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QUANTITATIVE AND QUALITATIVE CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN WESTERN ALGERIA: IMPACT OF POPULATION GROWTH

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Abstract- The growth in population, the emergence of new materials and packaging culture, the emergence of socio-economic activities, and changes in lifestyle and consumption, have greatly favored urban waste generation. The goal of this analysis is to see the evolution of waste output in urban areas in recent years (2012/2019) and to see the factors affecting the quantity and quality of waste generated in the west Algerian town of Oran. This would contribute to better decision-making surrounding the current situation. This research has shown that the population of the state of Oran is gradually growing each year and is moving in the Bir El Djir and Essenia sectors. The analysis of the waste indicated that household waste is mostly medium in size between 20 and 100 mm, so the study showed that household and related waste from the town of Oran produces a significant volume of biodegradable waste that can be recovered by composting. The findings of this study can help to identify safe, and long-term solid waste management systems.

Keywords: Household, Waste, Characterization, Population Growth, Municipal Solid Waste, Waste Sorting.

1. INTRODUCTION

The growth in population, the emergence of new materials and packaging culture, the emergence of socio-economic activities, and changes in lifestyle and consumption, have greatly favored urban Growth of the population, the advancement of socio-economic practices, and improvements in lifestyle and use lead significantly to the production of urban waste. In Algeria, there were 10.6 million tons of waste generated in 2010 [1], 11 million tons produced in 2014, and 14 million tons produced in 2017 (national waste agency).

In Algeria, as in other developing countries, the population is growing faster in major cities and affects waste development in urban regions, which needs a great deal of investment in the disposal and/or treatment and therefore contributes to the contamination of municipal landfills and landfill sites, thereby exposing people and the atmosphere to many hygiene and sanitation issues, such as leachate production. This last is a liquid that contains higher levels of contaminants in young landfills than in old ones [2]. The waste management status represents not just the amount of garbage output but also the quality of the problem's preservation at the level of the responsible authorities.

More than 3000 so-called unregulated landfills were reported by the Ministry of the Environment, covering a region of more than 150,000 hectares and generally located on agricultural land or by rivers [3], and prior to 2012, urban waste management in Oran was restricted to illegal dumping [4]. The objective of this study is to see the development of waste management in urban areas in recent years (2012/2019) and to see factors that affect the quantity and nature of waste output in the western Algerian city of Oran. Which should aid in successful decision-making upon on current situation.

2. MATERIALS AND METHODS

2.1. Study Area

The state of Oran is an Algerian regional district situated in the northwest of the country with a total area of 2,114 km^2 and a population of 1,454,078 in 2008. It has a Mediterranean Sea climate with an average temperature of 34 °C. Oran reflects Algeria's economic center owing to its significant strategic position and the resources it includes. It comprises two operating dams, a container terminal, an oil terminal, 13 clinics, four large manufacturing centers, three universities, and more facilities.

2.2. Population Growth Evolution in Oran

The western statistics center of Oran has carried out demographic surveys during the past ten years [5].

2.3. Evolution of Waste Generation and Composition in Oran

The waste generation data were obtained from the EPIC CET ORAN database for the years 2012/2018. Four double waste characterization campaigns (two for each

season) in conjunction with MODECOM [6], and the AFNOR Guideline (AFNOR XP X30-411) were undertaken during 2017, 2018 and 2019 at the Hassi Bounif landfill on numerous trucks coming from separate sectors of Bir El Djir as shown in Table 1.

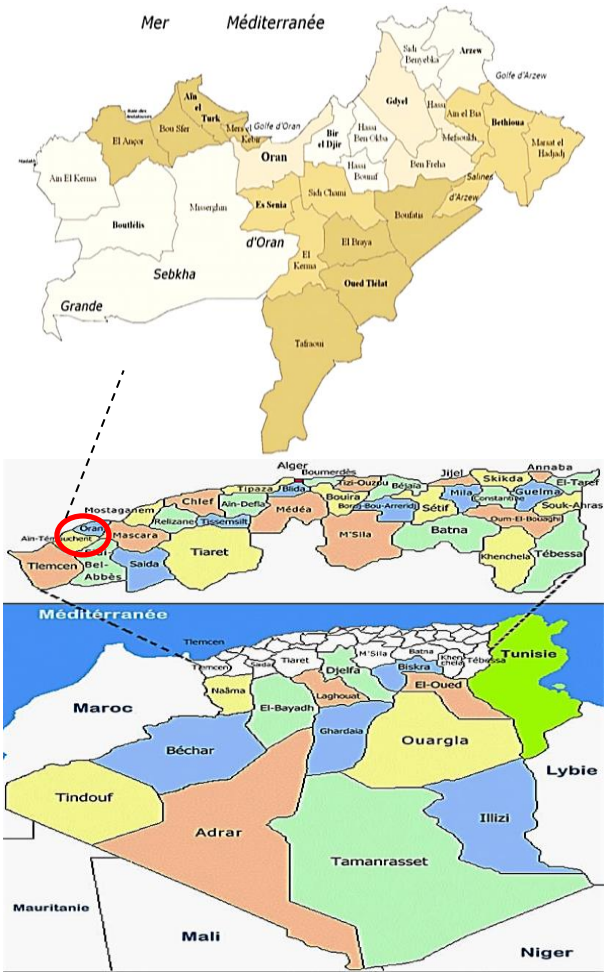


Figure 1. presentation of study area (google images)

Table 1. Time of unfolding of campaigns

Campaign	Period
C1	Winter 2017/2018/2019
C2	Spring 2018 /2019
C3	Ramadhan 2018
C4	Autumn 2018/2019

On the sorting tables planned for this stage, sorting by size followed by sorting by category was realized. A simulation and optimization design of the sorting tables was carried out with the program SolidWorks before their manufacturing (Figures 2a, 2b, 2c).

2.4. Physicochemical Characteristics of Waste

For the physicochemical study, the sorted waste was transported to the laboratory to be analyzed: pH by pH meter, density by weight, moisture content by drying at 105 °C as defined by Afnor NF U 44-171 and organic matter content by incineration at 550 °C as per Afnor NF U 44-160.

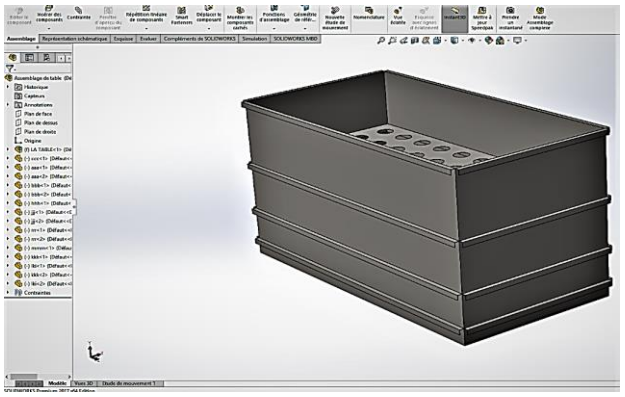


Figure 2a. Sorting tables modeling by SolidWorks

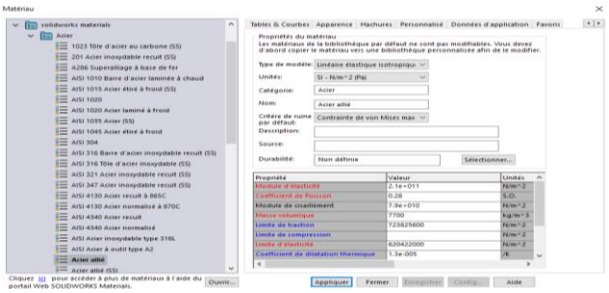


Figure 2b. Choice of sheet metal to withstand a weight of 500 kg

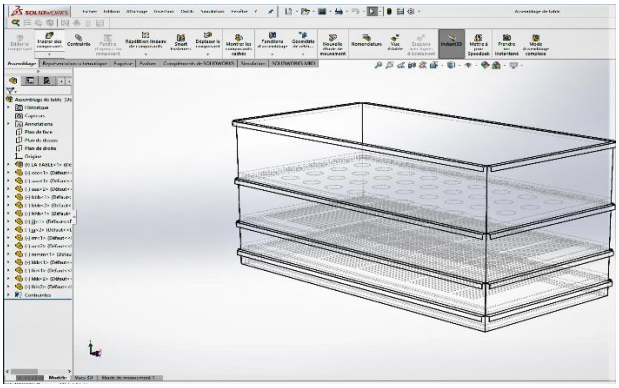


Figure 2c. Floors of sorting table designed by SolidWorks

3. RESULTS AND DISCUSSION

3.1 . Evolution of Population Growth in Oran

The analysis of the evolution of the population in Oran shows a remarkable increase of the population from 1,454,078 people in 2008 to 1,778,824 people in 2018. This increase is explained by two factors: increase of reproduction rate and mutations, development people due to various socioeconomic activities in Oran (Figure 3).

3.2. Land Use

The multi-date satellite images of the satellite pot made it possible to discern shifts in the land use of the state of Oran, which since 1986 [7], has undergone a rather impressive urban development. The findings revealed a net growth of 11.41 percent in built-up land between 1986 and 2004, with an overall decline of 12.23 percent in bare space and a marginal rise in vegetation areas Figure 5 [7]. Also, the most remarkable and visible urban extension is located in the east at Bir El Djir and southeast at Essenia Figure 6 [7].

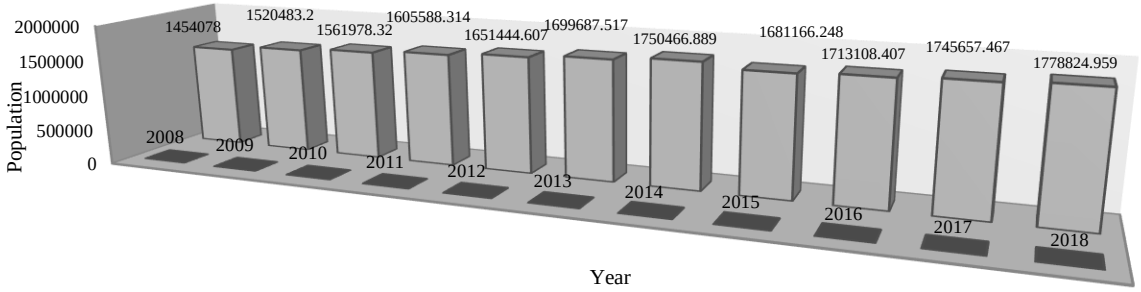


Figure 3. Evolution of population growth at Oran

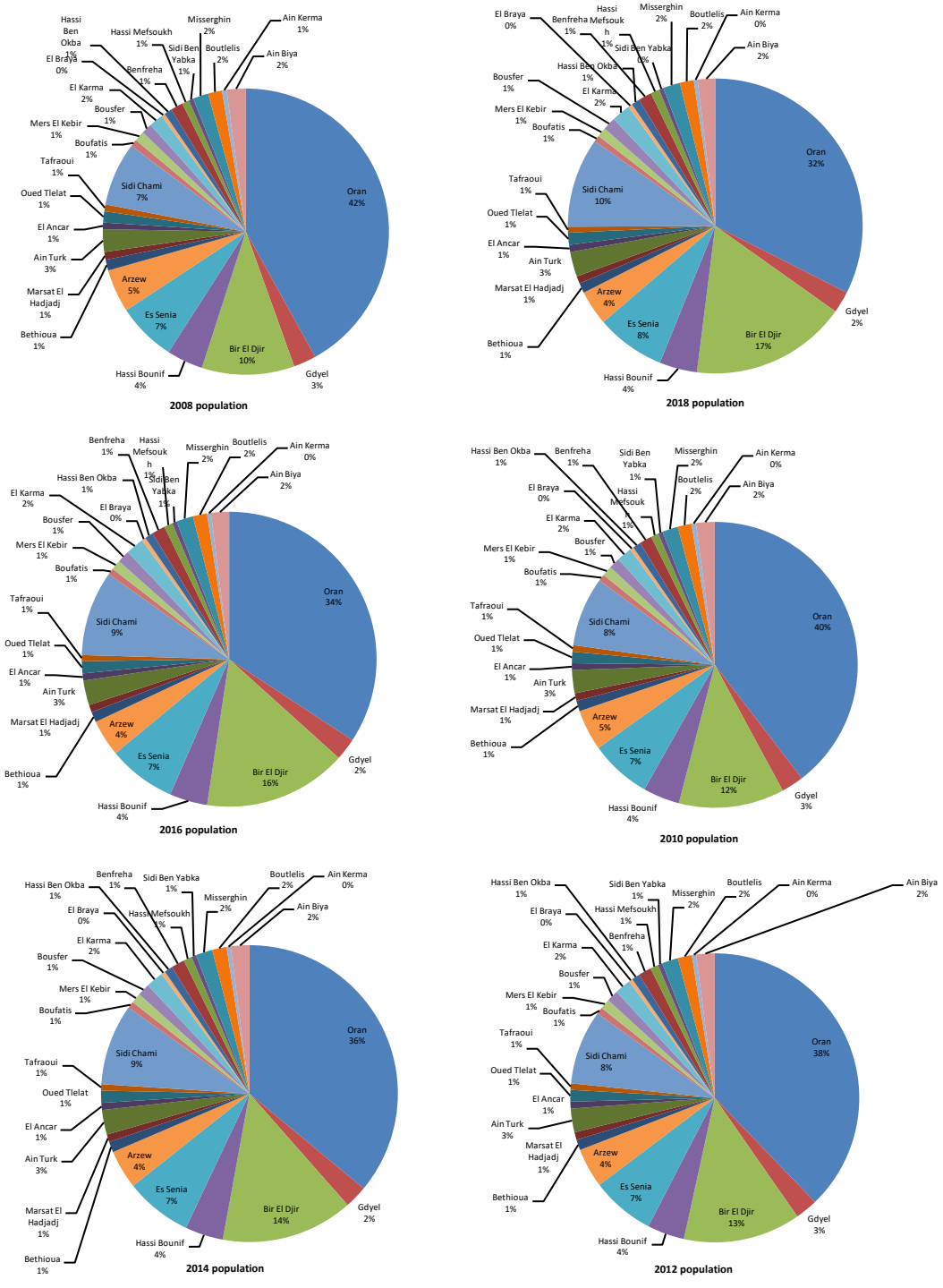
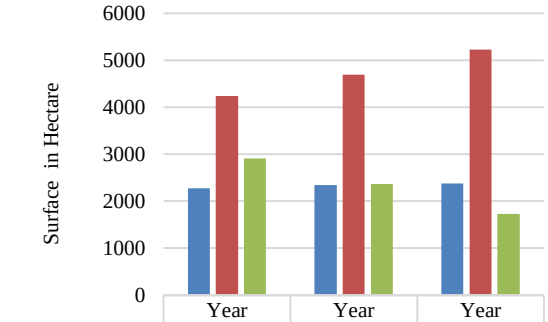


Figure 4. Evolution of population distribution in Oran between 2008 and 2018, Source: Oran statistics center



	Year 1986	Year 1995	Year 2004
Vegetating soil	2278	2348.56	2382.12
Built soil	4241	4693.4	5224.6
Bare soil	2914.48	2369.6	1729.16

Figure 5. Land use of Oran state since 1986 [7]

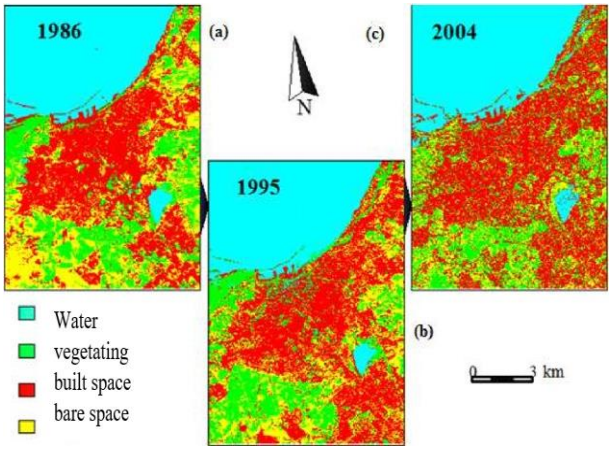


Figure 6. Satellite images of land use between 1986 and 2004 [7]

3.3. Distribution of the Population in Oran

Population distribution indicates a pronounced fall in the municipality of Oran from 42% in 2008 to 33% in 2017 of the total population of the state of Oran and a rise in the municipality of Bir El Djir in the east of the municipality of Oran from 10% in 2008 to 16% in 2017. This rise is largely due to the activities and service transition from Oran Center to other municipality of the province, and also the living cost in Bir El Djir is lower relative to Oran Center; renting and food prices mainly; the rest of the analysis is therefore focused on the Bir El Djir sector so the findings collected would be more descriptive.

3.4. Evolution of Waste Generation and Composition in Oran

3.4.1. Evolution of Waste Generation in Oran

The household waste generation continues to increase every year, the investigation revealed that the balance of the Hassi Bounif landfill was deficient in 2016, which explains the tonnage decreased this year relative to others, but the regular amount of waste generated per inhabitant shows that waste generation is increasing continuously. Hence the overall daily and per person waste generation amount is 0.7 kg.

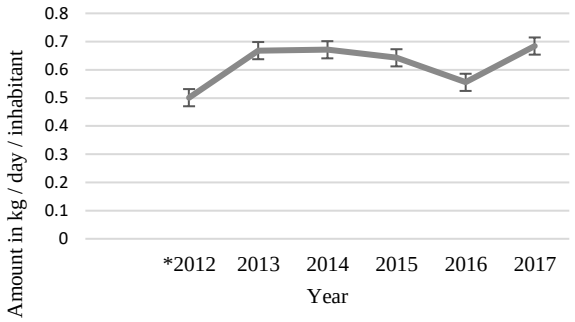
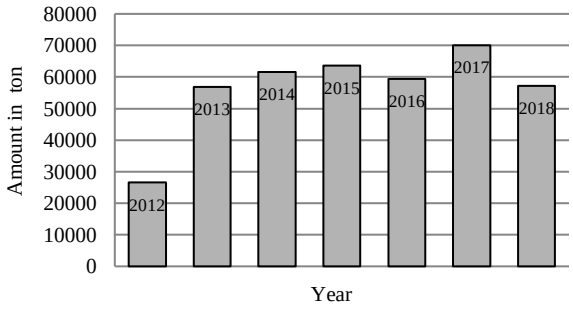


Figure 7. Amount of total yearly produced household and similar waste in Bir El Djir



*Data collected only for 8 months

Figure 8. Daily quantity of produced waste per inhabitant in Bir El Djir

3.4.2. Composition of household and similar waste in the city of Oran

- **Sorting by Size**: The findings indicate that household waste in the study area is usually between 20 and 100 mm in average size; this proportion represents the most plentiful proportion of the four characterization campaigns, The C1 initiative has the largest amount of 61%, accompanied by the C4 with an overall waste rate of 56%; the C2 is the last one with a 51% figure right after the C3 with a 55% rate of average size waste. The rate of waste greater than 100 mm ranges between 29% and 43% across the four seasons; this percentage typically includes a significant proportion of putrescible waste with a prevalence varying from 20% to 36% and plastic waste varying from 22.87% to 40.26%.

- **Sorting by Category:** The waste was collected and sorted according to the mode of characterization of household waste in 13 categories as mentioned in the Table 2. The findings indicate that the waste comprises primarily of putrescible with a total of 42, 56 percent for C1; 57.72 percent for C2; 55.60 per cent for C3, and 55.16 per cent for C4 for the four characterization campaigns. The high levels of putrescible in household waste during all characterization campaigns are clarified by the population's dietary routine and consumption pattern, which is focused on seasonal vegetables and fruits, such as high spring consumption of beans and peas, and fruit consumption such as watermelon, melon cantaloupe, strawberries, summer peaches and also food waste during the month of Ramadhan. These findings are consistent with those of [8] where the rate of putrescible in Chlef varies between 53.2% and 77.2% recorded in summer.

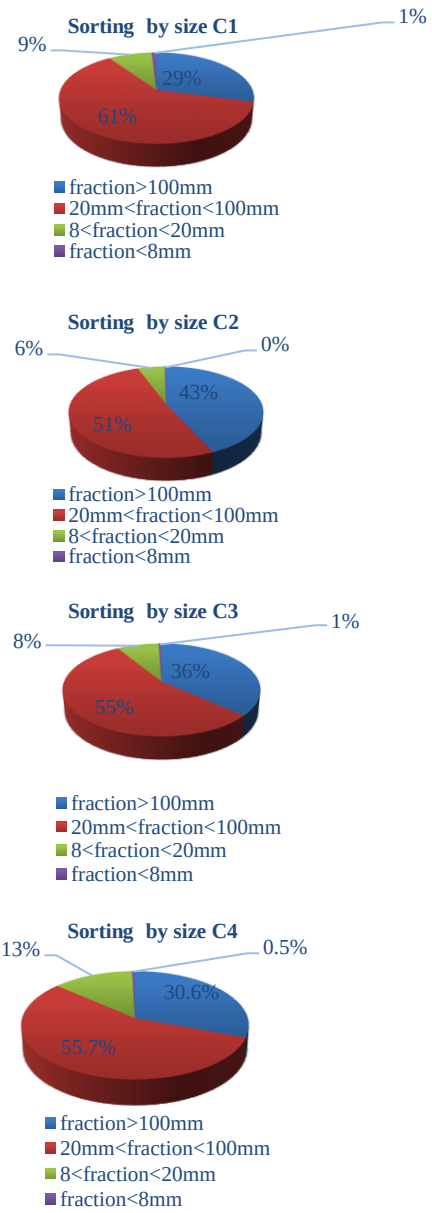


Figure 9. Sorting by size for the four campaigns of characterization of household in Bir El Djir

Thus the percentage of putrescible in Algeria has never reached a value lower than 50% from which the values recorded are: 76% in 2003 in Mssila, 74% in 2004 in Blida, 70% in 2005 to Constantine, 72 in 2006 in Chlef, 57% in 2007 in Algiers [9]and 50.26% in 2018 in Oran (this study).The results are close to those found in developing countries, where the highest value was recorded in Tunisia 68 % [10] Morocco with a putrescible rate of 65% [11], Egypt and Jordan respectively 60% and 56%[10] and Turkey 54.09% [12].

For the developed countries, it is the opposite where the percentage of putrescible in household waste never exceeded 50%: for France 28% [13], Denmark and Italy 29% [14], Germany 14% [14], Japan 30% [15], and an exceptional case for China with a rate of 59.2% [16]. The composition of household waste in Oran between 2012 and 2018 varied between increases for categories and decreases for others (Figure 6); composites, sanitary textiles and metals have increased by 2.13% for composites; which is explained by the increase in the consumption of liquid preserves such as juices, milk, etc. 2% for sanitary textiles which consist mainly of baby diapers which is to the increase in the reproduction rate of citizens and 1% for metals due to the consumption of soft drinks and preserved foods such as jams, fruits in syrup and tomato. The plastic content in household waste has known a remarkable decrease of 12%; this is related to the recovery of plastic waste by the informal before the collection due to its economic value. The putrescible waste remains dominant in the composition of household waste and it comes down to the high consumption of fruit vegetables and breads beside the bad habits of wastage.

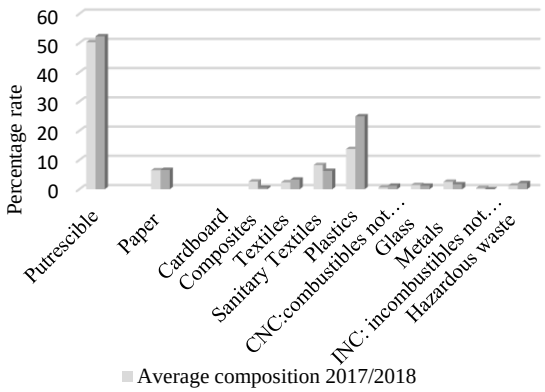


Figure 10. Household waste composition of Oran between 2012 and 2018

Table 2. Sorting by category of household waste from the province of Oran

Categories	Champagnes			
	C1	C2	C3	C4
Putrescible%	42.56674014	57.72811918	55.60475876	55.16328332
Paper %	5.682096498	7.555200851	5.142983036	4.854368932
Cardboard %	3.183933382			
Composites %	2.351212344	2.234636872	2.423441287	3.530450132
Textiles %	3.428851335	1.542963554	2.753910553	1.765225066
Sanitary Textiles %	10.04163605	7.92764033	6.482044503	6.619593998
Plastics	17.87901053	12.18409151	12.19299405	8.826125331
CNC: combustibles not classified %	0.244917952	0.691673317	0.605860322	0.92674316
Glass %	2.00832721	1.436552275	1.321877065	1.05913504
Metals %	2.302228753	2.447459431	1.101564221	4.413062665
INC: incombustibles not classified %	0.612294881	0.133014099	0.363516193	0.485436893
Hazardous waste %	0.146950771	0.532056398	3.965631196	0.441306267

3.4.3. Physicochemical Characteristics of Waste

Figure 11 shows that moisture content is a parameter mainly depending on waste category: its value is greater than 50% for putrescibles, sanitary textiles and paperboard and less than 50% for composites, textiles, fine wastes and very fine waste, energy recovery is not possible for waste with a water content greater than 50% [17]. According to [18], the leaching ability is almost zero for ultra-fine waste which makes the burial of this category an optimal solution.

Knowledge of density helps in conception of collection means and waste treatment units, it is 2 for CNC, 1.5 for INC, 1 for fine waste, 0.8 for ultra-fine waste and textiles sanitary, 0.7 for special or dangerous waste, 0.5 for composites and metals, 0.4 for putrescible textiles and glass, 0.23 for paperboard and 0.11 for plastic; figure 12. The work of [19] indicates that the average density of the household waste in developing countries is of the order of 0.5. This value amounts to the putrescible and

fermentable richness. On the other hand, it is of the order of 0.2 for the developed countries. mainly due to the abandonment of packaging waste such as plastics and cardboard.

Organic matter content is higher than 60% for most categories: 98% for textiles, 93% for sanitary textiles, 92% for paperboard, 87% for composites and 85% for putrescibles Figure 13.

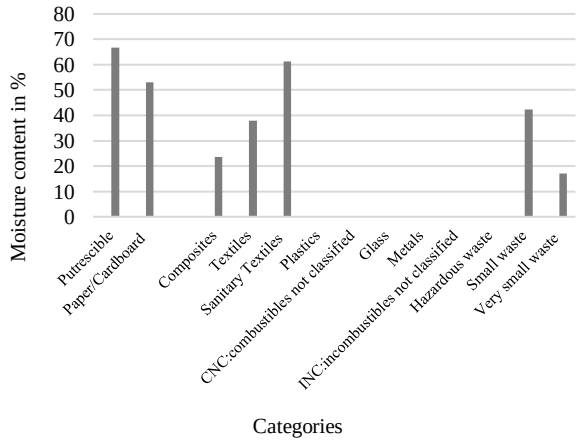


Figure 11. Household waste Moisture content in Oran

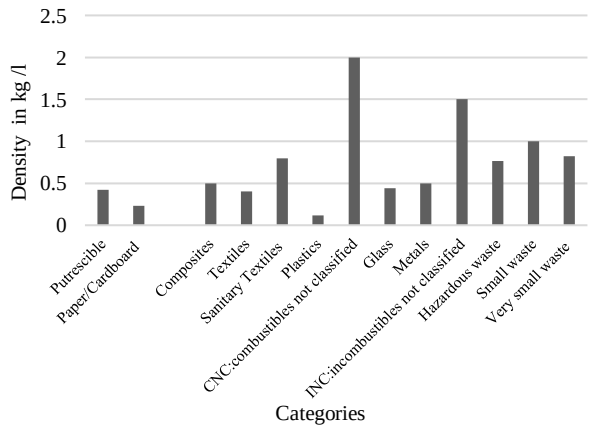


Figure 12. Household waste density in Oran

This means that these categories can biodegrade and be valorized by composting as well as they have a significant pollutant potential (biogas production) in case of burial in landfill [13]. At this point we can understand that the valorization of the putrescible fraction of household waste remains one of the most effective solutions knowing that the residual rate of material by different techniques of treatment is 0% for the treatment by recovery, 1% for the waste to energy technique, 35% for composting and 45% for anaerobic digestion; however, the choice of a mixed treatment system presents the most cost-effective solution [20].

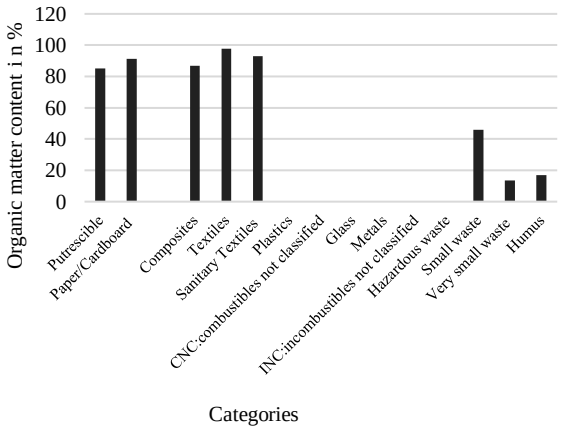


Figure 13. Household Organic matter content in Oran

4. CONCLUSION

This study has shown that the population of state of Oran is increasing more and more each year and is moving towards the Bir El Djir and Essenia sectors; this increase in the population has a direct influence not only on the rate of urban waste generation but also on waste management, which is a real problem in recent years despite the efforts of services in charge, [21] revealed that traditional energy sources are generating enough pollutants and ,thus ,extending the resources of energy using alternative technologies becomes a relevant topic to discuss.

The characterization of the waste revealed that garbage Households are mostly of average size between 20 and 100 mm, this information can help in the design of the waste treatment unit, so the study showed that household waste and similar in the city of Oran contain a large amount of Biodegradable waste that can be composted as a dual-use solution: waste disposal and increased life of the landfill and fertilization of agricultural soils. The most important aspect of this study was that it contains information related to any waste management plan. Indeed, in order to establish a sustainable solid waste management plan, it was essential to determine the composition and characterize the waste. Therefore, the results of this study should contribute to the determination of sustainable solid waste management systems in the long term.

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BIOGRAPHIES

Fatma Zohra Derias was born in Algeria on June 28, 1992. She received the B.Sc. degree in Chemical Process Engineering from University of Boumerdes, Algeria in 2013, and the M.Sc. degree in HSE from the same university in 2015. She is with Institute of Maintenance and Industrial Safety, Algeria as a Ph.D. student and Scientific Researcher since 2016 and as mobility program student in UTM JB, Malaysia since February 2020. Her research interests are in the area of waste management, and environmental studies, valorization of bio-waste and compost. Landfill technologies and renewal energies.

Mokhtaria Mekakia Mehdi was born in Oran, Algeria on April 13, 1964. She received B.Sc. degree in Hydrogeology from Oran University, Oran, Algeria in 1989, an M.Sc. degree in Ecology and Environment from Ibn Khaldoun University, Tiaret, Algeria in 2001, and Ph.D. in Hydrochemistry from Badji Mokhtar University, Annaba, Algeria in 2008. Currently, she is a teacher in the Department of Geography and territory development and a permanent member of a research team at the industrial safety and sustainable development engineering research

laboratory. She is vice-rector in charge of higher education of the first and second cycle, continuing education and diplomas, and higher education of graduation at the level of Mohamed Ben Ahmed University, Oran, Algeria.

Zoubida Lounis was born in Oran, Algeria in 1961. She holds a diploma in petrochemical engineer from the Algerian Petroleum Institute at Algiers, and worked as a design engineer at the Algerian Gas and Electricity Company until 1989. She joined the University of Oran, Algeria as a Researcher since 1989. She obtained Master degree in Materials Chemistry in 1997. In 2007, she obtained the Doctorate at the Chemical Research unit of the University of Reims in France. She was promoted to grade of Professor in 2012. From 2008 to 2014, she held the position of Director in charge of Pedagogy at the University of Oran. Since 2014, she held the position of Director of the Industrial Security and Sustainable Development research laboratory at the University of Oran. From 2014 to 2018, she chaired the scientific council of her faculty. She is the Director of the Doctoral School in the Industrial Hygiene and Safety Process since 2012. She was appointed in 2020 as Head of Science and Technology LMD training at the University of Oran. She participated in the development of several LMD training programs in license, master and doctorate. She also developed around ten research projects, where she held the role of research team leader. She is the author of several publications in the field of catalysis, operational safety and safety assessment. Editor-in-Chief and member of Editorial Board of Algerian Journal of Environmental Science and Technology.