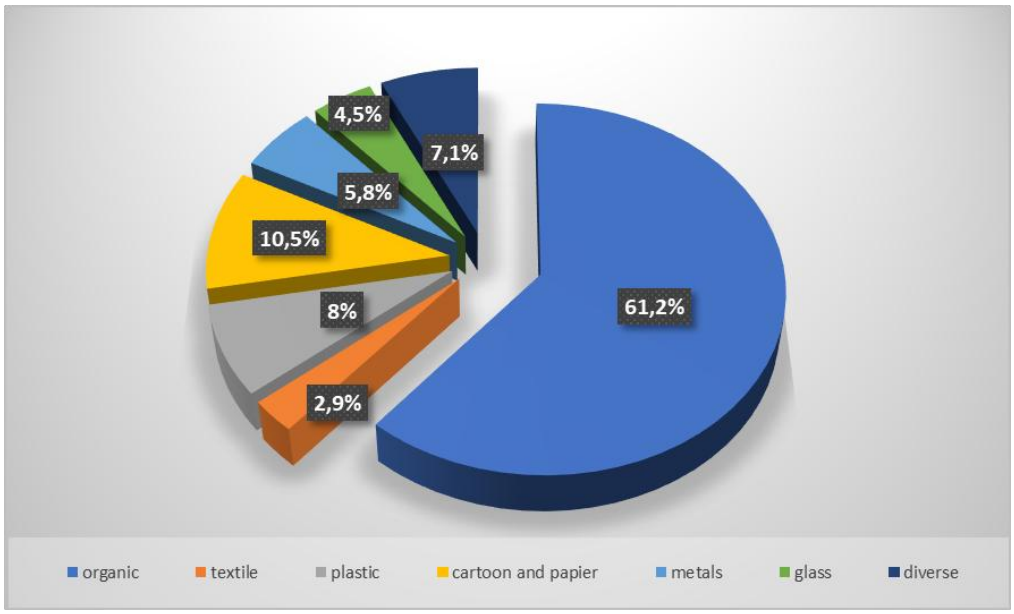

Figure 5.a.Characterization of solid waste generated from food-processing sector.

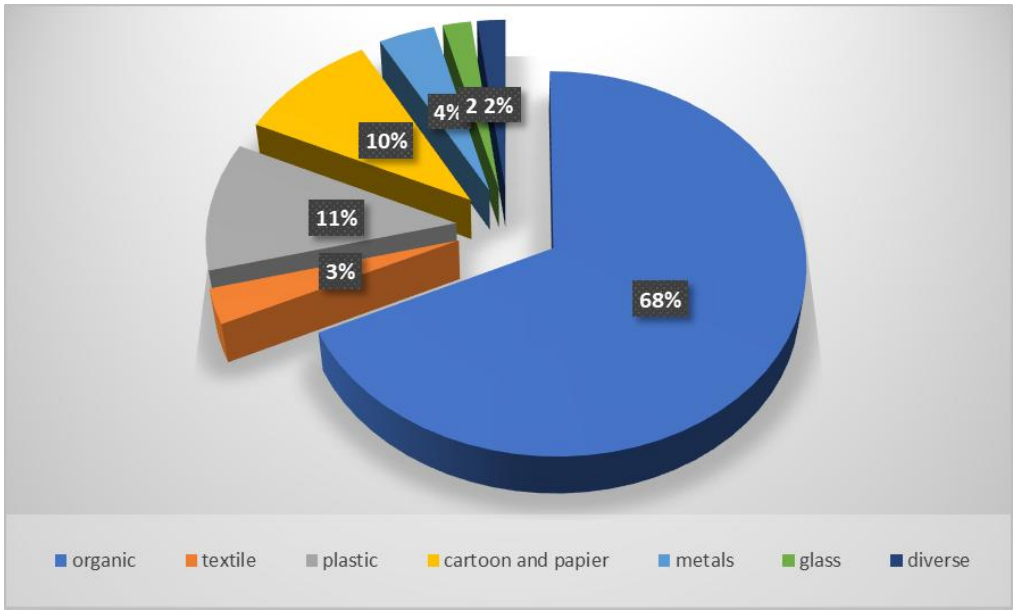

Figure 4.b.Characterization of solid waste generated from Olive Mills.

4. Agricultural sector

While the threat of touristic and industrial wastes was outlined for decades, the agricultural waste concern was been later considered as a further source of great amounts of organic residues. Within recent years it was remarked that the quantity of agricultural wastes marginally increased in Tunisia which deserves an insertion of a relevant waste management strategy. As the agricultural waste can be restricted to animal manure as well as arboriculture wastes, the Valley of "la Medjerda" seems to be the ideal study city to evaluate the waste derived from agricultural activities in

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International Journal of Advanced Research in Science, Engineering and Technology
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term of animal manures generation. Indeed, the North-West of Tunisia is known by animal farming with 237.300 of bovine animals, 1.723 600 of sheep and 219.900 of goats. Thus, a relatively high volume of manure reaching 1.535.938 tons/year were produced which presented 35% of the total amount yielded throughout the country [15]. Additionally, the total area of the holding consists of the utilized agricultural area (arable land, permanent grassland, permanent crops…) is estimated 551.700 Ha in the North-Western region of Tunisia which leaded to a generation of 310.200 tons/year of dead wood and brushwood, pruning and forestry products. Therefore, Figure 5 confirms that the notable agricultural activity of the area influenced the main characteristics of SW generated which explains the high organic fraction (73%) recorded.

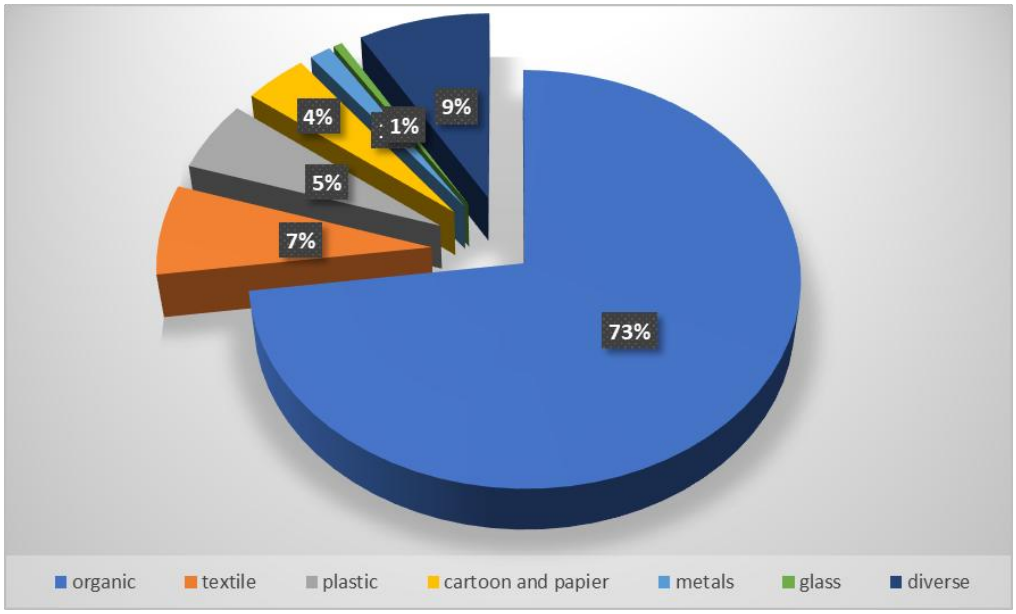

Figure 5. Characterization of solid waste generated from agricultural sector.

5. Sustainable future scenarios

Basing on the characteristics of the generated waste from each sectors of activities, it is obvious that the organic fraction dominated and then a specific design might be drawn. Nevertheless, despite that notable rate of organic fraction , only 5% of the of total technical performance of SW recovery was devoted to the composting process and a complete lack of anaerobic treatment must be underlined [10]. To overcome the environmental concerns caused by the huge amounts of the biodegradable residues, biological treatment might be the most appropriate operative code. Table 1 summarized the process dealing with each kind of organic residue gathered from different areas. Then, “Compost or biogas” might be the question raised by the decision makers. Thus, the geographical distribution as well as the sector of activities allowed the elaboration of a suitable approach to take advantage of the biomass gathered and to produce valuable end-products. So, the intention of the government should not be only focusing on the green energy production but also on the way to reduce the amount of wastes sent to landfills. Moreover, it should be taken into consideration that the recovery of the organic wastes is not always achieved by the same method, it depends deeply on the characterization of the organic material, then various organic streams were classified basing on the adequate biological process recommended.

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Table 1. Biological processes for organic waste exploitation.

Sector of activity	Source of organic waste	Composting	Anaerobic digestion
Urban area	Municipal and wholesale markets	✓	✓
	Urban green spaces	✓	
	Food waste from refectories	✓	✓
Touristic sector	Food leftovers, kitchen wastes	✓	✓
	Green waste from gardening activity	✓	
Industrial and food-processing	Winemaking residues	✓	✓
	Livestock slaughterhouses wastes		✓
	Poultry slaughterhouses wastes		✓
	Fruits and vegetables waste from canneries	✓	✓
Agricultural sector	Animal manure	✓	✓
	Solid and liquid dropping	✓	✓
	Crops residues (olive leaves, margins, wheat straw…)	✓	✓

VI.CONCLUSION AND FUTURE WORK

This work ascertains that the urbanization rates and human activities create a considerable difference within regions and cities in term of waste materials. Then, the identification of waste streams generated from each sector showed that to achieve a solid waste management strategy, it is crucial to adopt a particular model fitting with the specificity of the area and its characteristics. Decision makers can start with the simplest solutions in order to guarantee the completion the main objectives and then strategies and approaches will more and more developed referring to the waste management situation. Further works will be devoted to the optimization of the co-composting process of different kind of organic residues such as agricultural and food wastes.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

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ACKNOWLEDGEMENT

The authors express their sincere appreciation to the National Agency for Waste Management of Tunisia (ANGed) for the valuable efforts and helps during this work.

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