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Physico-chemical Characterization of Household Waste from the City of Tsévié (Togo)

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ABSTRACT---- ***No previous studies have been carried out on the type of waste in the municipality of Tsévié, the capital of the maritime region in Togo. As part of the implementation of the Water and Sanitation project in Togo (PEAT2), two characterization campaigns were carried out on the household solid waste in this city.***
The characterization method used is that of MODECOM (Method of Characterization of Household Waste). This method involves sampling 500 kg of waste on all collected waste. Two types of sorting are carried out. Sorting by size (<10 m, 20-100 mm >100 mm) and sorting by category (13 categories). Since waste varies according to its source, samples are made up of two types: market waste and household waste. The results indicate that the fine and extra fine fractions are the majority with 54.45% in the rainy season and 56.57% in the dry season. These physico-chemical analyses carried out on the waste of the city of Tsévié, constitute a database and allow the local authorities to plan a better waste management in the municipality.

Keywords--- Waste, management, characterization, household waste, management, Tsévié

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1. INTRODUCTION

With an area of 25 km^2, it is located at about 35 km to the north of the capital Lomé. The city of Tsévié has an estimated population of 54,474 according to the 4th general census of population and habitat carried out in 2010. All over the world, the problem of waste is acute. Indeed, some of these wastes contain very hazardous elements to the environment and to human health such as heavy metals[1]. The management of this waste remains one of the most pressing environmental issues for all cities in the world[2]. The main constraints for implementing an effective and sustainable waste management policy are the lack of data on the characterization of municipal solid waste, which is a prerequisite for any management strategy[3]. The management of solid urban waste must be at the heart of the environmental issues that public authorities must face on a daily basis. To our knowledge, no studies have been carried out in the past on the nature and typology of waste in the city of Tsévié. Knowledge of the nature and quantity of a city's rubbish dump is fundamental to optimizing management and establishing recovery and recycling systems.
The aim of this study is to determine the waste typology of the city of Tsévié in order to set up a database to enable local authorities to take objective decisions not only in improving the waste management of the city but also improve the daily lives of the inhabitants.

2. MATERIALS AND METHODS

2.1. Physical Characterization

Physical characterization was performed on the city's household waste. Method of physical characterization used is that of MODECOM proposed by the Agency for the Environment and Energy Control[4]. This method consists of sampling 500 kg of waste on all collected waste. The sorting material used for size characterization consists of a table with three compartments of different sizes: large (> 100 mm), medium (100-20 mm) and fine (20 mm)[4,5]. The fines are separated into coarse (20-10 mm) and extra fine (10 mm) ends. The sorting by categories is done only on waste of grain size > 100 mm and between 100-20 mm. A systematic sorting of ten categories was carried out: putrescibles, paper and board, textiles and sanitary textiles, plastics, glass, metals, unclassified fuels (CNC), unclassified non-combustible fuels (INC), composites and special waste[6]. The equipment used includes: hook scale for weighing, shovels, personal protective equipment, two tarpaulins of 5 m2 and buckets of 50, 80 and
100 L.

2.2. Chemical Analysis of Waste

-The water content is determined on a 10 g sample by drying in the oven at 105°C until constant mass. Moisture is determined by drying in a 105°C oven to a constant weight [7].

-COD is determined according to AFNOR NFT 90-101 by volumetric titration of potassium dichromate ($K_2Cr_2O_7$) of 0.25N normality and 95% purity with Mohr salt solution ($(NH_4)_2Fe(SO_4)_2,6H_2O$) of normality 0.25N and 37% purity.

-The measurement of the Biological Oxygen Demand (BOD_5) is made using a BOD-meter

-Conductivity and pH measurements were performed using a HANNA conductivity meter and pH meter, respectively.

-The ammoniacal nitrogen content of the samples is determined by colorimetric method. It is made using a JENWAY spectrometer. To 50 mL sample, is added 2 mL of Nessler reagent. After 10 min, the solution absorbance is measured at 420 nm.

-NTK nitrogen, the sum of ammonia nitrogen and organic nitrogen, is measured according to AFNOR ISO 11261, June 1995[8].

-Total phosphorus is determined from a 2-step 0.1 g sample[9]. The first step is a sulphuric acid digestion that transforms all the phosphorus present into orthophosphate. In the second step, orthophosphate ions are dosed by a colorimetric analyzer.

-Total phosphorus; ammonium and nitrates are determined using a spectrophotometer.

3. RESULTS

3.1. Granulometric composition of household solid waste from the City of Tsévié

3.1.1. Sorting of Waste by Size

The distribution of waste by particle size makes it possible to have an idea of the methods of waste management. It provides important information that can be used as criteria for choosing the means of transport for solid household waste[10]. The percentage of fine parts varies depending on the state of degradation of the waste and therefore with the age and composition of the waste[11]. Figure 1 shows the distribution of waste by size over the two seasons of the year.

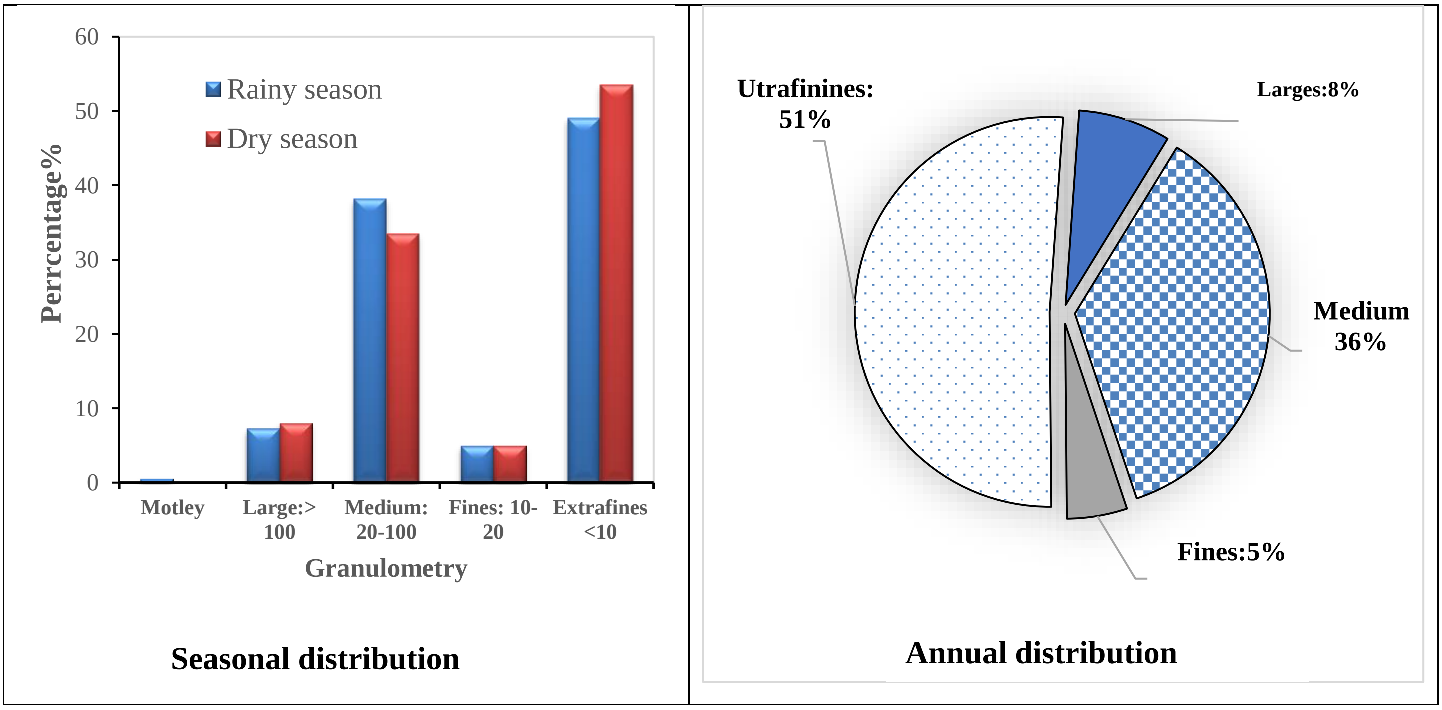

Figure 1: Average particle size distribution of solid household waste in the city of Tsévié

The fine parts (10-20mm) represent the lowest fraction with a rate of 5% for both seasons followed by large (>100 mm) which represent 8% in the dry season and 7.3% rainy season. Extrafines dominate for both seasons with percentages of more than 53.5% during the dry season and about 49% during the rainy season.

3.1.2 Composition by Category

Figure 2 shows the proportions of household waste by category. The extra-fine fractions represent on average 54% in the dry season compared to 50% in the rainy season followed by putrescible 26% in the dry season and 24% in the rainy season. Plastics have a rate of 6.4% in rainy season against 4.7% in dry season, the other categories namely CNC, INC, paperboard, metals, specials have rates below 4%.

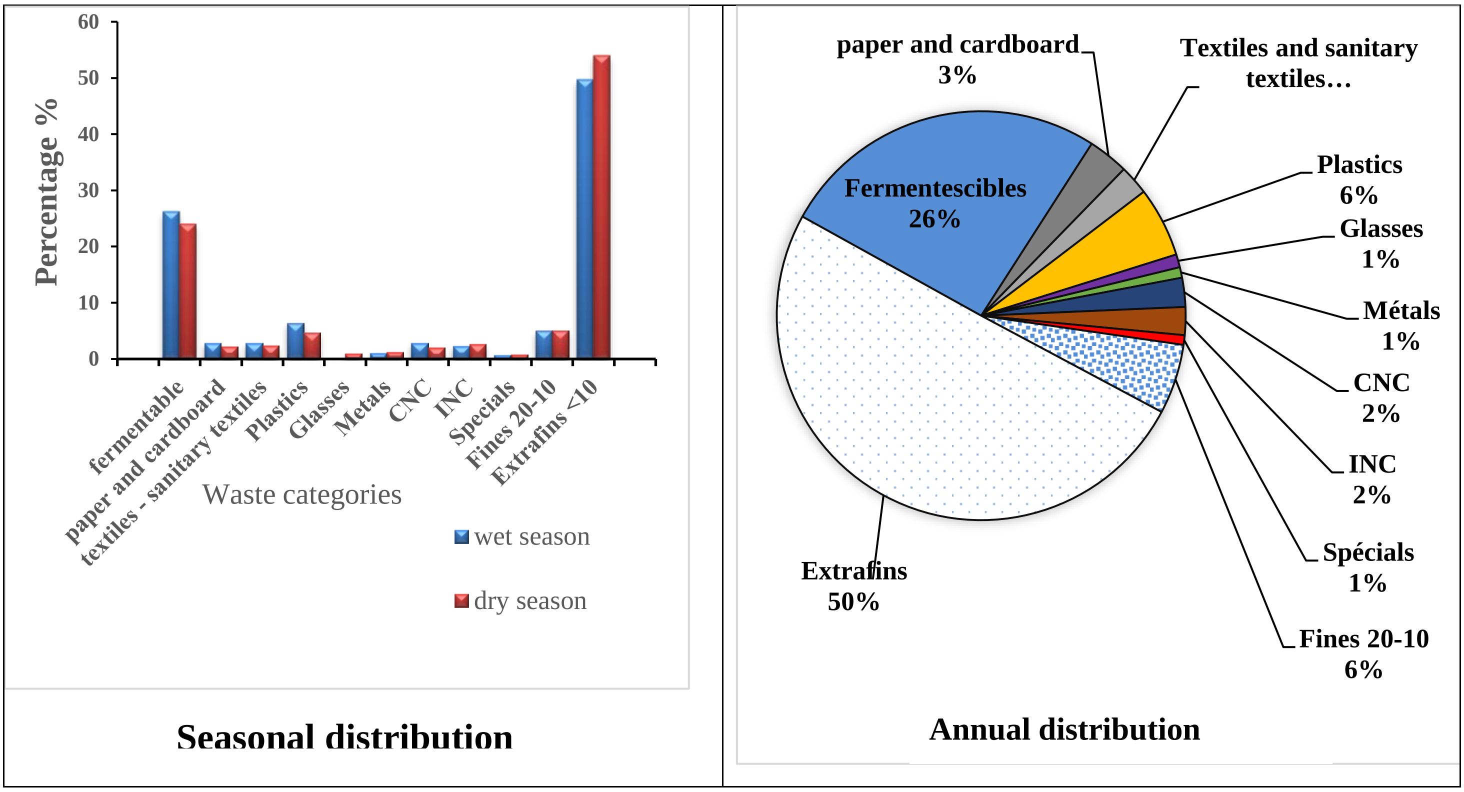

Figure 2: Composition by category of household solid waste in the town of Tsévié

3.2. Composition of Waste from the Tsévié Central Market

3.2.1. Sorting of Waste by Size

The mediums predominate with a percentage of 52% followed by the big ones (24%) and the extrafines (22%). The fine parts are very negligible (2%) and the heteroclites are non-existent. Figure 3 shows the size composition of the waste in the Tsévié central market.

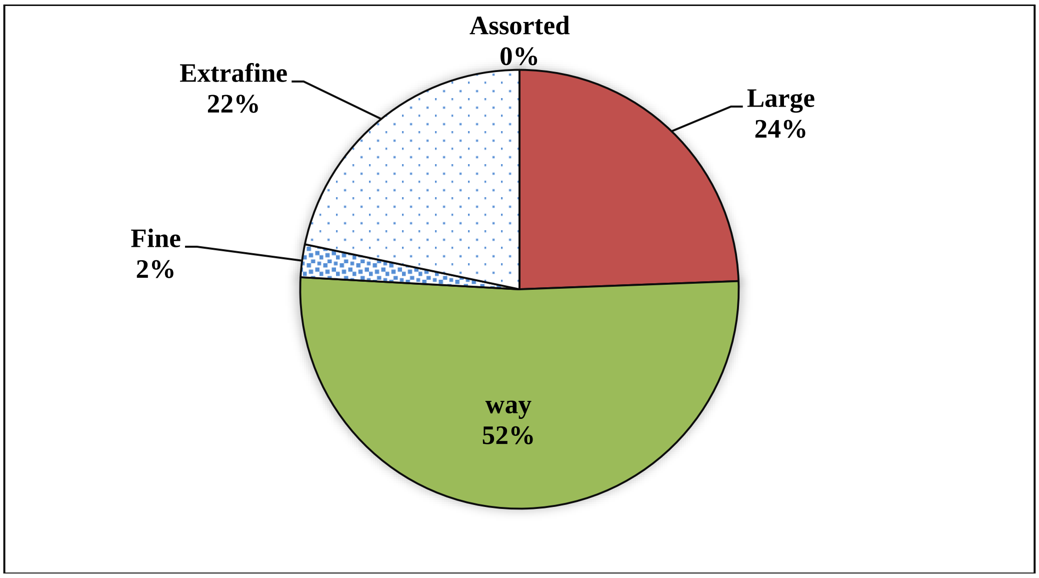

Figure 3 : *Composition from the Tsévié Central Market Waste by Size*

3.2.2. Composition by Category

These results are shown in Figure 4.

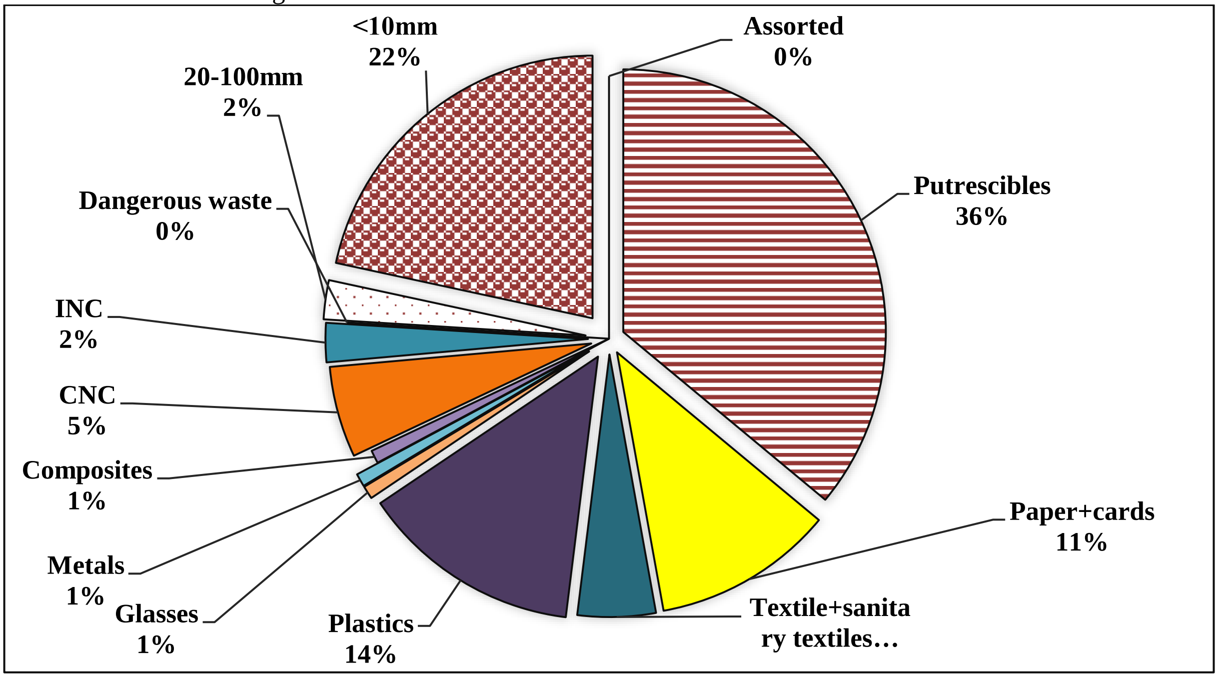

Figure 4 : *Composition by category of solid waste from the Tsévié Central Market*

Putrescibles 36%, extrafines 22%, plastics 13%, paperboard 11%, CNC 6% while the other categories namely metals, composites, INC, textiles and fine have proportions below 5%.

3.3. Physico-chemical Parameters on Waste from the Town of Tsévié

The physico-chemical parameters were determined on the reconstituted waste on the basis of the results of the physical characterization and on certain fractions, namely putrescibles, paper, cardboard, fine and ultrafine. These results are shown in table 1 and 2.

Table 1 : Evaluation of the Physico-chemical Parameters of Tsévié waste

Settings	**Methods**	**Lixiviat1 :Market**	**Lixiviat 2 : Households**
pH	Electrometry	5 ,47	5,56
Conductivity µS/cm	Conductimetry	5390,00	5660,00
Azote total mg N /L		33,80	20,30
Dem.Chim.en oxyg mg O_2/L	Digestion with K_2CrO_7	7200,00	8000,00
Dem.Bioch.en oxyg mg O_2/L	Respirometry	500,00	13000,00
Phosphore total (p) mg P/L	Spectrophotometry	15,30	21,80
Potassium (k) mg/L	SAA	18,70	19,90
Chlorides mg Cl^-/L	Argentimetry	700,80	500,60
Nitrate mg NO_3^-/L	Spectrophotometry	3,70	4,60
Ammonium mg NH_4^+/L	Spectrophotometry	32 ,90	19,20
Nitrite mg NO_2/L	Spectrophotometry	Inf à 0,25	Inf à 0,02520

Table 2: Some Physico-chemical Parameters of certain Waste Fractions

	Wet season			Dry season		
Samples	TH%	pH	Conductivity (µS/cm)	TH%	pH	Conductivity (µS/cm)
Cardboard	24 ,47	8 ,41	2530	15,00	8, 58	1807
Paper	26,00	8,11	2200	8,14	8,20	2140
Putrescibles	64,54	7,34	3570	51,72	7,20	3080
X< 10mm	58,41	8,62	2290	23,00	9,20	6850
10mm<X<20mm	45,41	8,62	2460	15,00	9,25	6860

4. DISCUSSIONS

4.1. Composition of Household Waste

4.1.1. Size Composition

Fine parts (10-20mm) represent the lowest fraction with a rate of 5% for both seasons followed by large (>100 mm) which represent 8% in the dry season and 7.3% in the rainy season (10), by characterizing household solid waste from Abomey Calavi (Benin), has also established that the fraction of waste with a diameter greater than 100 mm represents the lowest proportion in contrast to the city of Kara (Togo) where the lowest fraction is that of large (>100mm)[12]. Extrafines are the majority with percentages of more than 53.5% during the dry season and about 49% during the rainy season. These results are similar to those of the city of Kara where extrafines (10mm) represent 32.89-51.20% of waste[12]. The use of firewood and charcoal would generate ash and coal debris from these fractions. This high proportion of extrafines (10 mm) is also observed in Lomé (Togo) between 46% and 58%[6]. Extra-fine fractions are more important in the dry season than in the rainy season. This is likely due to the fact that low-humidity waste in the dry season is more easily reduced into small fractions[12]. The high proportion of small fractions (10mm) would be due in part to the management and method of collecting waste at the source[13,14]. The waste generated is first disposed of on the ground before being collected and discarded. They are loaded with sand, gravel and other fine particles during the sweep and collection.

4.1.2. Composition by Category

Extrafine fractions account for an average of 54% in the dry season compared to 50% in the rainy season. The decrease in extrafines during the rainy season is due to the low rate of sand collection in households and especially to a leaching of waste by rain[6]. This high proportion of extrafines (10 mm) is also observed, in Ouagadougou (Burkina Faso) 74%[14]. and in Lomé (Togo) on average 46% in the dry season against 56% in the rainy season[6,15]. This high proportion of fines and extrafines could be due to low consumption and/or high recovery in this size. Another explanation is the reduction of large elements into medium and fine fractions during waste handling at the source. Putrescibles are around 26% in the dry season and 24% in the rainy season. On the other hand, the rate of putrescibles is higher in Kara (7.54-10.62%) in the dry season and (9.09-18.22%) in the rainy season[12]. The rate of putrescibles decreased in the rainy season, which may be due to a variation in feeding between the dry season and the rainy season and the beginning of waste degradation. Apart from plastics which have a rate of 6.4% in the rainy season against 4.7% in the dry season, the other categories namely CNC, INC, paperboard, metals, specials have rates below 4%. This low level of plastics and metals reflects the intensity of reuse and/or recycling. As for glasses, they are only thrown out when they are broken, hence their negligible proportions.

4.2. Composition of Waste from the Tsévié Central Market

4.2.1. Composition by Size

Unlike household waste, waste from the Tsevié central market has a different pattern in terms of size distribution. Mediums (100 > waste > 20) predominate for market waste with a percentage of 52%, large (waste > 100) 24% and extrafine (waste > 10) 22%. The fine parts 20 > waste > 10 are very negligible with a proportion of 2%. Heteroclites (Waste size >>> 100 mm), are non-existent. The predominance of large and medium-sized products is due to the fact that most of the market waste consists of packaging waste, which is cartons, plastics and bags of all kinds.

4.2.2. Composition by Category

Putrescibles predominate (36%) followed by extrafines (22%). This could be due to the mode of production and management of market waste. In fact, in the market many foodstuffs are sold but these are mostly made of putrescible materials. Furthermore, a good part of the market is not cemented, food remains, peelings, packaging, plastic bags are usually thrown on the ground and are then heavily loaded with fine sand and gravel. Plastics (13%) and paperboard (11%) come from packaging goods. Apart from the NCCs (6%), the other categories have scopes of less than 5%.

4.3. Physico-chemical Parameters on the Leachate of Reconstituted Waste from the Town of Tsévié.

The whole phosphorus contents of 15.3 mgP/L for market waste and 21.8 mgP/L for household waste appear to be reasonable because they are obtained with raw waste samples. The high chloride ion content (700.8 mgCl-/L for market waste and 500.6 mgCl-/L for household waste) may be due to contamination of the garbage by pesticides found in household waste.

The NTK values obtained (33.8 mgN/L for market waste and 20.3 mgN/L for household waste) indicate that these waste fractions have an average amount of total Kjeldhal nitrogen and may also undergo an amply rapid degradation of biodegradable organic matter if recovered into composting. A compostable waste must have a C/N ratio close to 15 for a sufficiently rapid degradation of biodegradable organic matter to occur[14]. The leachate of this market waste gives a pH value equal to 5.47. That of household waste gives a pH value equal to 5.56. These values indicate an acidic pH, reflecting the start of the degradation of organic matter in household waste.

The conductivity measured in the leachate of market waste is 5390 µS/cm and that of household waste is higher and is 5660 µS/cm. These two values (5390 µS/cm 5660 µS/cm) indicate that the ions are mobilized in solution by the phenomenon of leaching (120 h). The solubilization of ions increases with the contact time with the leaching juice. This great solubilization implies a strong mineral charge in this garbage. This would be related to the composition of the waste especially the extrafine fraction which is generally representative. Indeed, physical characterization has shown that extrafine fractions are essentially mineral and therefore can mobilize charged compounds. The gradual acidification of the solution will promote the solubilization of ions and will be accompanied by an increase in conductivity.

The high conductivity content is correlated with the acid pH. Thus, after 120 hours of leaching, the observed behavior is the gradual introduction of an increasingly acidic medium (5 pH 7) indicating a slightly acidic phase biodegradation process[16]. Comparing these results with those of the literature, we find that the values obtained are within the conductivity range of household waste, 2500 - 25000 µS.cm-1[17].

The COD which reflects the state of degradation of waste has a value of 7200 mgO2/L for market waste and 8000 mgO2/L for household waste. This high mobilization of organic compounds is characteristic of a fresh waste dump[18].

BOD5 quantifies the level of biodegradability of leachates. This is the amount of oxygen consumed for 5 days by micro-organisms during degradation of organic matter at 20°C and in darkness. The measured BOD5 (65mgO2/L) is high and indicates that waste has a very easy capacity to release organic pollutants. The direct exploitation of the quantities of COD and BOD5 involved by the fractions led to the conclusion that this waste contains a highly reactive organic matter.

The quantities of ammonium ions (NH_4^+: 6.7 mg NH_4^+/L) and nitrates (NO_3^- : 6.3 mgNO_3^-/L) released by this household waste remained very low compared to that of total nitrogen Kjeldhal (NTK). The amount of total nitrogen in the solution after 120 hours reflects a resumption of biological activity that converts some of the nitrogen into volatile compounds containing nitrogen.

It thus made it possible to assess the reactivity of the waste by promoting access to the composition and quality of the organic matter released and to facilitate a follow-up of the resumption of biological activity over a period of 120 hours. The set of global parameters used to characterize organic matter in test solutions has shown that these wastes will develop long-term processes of degradation in their receiving environment. The monitoring of the evolution of nitrogen species released in the solutions also confirmed this biodegradation behavior.

The elements N, P and K found in this garbage are the main nutrients needed for crop production. Unless there is a high specific need on the part of certain plants or marked deficiencies of the soil, the contribution of these three elements in addition to magnesium would help to cover the needs of fertilization of the crops. This demonstrates that the waste from the town of Tsévié can be used to produce compost as an organic alternative to reduce the excessive use of chemical fertilizers.

4.4. Physico-chemical Parameters on some Waste Fractions in the City of Tsévié.

Moisture: We note that moisture is not uniform and depends on each type of. Moisture plays a role in the biological activity of the soil and in the production of acidic or complexing substances resulting from the biodegradation of organic matter. It also influences the process of precipitation and solubilization of mineral elements[19]. According to the results (Table 2), putrescibles have a much higher moisture content than the other waste fractions studied 64.54% (rainy season) and 51.72% (dry season). The fraction of fines (10mm <X< 20mm) has a humidity of 45.31% in rainy season compared to 15.21% in dry season. Ultrafinines (X<10mm) 58,41% in rainy season against 23% in dry season. Papers 26% in rainy season against 8,14% in dry season. Cartons have a moisture content of 24.47% in the rainy season compared to 15% in the dry season. The overall humidity of Tsevié household waste is 47.58% in the rainy season compared to 19.45% in the dry season. This low rate would be due to the low quantity of putrescibles despite their high-water content. Decomposition of organic matter is inhibited in the dry season when the moisture content is below 20% and remains in the optimum range in the rainy season [20,21].

The results recorded in Table 2 show the pH values above 7. This may be related to the high content of extrafines, which contain a lot of ash. The pH of reconstituted waste is very close, but slightly lower than that of fine fractions. The pH values in reconstituted waste (7.24 – 9.25) do not differ significantly according to the seasons. But the pH of the fine fraction reveals a dilution effect in rainy seasons[22].

Electrical conductivity is a measure that gives an approximation of the concentration of soluble salts in the sample. The values of electrical conductivity measured in the waste samples in our study vary between 2020 and 3570 µS/Cm in the rainy season and between 1807 and 6860 µS/Cm in the dry season. These results compared to those of the literature show that the values obtained are within the conductivity range of household waste, 2500 - 25000 $\mu S.cm^{-1}$ [14].

5. CONCLUSION

The results of the physical characterization show that the fraction of fine and extra fine represents a large part of household waste, which is average 57.54% in the dry season and 54.45% in the rainy season. As for waste from the Tsévié central market, putrescibles account for the largest proportion, 36%, fines and extra fines which account for 24% of the waste produced. In view of the diversity of waste in the city of Tsévié, it is essential to promote the recovery channels, for no single treatment channel can fully support all waste. The important share of putrescibles requires that they be converted into compost or biochar for added value in agriculture or energy. More efficient management techniques and an adequate scanning system will reduce fine fines and extras that are nothing but sand. Recycling plastics will be an asset to reduce their pollution in the city. The direct exploitation of the quantities of COD and BOD5 involved by the fractions led to the conclusion that this waste contains a highly reactive organic matter.

6. ACKNOWLEDGEMENTS

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