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Treatment and Valorization of Leachates from Controlled Landfills by Composting the Fermentable Fraction of Household and Assimilated Waste

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Abstract: Leachate generated by urban waste is one of the significant constraints of landfill management. Because of their pollutant load, it poses a threat to the environment and human health. It is, therefore, imperative to contribute to its elimination. This work consists in proposing a reliable and feasible solution based on an integrated research and development approach that respects the concept of 3R (reduction, recycling and reuse). The solution is to use leachate instead of water in the composting process of the organic fraction of household waste. A platform was built on the site of the Mohammedia landfill, located near the city of Rabat, the Moroccan capital, to conduct an experimental study on 30 tons of household and similar waste (HAW). The sorting operation allowed to separate the fermentable fraction of 58.26%. Leachate stored on-site was used for composting. The results found that the composting process caused the consumption of about 8.1 m^3 of leachate and the production of 5.85 tons of compost at 9% moisture.

Keywords: Landfill management; sorting operation, fermentable fraction; leachate elimination; composting process.

1. Introduction

The amount of solid waste generated in Morocco, as is the case in all developing countries, poses a severe threat to the environment and public health, given the fact that the current conditions of collection, transportation, landfilling or recycling of this waste are insufficient [1].

It is well known that leachate from urban waste is one of the significant constraints for the management of landfills. In fact, because of their pollutant load, they represent a threat to the environment and human health [2-4].
Water is the primary vector of landfill leachate evolution. Inputs to a storage center consist of direct rainfalls plus water supplied by the waste.

The chemical and biochemical compositions of leachate are not only very diverse but also variable in time and space. More than 200 families of organic compounds have been identified in numerous studies on the characterization of leachate in waste disposal centers [5]. Among them, cyclic or aromatic carbon compounds but also alcohols, ethers, ketones, acids, phenols, phthalates, furans and finally nitrogen compounds, sulfur and phosphorus [6].

Of all these molecules, some, such as chloro- and dichlorobenzene, toluene, styrene, naphthalene and xylenes, are recognized as priority pollutants and pose a serious threat to the environment.

It should also be noted that the physicochemical quality of leachate depends on many factors such as the mode of operation of the repository (the management of the site, its topography, its geographical location and the degree of compaction of the waste). It also depends on the seasonal climatic variations (precipitation, humidity,

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evapotranspiration ...), but especially the nature of stored waste, and their stage of evolution (age) [7-11].

Depending on the stage of the biological evolution of the waste, three types of leachate were distinguished (Table 1):

- Young leachate: characterized by a relatively biodegradable high organic load. These leachates can be loaded with metals (up to 2 g/L) because of their relatively low pH (<6.5).

- Intermediate leachate: As the waste stabilizes, the organic load decreases and volatile fatty acids (VFA) become scarce in favor of compounds of high molecular weight. The emergence of these compounds tends to decrease the biodegradability of the leachate. As a result, the pH is close to neutral, and the metal charge becomes negligible.

- Aged or stabilized leachate: characterized by a low organic load, composed mainly of humic substances (fulvic and humic acids). Also present are compounds of low molecular weight just as refractory to biodegradation.

Table1. Temporal evolution of chemical and physicochemical characteristics of leachate [12,13].

	leachate young	Intermediate leachate	Stabilized leachate
Age (year)	<5	5–10	>10
pH	<7	=7	>7
COD (g O_2/L)	>20	3–15	<2
BOD_5/COD	>0.3	0.1– 0.3	< 0.1
	80 % Volatile Fatty Acids (VFA)	5–30 % VFA + Humic and Fulvic Acids	Humic and Fulvic Acids

Also, leachate flow control consists first of all in confining waste to prevent groundwater pollution, then collecting leachate, storing them and then treating them. Leachate can only be released into the natural environment after treatment and provided that its composition complies with the regulatory rejects values.

In Morocco, the amount of household and assimilated waste (HAW) currently stands at 8 Mt/yr [14] with a collection rate of around 90% by 2020 and to have only landfills controlled by the National Household Waste Program (NHWP). The quantities of HAW and leachate produced at certain landfills in Morocco are given in Table 2.

Leachate produced in Moroccan landfills is characterized by very high COD, BOD_5, conductivity values [14], and pathogens which means that these leachates must be cleaned up before any use/reuse or direct discharge into the natural environment.

In addition, leachates are rich in pathogens, which also requires hygienization before they are rejected [15-17].

Table 2. Quantities of HAW and de leachate produced at different Moroccan public landfills [7,8,18-20].

City	HAW t/day	HAW t/year	Leachate m^3/day	Leachate m^3/year	Leachate / HAW m^3/t
Agadir	360	131.400	150	54750	0.42
Tangier	572	208.780	262	95630	0.46
Fez	900	328.500	360	131400	0.40
El Jadida	425	155.125	156	56940	0.37
Rabat	1792	654080	480	175200	0.27
Casablanca	3800	1387000	1400	511000	0.37
Oujda	418.8	152862	100	36500	0.24
Meknes	554	202210	271	98915	0.49
Mohammedia	500	182500	180	65700	0.36

Leachate treatment techniques are manifold [15,21,22], including:

- Physico-chemical method: oxidation by ozone or hydrogen peroxide, coagulation, concentration, precipitation, evaporation, forced evaporation and evaporation-incineration;

- Membrane separation method reverse osmosis, nano-filtration and ultra-filtration;

- Biological method: aerated lagoons, fixed culture and membrane bioreactor;

In Morocco, at present, several experimental leachate treatment studies have been carried out but the results have not been satisfactory, we quote below some examples:

Oum Azza landfill (Municipality of Rabat) of 100 hectares managed by the PIZZORNO company produces 480 m^3/d of leachate from 1792 t/d of HAW [19]. These leachates are treated according to the reverse osmosis process, with a cost of treatment of 214 DH/m^3 of leachate. However, the treatment concerns only 10% of the total volume of leachate in addition to the concentrate resulting from this treatment still poses problems.

Landfill of Fez city of 110 hectares managed by the ECOMED company produces 360 m^3/d of leachates from 900 t/d of HAW or 328.500 t/year of HAW [2,7]. The solution consists of forcing the evaporation of the leachates by exploiting the heat produced from the biogas, and the residual sludge is returned to the landfill.
Besides, the start-up of this evaporator has revealed other disadvantages:

- Foaming
- Toxic gas emanation
- High energy consumption

The landfill of *Agadir city* covers an area of 41 hectares, managed by TECMED company for a dozen municipalities with a production of 360 t/d of HAW and 150 m^3/d of leachate. The natural evaporation envisaged to eliminate this effluent by a system of recirculation and sprinkling did not lead to satisfactory results. Indeed, during the last six years of exploitation, a quantity of only 155.380 m^3 was eliminated by this process, the equivalent of barely three years of leachate production.

In the light of all that has been achieved at national and international level [23] and given the current state, our contribution, in the framework of this project, is to propose other alternatives to manage these leachates generated within the controlled landfills in Morocco.

This project consists first in a selective sorting of the HAW and a collection of the young leachate, then after the composting of the fermentable fraction (FF) by using the leachate collected during the first stage as process water of composting.

By taking into account the context and the stakes, this article covers all the technical and technical-economic aspects according to an integrated R&D approach to the 3R concept (reduce, recycle and reuse).

This research and development work was realized in the laboratory of the National School of Mines of Rabat (ENSMR) in collaboration with the State Secretariat for Sustainable Development and the laboratories mentioned above. The running parallel pilot tests in the controlled landfills of Mohammedia and Oum Azza, were done to propose a reliable and feasible solution for the treatment and valorization of leachates in Morocco.

2. Material and Methods

An active public dump located about 7 km from the center of ben yekhlef, Morocco had been selected for investigation. The area of the landfill covers 47ha and concerns the following municipalities: Mohammedia, Beni Yakhlef, Echellalate, Benslimane, Bouznika and Mansouria, with a population of 409,000 inhabitants. 500 tons of solid wastes are being disposed daily at this site and the leachate generated are stored in evaporation ponds, the volume produced each day is estimated at 180 m^3 per day.

In this study, raw leachate samples of 200 L were collected from the artificial pond in 25 L polyethylene bottles, transported to the laboratory and stored at refrigerator before being analyzed and used as process water of composting.

The study of the composting process of the fermentable fraction (FF) was carried out initially for a quantity of 770 kg of HAW on the site of the ENSMR and in a second time for a larger quantity of 30 tons of HAW on site of the landfill.

In order to separate by class the waste and determine the weight of each category: fermentable material, paper, plastic, textile, glass, metals, we manually carried out sorting three samples of 100 Kg.

2.1. Preparation of composts

Aerobic composting on a sealed surface was retained. This technique is simple and adapted to the amount of material to be treated. A platform of 100 m^2 (10 m × 10 m) is built of concrete to avoid losses of soluble elements leaching during watering (Figure 1). It is sloped to allow the flow of excess water (leachate) to an evacuation view (Figure 2).

Figure 1. Photografy of platform under construction

Figure 2. Photografy of leachate collection basin

Samples were manually sorted and the fermentable fraction is packed into piles for composting. During composting, the pile was aerated to provide oxygen and mix the substrate to avoid the anaerobiosis source and create a biotope favorable to the development of the composting process.

Monitoring of the process consisted of regular measurement of the pile temperature (every 2 days), the humidity (at each reversal), the pH (every week) and the C/N ratio (every 2 weeks), pile temperatures were measured with the aid of an electronic thermometer equipped with an 80cm penetration probe. The evolution of the moisture during composting was followed by sampling during the return of samples which are weighed and then dried at 105°C up to constant weight. The pH of the samples is determined on an aqueous suspension at a ration S / L of 1/5 [24]. An analysis of the evolution of physicochemical parameters, coupled with the sensory approach, in particular odour and colour, enabled the maturity of the composts to be estimated.

2.2. Evaluation of some agronomic characteristics of composts.

The laboratory compost sample (0.5 kg) is a mixture of six (quartering) samples taken at mid-depth and at different locations in a pile in order to obtain as representative a sample as possible. The moisture content is determined after drying at 60 °C in an oven to constant weight (to avoid deterioration of organic compounds and loss of evaporation of mineral elements). The water retention capacity (CRE) is determined by dropwise elution for 48 h [25]. Part of the dried samples was manually crushed and sieved to 2 mm for chemical analysis.

The electrical conductivity (EC) and the pH are determined on a 1/5 aqueous extract of the milled dry matter, after 15 minutes of magnetic stirring. Total organic matter (loss on fire 550 ° C for 4 hours), total organic carbon, total nitrogen Kjeldahl, total phosphorus (perchloric acid attack), assimilable phosphorus have been performed per national and international standards. The total concentrations of K, Ca, Mg, and metallic trace elements (Cu, Zn, Cd, Ni, Pb) were determined by atomic absorption spectrometry, after mineralization of a compost sample with a mixture of HNO_3, $HClO_4$ and HF, and residue recovery with HNO_3 and HCl (SAA, 2003).

2.3. Measurement of stability and maturity of elaborate composts.

For stability and maturity, Haug [26] provided a subjective, yet practical definition: "the point at which the rate of oxygen consumption is reduced so that anaerobic or odorous conditions are not produced to the extent that they cause problems with storage and end-use of the product."

The stability of the compost is determined by measuring the variation of the temperature of a humidified compost sample placed in a thermos as a function of time.

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3. Results and Discussion

3.1. Characterization of leachate

The results of the physical and chemical analyzes of leachate are presented in Table 3.

Table 3. Characterization of leachate from Mohammedia landfill.

Parameter	Mohammedia **May 2016**	**GRLV* N° 6199 du 28/10/2013**
T (°C)	24.4	30
pH	7.14	5.5 – 9.5
SM (mg/L)	142	100
Conductivity (mS/cm)	35	2.7
COD (mgO$_2$/L)	56640	500
BOD$_5$ (mgO$_2$/L)	2173	100
NTK (mgN/L)	11844	40
NH$_4^+$ (mgN/L)	4763	--
Chlorides (g/L)	6.45	--
PT (mgP/L)	37	15

* General Release Limit Values to Surface Water or Groundwate

Leachate analyzes show waters with high concentrations of COD, BOD_5, Kjeldahl nitrogen (NTK), ammonium (NH_4^+) and total phosphorus (P)… which exceed the standards for direct discharges into the natural environment.

The BOD_5 has a value of 2173 mg/l, and the COD is 56640 mg/l, the ratio BOD_5/COD = 0.038 indicates that the leachates taken is of stabilized type and it was in the ripening phase. This finding is confirmed by the pH value above 7, pH of the stabilized leachates (Table 1).

The concentrations of Kjeldahl nitrogen (NTK), ammonium (NH_4^+) and total phosphorus (P) for the leachate sample in our study are respectively 11844 mg/l; 4763 mg/l; 37 mg/l. The presence of the NTK is due to the phenomenon of mineralization, which is a process of transformation of organic compounds into mineral compounds so a part of the organic nitrogen which has turned into mineral nitrogen.

The average electrical conductivity at 20 °C is of the order of 35 mS/cm, indicating strong mineralization of leachate, which is most probably due to chloride ions (6450 mg/L).

3.2. HAW Composition

Knowledge of the composition of waste is essential in order to assess the potential for recovery such as composting, the recovery of metals or other recyclable materials: paper, cardboard, glass, plastics, and to size the processing facilities.

Table 4 shows the results of the composition by category of waste for the study area. It appears that the household waste produced in this landfill contains a large part of organic matter (58.26%), followed by plastics (12.73%), textiles (3.26%), Carton and paper (7.47%), Glasses (1.34%), metals (0.87%), rubble (0.58%). These findings obtained confirm previous studies that show that organic matter is found in large quantities in household waste produced in most cities in Morocco [27].

It should be noted that the lower values in percentage composition of metals and glasses fractions is due to the development of recycling and reusing practices during the last decade.

The relatively high percentages of paper and plastic fractions can be explained by the source of these materials, which is mainly related to the industrial, commercial or administrative activity.

Table 4. HAW Composition of the Mohammedia landfill.

Fractions			**Percentage**		
COMBUSTIBLE PART	Plastic	PET with cap	1.34%	12.73%	38.76%
		High Density Polyethylene (HDPE) & Polypropylene (PP)	0.81%		
		Low Density Polyethylene (LDPE): plastic bags	10.58%		
	Carton and paper		7.47%		
	Various fuels		7.52%		
	Baby diapers		5.95%		
	Tetra Pack Carton		1.18%		
	Textiles		3.26%		
	Wood		0.37%		
	Shoes and elastomer		0.28%		
Fermentable organic material			58,26%		58.26%
METALS	Iron Aluminum		0.64%		0.87%
	Aluminum		0.19%		
	Aluminum powder		0.04%		
VARIOUS WASTE	Glasses				1.34%
	Waste demolition				0.58%
	WEEE				0.10%
	Medical & Pharmaceutical Waste (MPW)				0.06%
	Battery				0.02%
Total %			**100%**		

3.3. Compost preparation and characterization

3.3.1. Laboratory test

A sample of 770 kg of HAW from the Mohammedia landfill is manually sorted. The fermentable fraction (462 kg) is packed into piles for composting — the daily record of temperatures allowed to delimit the volume of the piles and the periods of reversal.

The reversal frequencies, temperatures and volumes of leachate used in the laboratory test are given in Table 5.

Table 5. Evolution of the parameters studied in the composting operation during the period March, April, May and June (laboratory test).

Turnaround	Pile temperature (°C)	Consumed volume of leachate (L)
1st day	35	0
3rd day	38	0
14th day	42	30
21th day	43	30
28th day	43	55
35th day	50	55
42th day	53	40
44th day	58	0
60th day	58	40
64th day	66	0
70th day	58	0
77th day	54	0
120th day	30	0

The records indicate that the temperature increased slightly to around 38 °C on the 3rd day and around 58°C on the 44th day (Figure 3) From there, it remained almost constant until the 60th day signaling a slowdown or even a stop of the process of degradation of the biomass. At this date, the head had the 4th turnaround to revive the microbial activity. From the 60th day to the 64th the temperature increased by eight units from 58°C to 66°C. This increase corresponds to the recovery of the activity of decomposing microorganisms. It began to decrease to 30°C on the 120th day.

The increase in temperature during composting is a good indicator of the evolution of biological reactions. During composting, the microorganisms degrade the biodegradable organic materials and the energy contained in the chemical bonds of the compounds is released, thus causing an increase in the temperature of the heap [28].

Measurements of the temperatures recorded during the composting process indicate that the composting of the heap (FF) takes place in four phases: mesophilic, thermophilic, decreasing and stabilization whose maximum temperature reaches 66°C, which is similar to that described by Rashad and all. [29].

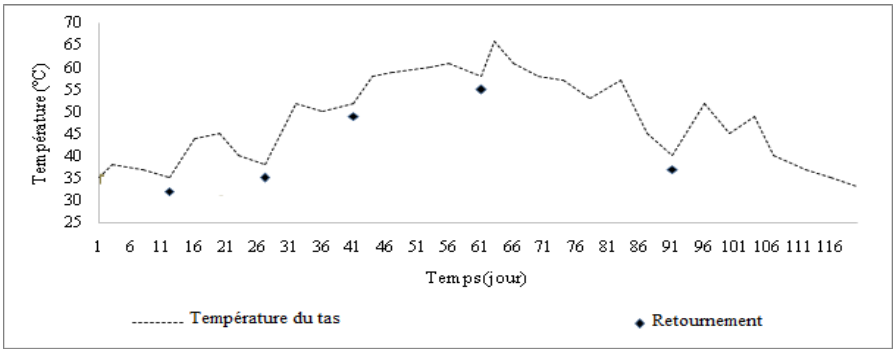

Figure 3. Evolution of the temperature during the composting of FF

The test showed that the watering of the fermentable fraction, by leachate during March, April, May and June with 10 turnarounds, consumed about 250 liters of leachate and gave a quantity of compost of 325 kg. This test allowed us to better understand the composting parameters, but above all it showed that the composting operation of the fermentable fraction of the HAW of the Mohammedia landfill required the use of the equivalent of 325 liters of leachate/tonne of HAW, corresponding to an absorption of almost 90% of the leachate produced at this landfill.

The results of the physicochemical characterization of the obtained compost are presented in Table 6, characterized by 30% humidity, a C/N ratio of 24.9, dark brown, friable appearance, the odour of the earth with a positive germination test [30]. Table 6 summarizes the physicochemical analysis of the compost obtained.

Table 6. The physicochemical analysis of obtained compost.

Parameter		Value
Moisture (%)		30
pH		7.2
MO (%)		69.7
Mineral matter (%)		30.3
Organic carbon (%)		34.86
Nitrogen (%)		1.4
Chlorides (%)		2
Phosphate (%)		0.08
Heavy metals (ppm)	Pb	26
	Cu	15.7
	Cd	6.5
	Ni	8
	Co	6.5
	Cr	0.6

Heavy metal content is considered another vital quality parameter necessary for protecting the soil and water resource from pollution. Heavy metals concentrations in the composts were found to be considerably lower compared to the contents found in the HAW composts from USA and European countries [31,32].

These experimental results are broadly in line with international standards and reveal that quality compost can be produced from household waste in Morocco after sorting HAW.

3.3.2. Pilote test

The sorting of 30 tons of HAW resulted in a fermentable fraction (FF) of 58.26% with a moisture content of 86%. This fraction was used as a raw material for the composting process.

Table 7 shows the temperature and moisture readings before and after the addition of leachate and the leachate volumes added to the fermentable fraction.

Table 7. Evolution of composting parameters of the fermentable fraction (pilot test).

Date	Temperature **(°C)**	Moisture before **(%)**	Leachate added **(m^3)**	Moisture after **(%)**
05/11/2016	18°C	76.38	2.2 m^3 (Rainwater)	86%
05/15/2016	55°C	56	0	56
05/20/2016	80°C	45.37	3.3	54.6
06/06/2016	84°C	45.26	2.6	56.8
09/07/2016	45°C	39.95	0	39.95
08/15/2016	30°C	31.56	0	31.56
09/15/2016	28°C	9	0	9
Total	---	---	8.1	---

Figures 4 and 5 respectively show the shape of the composting curve of the fermentable fraction in the watering conditions with the young leachate of the Mohammedia landfill as well as the volume of the leachates and the humidity as a function of time.

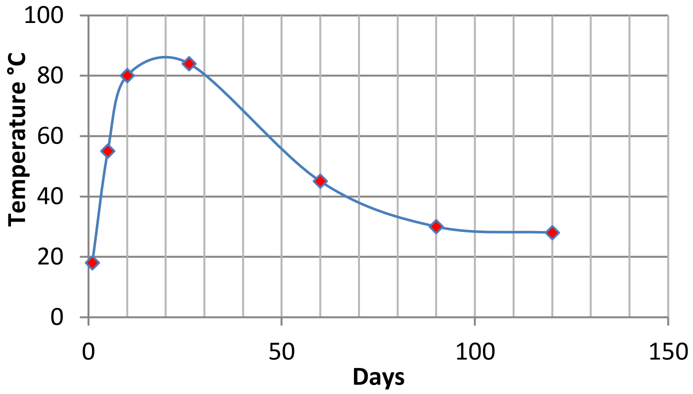

Figure 4. Composting curve of the fermentable fraction

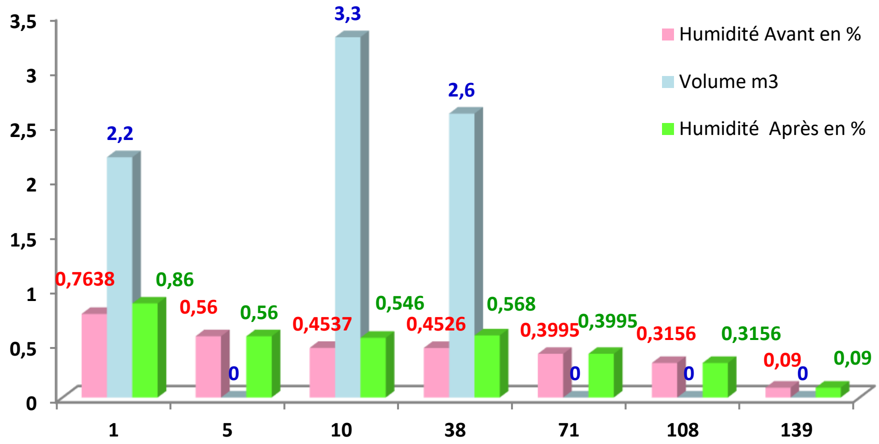

Figure 5. Added Leachate Volume and Moisture over Tim

The changes in temperature in the compost and ambient temperature over the 120 days indicated that the temperature reached its highest temperature of 86°C after twenty days. After three weeks, it started to decline and become stable (~ 30 °C) from the 90th day (Figure 4). Figure 6 shows the heat release due to temperature rise.

Figure 6. **R**eversal phase and heat release

Figure 7. **C**ompost obtained at the end

The decrease in moisture content throughout the composting period was related to changes in temperature. This could be as a result of moisture loss through evaporation at high temperature [33].
The results obtained are presented as follows:

- The amount of young leachate consumed is 8.1 m^3 per 30 tons of HAW corresponding to an absorption rate of 270 liters/tons and therefore to the consumption of approximately 75% leachate produced by the Mohammedia landfill.

- The amount of compost obtained is 5.85 tons, with a moisture content of 9%.
- For a moisture compost of 30%, we will have 7.1 tons.

The characteristics of the compost obtained (Figure 7) are given in Table 8.

The stability tests of the compost as a function of the temperature for seven days are given in Table 9.

Table 8. Characteristics of the obtained compost.

Parameter		Value
Moisture (%)		9
MO (%)		54.04
Mineral matter (%)		36.8
Chlorides (%)		6
Sulfates (%)		0.8
Phosphate (%)		2
Metals (ppm)	Fe	4345
	Pb	147
	Zn	185
	Cu	43
	Cd	< 15
	Ni	< 15
	Co	< 15
	Cr	< 15

Table 9. Study of compost stability.

Day	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Temperature °C	18	25	25.5	26	26.5	27	28

We can see that the temperature did not exceed 28°C, which is consistent with the stability properties of composts.

3.3.3. Description of the proposed pilot process

The process proposed in this study aims to develop a technically and operationally efficient and economically viable tri-composting system while taking into account the main difficulties encountered in the experiments realized in Morocco.

- The trucks unload the HAW (30 t/d) on a metal grid with a mesh allowing the passage of the water (6 m^3/d) towards a basin of liquid retention and the retention of the solid fraction (24 t/d) as a heap.
- The heap is visually sorted to isolate massive size waste (100 - 300 mm).
- A conveyor conveys the waste on a sorting platform riddled with holes 8 mm in diameter (to separate fine extraneous waste, sands, ...) with the following dimensions: 2 m wide, 10 m long and 1 m of the ground. This platform makes it possible to separate manually the waste of average size (100-200 mm) and in particular the fine waste (8-20 mm). This sorting step is very interesting to ensure the quality of compost free of any undesirable substance. It is realized by 20 sorters which ensure around 24/20 = 1.2 t/d/sorter (ie a sorter assuring 150 kg/h at the rate of 8 working hours per day).
- For the solid fraction of 10 t/d, recyclables (metals, glass, plastic) and those oriented towards energy recovery (AF) are recovered by positive sorting and deposited in four barrels of 20 liters each and the fermentable fraction (FF) remains on the sorting table then conveyed by a conveyor to form a pile at the exit of the sorting factory (14 t/d).

Figure 8 presents a simplified Layout of the Sorting factory. The infrastructure and equipment needed to set up the operation of this factory are sorting platform, press, two conveyors, metal grid as well as the leachate pumping system or water.

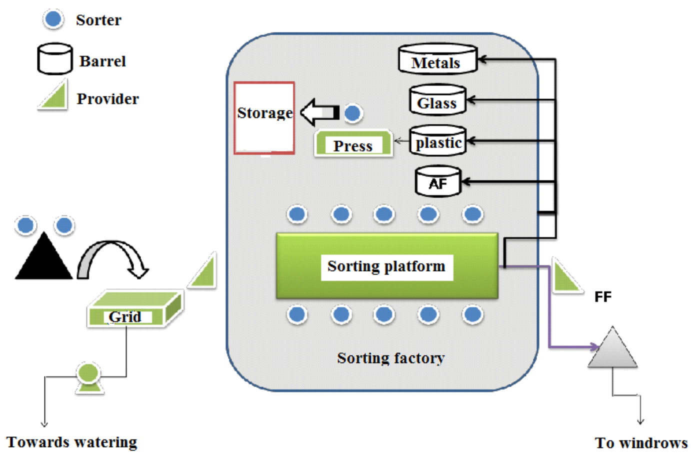

Figure 8. Sorting factory of the composting unit

At the end of the tri factory,14t/ d of the fermentable fraction (FF) is recovered. This material has a density of approximately 0.4 t/m^3, for a total volume of 35 m^3 per day.

3.3.4. Windrow construction and dimensions

- Composting through the construction of 10 windrows in rows spaced 4 meters apart (for machine traffic) (Figure 9).
- For technical reasons and given the production of 14 t/d of the fermentable fraction, after seven days we will have a windrow width 6 m, height 2.5 m and a length 32.7 m, a volume of 35 x 7 = 245 m^3.
- For a period of 70 days, the time of the first phase of manufacture of the compost, we will have 10 windrows occupying an area of:

(32.7 + 4 x 2) x [(10 x 6) + (4 x 11)] = 4232.8 m^2

3.3.5. Operating mode

- The first window is placed at a distance of 60 m from the sorting platform.
- The assembly of the 1st swath lasts 7 days.
- From the eighth day, we start to deposit the 2nd windrow, which lasts another 7 days, at the same time, we proceed to the turnaround of the 1st swath for the phase of aeration.
- On the 15th day, the first windrow and the 2nd windrow are turned over, and then the third windrow is started.
- On the 22nd day, a turnaround of the 1st, 2nd and 3rd windrow and we start the assembly of the 4th windrow.
- The 29th day, a turnaround of the 1st, 2nd, 3rd, 4th windrow and we start the assembly of the 5th windrow.
- On the 70th day, the 1st windrow is moved to storage in the hangar of an area of about 500 m^2 sheltered from the weather, to undergo the maturation phase which lasts 30 days. The 2nd windrow will take the place of the 1st, the 3rd windrow will take the place of the 2nd and so on, which frees the place of the 10th windrow to start a new cycle of production. Each windrow will undergo 10 turnarounds during the fermentation phase (once a week).
- The production of 1st windrow compost weighs 7.1 tons or 49.7 tons every 7 days, which gives an annual production of about 2590 t / year.

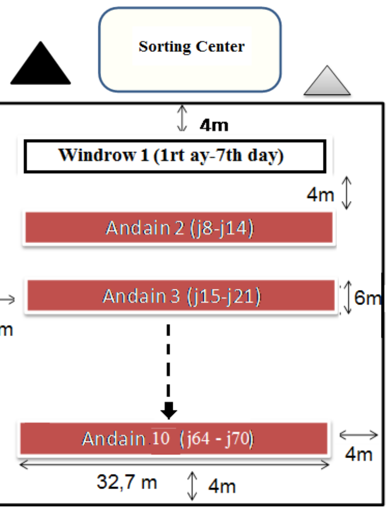

Figure 9. Arrangement of windrows in the fermentation area

It emerges from all these experiences; the following findings:

- This process consumes 300 L of leachate per tons of HAW. This result remains very interesting because it makes it possible to eliminate the leachates already stored.
- The compost analysis shows that the final product meets safety and use standards as a fertilizer to improve agricultural land by improving the C/N ratio by adding nitrogen-rich materials such as Chicken dung (Making a new balanced compost from the fermentable part of household refuse and chicken dung.

• The compost obtained has an organic material content of about 54%, which also makes it possible to use it as a substitute fuel by making briquettes.

Conclusion

The study that we carried out made it possible to propose a solution for the leachate management which poses problems at the level of all the dumps in Morocco. This solution is characterized by several advantages which can be summarized as follows:

Technical advantages

- Reduced leachate and HAW volume
- Increased life of the landfill site (60% removal of HAW);
- Recycling of plastic waste, glass, cardboard / paper and organic
- Develop biotechnology
- Improved landfill management;
- Simple and possible technical feasibility,

Socio-economic advantages

- Social integration of unskilled labor and job creation (170 workers to handle 250 t/d of HAW;
- Creation of waste recovery cooperatives in landfills;
- Wealth creation and development of the circular economy.

Environmental advantages

- Reduction of the volume of waste
- Contribution to reducing the emission of greenhouse gases,
- Reduction of pollution of water and soil resources by leachates,
- Production of compost for the natural amendment of soils and rehabilitation of soils subject to agricultural intensification;

Educational Advantages - Sensitization of Environmental Preservation:

The educational visits of treatment centers and valorization of HAW, groups of students and members of associations, allow taking into account the different types of treatment of household waste in the city.

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