For an Integrated Management of Municipal Solid Waste in Algeria. Systemic and Methodological Approaches

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New schemes of Municipal Solid Waste Management for the wilaya of Oran, Algeria

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Abstract – The aim of this study is the design of a new mode of integrated municipal solid waste (MSW) management in the district of Oran, Algeria based on an approach taking into account systems by themselves, the different multi-sectors, and the various technologies previous studies have been done on two sanitary landfills located in Algiers and Biskra. It was showed that an accurate pretreatment is recommended before landfilling to avoid the emission of biogas and to reduce the pollution by leaching. The treatment by composting of the organic fraction is especially suitable for waste before their burial. The advantage is that this procedure provides a natural organic fertilizer for Algerian soils and in addition reduces the waste volume. In this context a composting guideline is proposed, which would be used for a better waste management procedure. It includes several field scenarios.

Keywords: *Landfills, Leachate, Municipal Solid Waste, Water Balance, Water Pollution, Physical characterization, MSW, Composition MSW.*

1. Introduction

Regarded to Developed countries, the lack of an elaborated municipal solid waste management has resulted from deterioration of the cities cleanliness. This is a especially true for suburbs where unhealthy and fragile population' situation leaking to rural exodus. Consequently water, soil and air are deteriorated. The health risks increase more with toxic fumes, various liquids or gases, in addition to garbage spills in depressions street corners.

Algeria in emergency development, is also concerned by this problem. This fifthly years ago the consumption and production mode have significantly changed significantly, thus affecting directly the ever-increasing quantities of waste and their composition. These changes have been are hardly managed by the local authorities structures. In general the collect in the cities concerns a mixture of

putrescible from, recyclable to dangerous wastes generated by the households, by the artisans, the industrial and commercial activities without differentiation between them.

1.1 Problems in the Algerian cities

Facing other difficulties, such as providing decent housing, access to education and to health services, local authorities (municipalities and cities) are hardly concerned by the cleanliness of the population sanitary conditions. This environmental degradation is spreading throughout the country in both urban and rural areas.

Presently the municipal solid wastes are hardly treated, however only 80% of MSW are collected, but they are not recycled. They are stored in open air or sanitary landfills. They are far from offering the guarantees required (see Table I). [1] The prospects results for 2020, the MSW production and the dumped wastes, are not encouraging if we don't initiate an appropriate method of recovery for recyclable or organic materials

Table I: Projections of the Algerian population and MSW generation in 2020

Algeria	2005	2010	2020
Total population (million)	34.8	38	44.3
Urban population (million)	24.4	26.6	31.0
Rate of waste generation (kg / capita / year)	0.9	1.0	1.2
MSW production (million tons / year)	8.0	9.7	13.6
Collection rate (%)	80	80	80
Dumped wastes (million tons / year)	6.4	7.8	10.9

The analysis of the current situation of urban the sector of waste solid shows some failures in the waste collection, the transport and the final disposal. Its including hazardous waste, and gaps whose can affect the valorization and storage. These failures and shortcomings have institutional, technical, socio-cultural and educational origins even if a national program of municipal waste management PROGDEM (National Program of integrated management of household waste and assimilated) was launched in 2002 to eradicate the practices tipping and organize the collect transportation and disposal environmentally sound urban waste. [2]

1.2 Municipal Solid Waste in Oran city

Oran city has a population of 962,591 people, which represents 70% of the total population of the whole Oran territory

This specific evolution is explained much more by the saturation of its capacities of reception than by its urban growth towards surrounding municipalities (Sidi Chami, Bir el Djir, Es Senia).

The data of table II show the clear concentration of the population in the zone of study with 609,014 inhabitants in 2008 (42% of total population of the city). In figure 1 we can find all the communes of the wilaya Oran, included the Oran municipalities group,

Table II: Communes of the Oran municipalities group

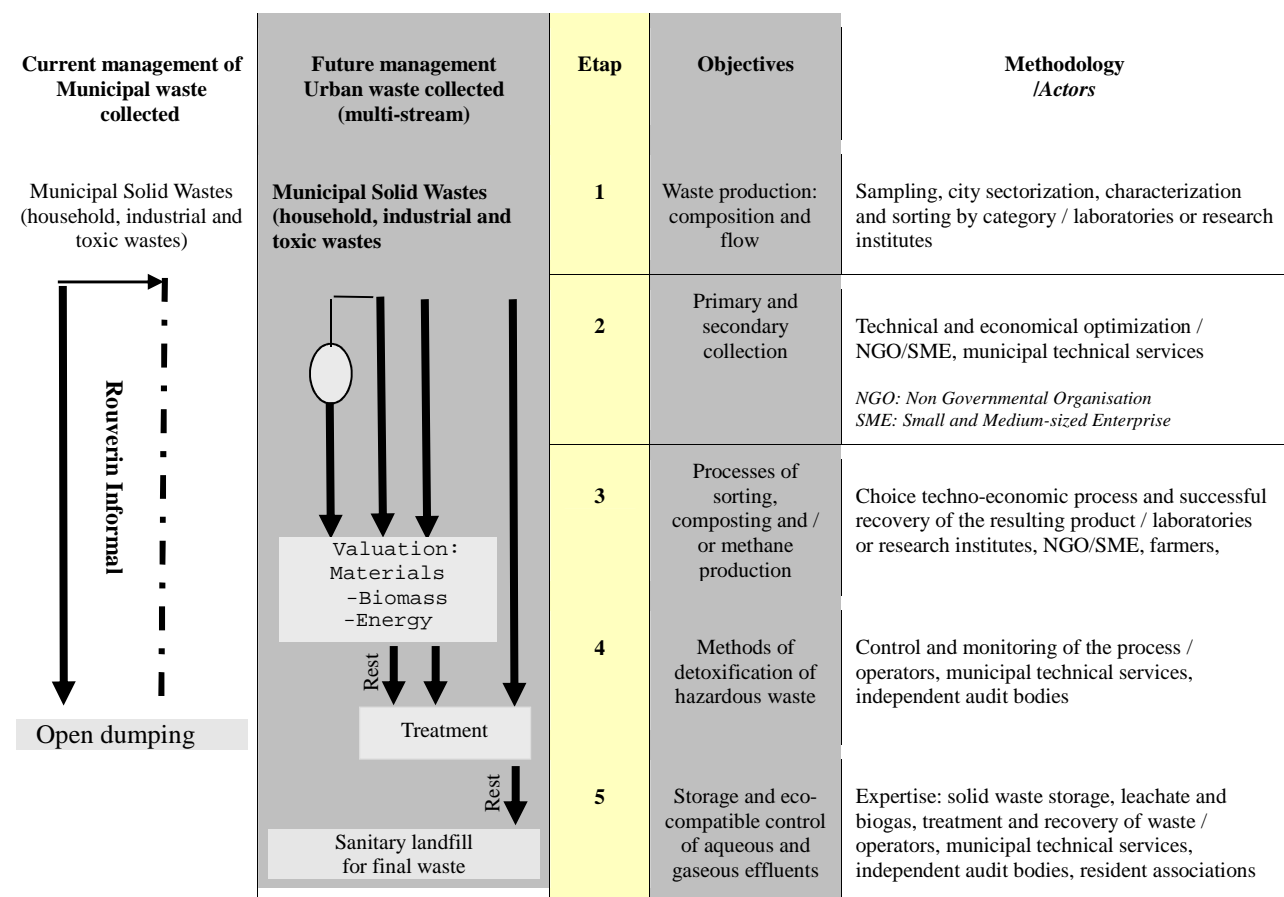| Communes	1977	1987	1998	2008
Oran	502,014	603,931	634,113	609,014
Es-Senia	19,969	34,324	64,797	96,928
Bir El Djir	8,015	20,510	73,029	152,151
Sidi Chami	4,587	16,935	58,857	104,498
Total	**534,585**	**675,700**	**830,796**	**962,591**
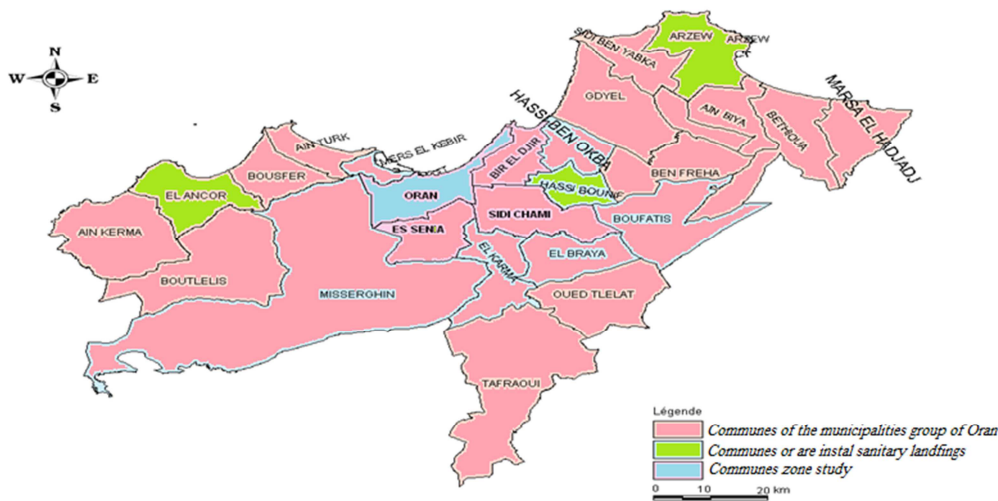
Figure 1: Chart of Oran city

1.3 General approaches for the Municipal Solid Waste (MSW) management

The general approaches for the MSW in advanced countries were reported in the past to ~~on~~ strengthening legislative and institutional frameworks. [3] However recently, the role of various actors in this field have been clearly defined, and the adoption of the "polluter pays" principal has contributed to help to channel increase waste stream. The PPP (Public-Private-Partnership) in waste management, the techno-economic selection of the processes used for the treatment and the recovery, and the establishment of a permanent policy of education and awareness on waste management solids, has also help~~ed~~ to improve the cleanliness of advanced country cities. In either point view, urban waste disposal is a persistent problem in most cities, promoting increased urban waste recycling and it can be considered as job creation opportunities. Looking to the future, a new concept of integrated solid waste management has been developed in advanced countries. It is based on:

- Sustainable development to realized the objectives of Rio (1992) reaffirmed in Johannesburg (2002) including the protection of biodiversity, the promotion of renewable energy, the conservation of natural resources, the fight against poverty and the good governance;
- Systemic approach to address the problems of urban anthropogenic systems such as those of natural ecosystems, taking into account all actors and all technological, social-cultural, and economical aspects and regulation;

- Multi-way approach to take into account all the possibilities of MSW disposal: collecting, recovering, treating and safely landfilling;

-Methodological approach to develop tools of assessment, design, control and expertise in relation with local research teams. [4], [5]

Hazardous waste generated by households, by industrial either by artisans and, by health centers or by hospitals, should be removed from traditional collection. For these dangerous waste, it must be preferred a specific collection (door-to-door, voluntary waste drop-off)

Every step of the MSW removal procedure is studied by a methodological approach in order to understand the various aspects (see figure 2)

Step 1: Methods and protocols to characterize urban waste and to monitor their local and temporal evolution.

Step 2: Modeling for the optimization for types and circuits collection

Step 3: Process design locally adapted for recycling, composting or anaerobic digestion.

Step 4: Guide for audit and control for environmental monitoring of treatment centers.

Step 5: Memorandum of expertise not only of old sites, which should allow prioritization of future closure and / or rehabilitation, but, in addition, of recent sanitary landfills (90 over the whole of Algeria) which do not yet meet international standards for environmental protection. [6]

Current management of Municipal waste collected	Future management Urban waste collected (multi-stream)	Etap	Objectives	Methodology /Actors
Municipal Solid Wastes (household, industrial and toxic wastes)	**Municipal Solid Wastes (household, industrial and toxic wastes**	1	Waste production: composition and flow	Sampling, city sectorization, characterization and sorting by category / laboratories or research institutes
Rouverin Informal		2	Primary and secondary collection	Technical and economical optimization / NGO/SME, municipal technical services *NGO: Non Governmental Organisation SME: Small and Medium-sized Enterprise*
	Valuation: Materials -Biomass -Energy	3	Processes of sorting, composting and / or methane production	Choice techno-economic process and successful recovery of the resulting product / laboratories or research institutes, NGO/SME, farmers,
	Rest / Treatment	4	Methods of detoxification of hazardous waste	Control and monitoring of the process / operators, municipal technical services, independent audit bodies
Open dumping	Rest / Sanitary landfill for final waste	5	Storage and eco-compatible control of aqueous and gaseous effluents	Expertise: solid waste storage, leachate and biogas, treatment and recovery of waste / operators, municipal technical services, independent audit bodies, resident associations

Figure 2. Methodological approaches for integrated management of municipal solid waste (Bouhadiba, et al. 2010)

2. Methodology and analytical conditions

2.1 Origin of waste and sampling

The studied zone is limited to Othmania Sector that population is estimated to 38,666 inhabitants and represents 6.35% of - municipalities group of Oran population. The waste generated in this sector, are collected and transported directly to the landfill of El Kerma sector (Figure 3).
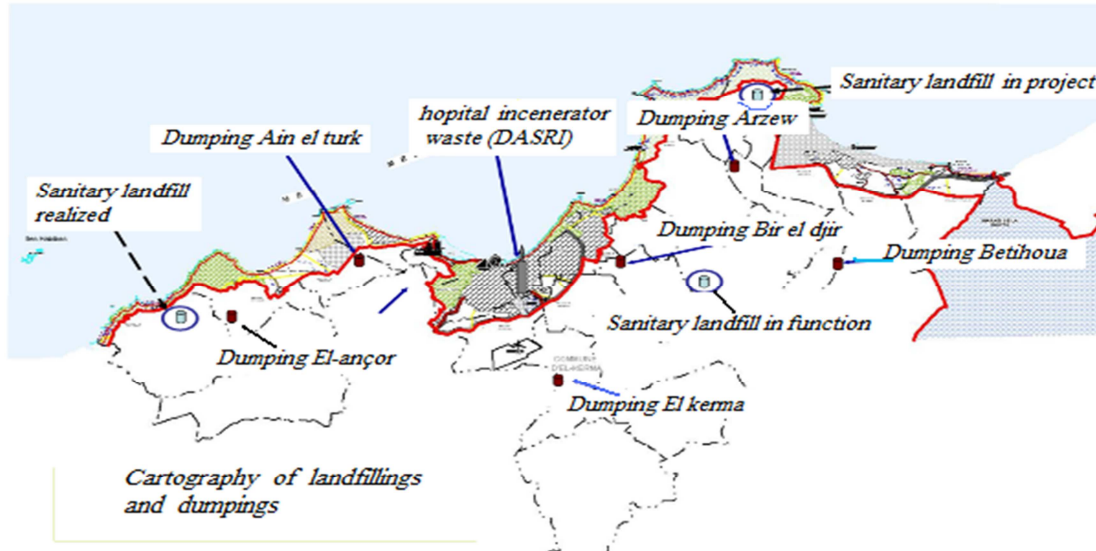
Figure 3: Localization of landfills in Oran City
(Source: Direction of the environment of city Oran, 2010)

a) MSW composition

The origins of MSW are multiple:
- Residential waste produced by households;
- Commercial waste produced by economic activities (administrations, trade, craftsmen, etc);
- Green waste from municipal parks and gardens;
- Waste produced by the municipal markets, (mostly organic);
- Hazardous waste produced by hospitals, healthcare centres and laboratories
- Construction and demolition waste.

b) Sampling

At Disposal Facility: landfill of El Kerma. This method produces the most accurate waste characterization data, and it is especially suitable for waste that is typically composed of many small pieces of numerous materials. Generally, an entire vehicle-load of waste was identified for sampling, but only a portion of the load was pulled out for actual sorting.

After weighing, the truck was headed with all its waste in a place provided for this purpose. For a good representatively, 10 samples were collected at different locations of the waste pile and the content of 5 closed bags was added. Finally the mixture was mixed. The quartering of this mass preserved a final sample of 257.25 kg (According to Bernoulli's equation, [7] 1029 kg were taken with an error range of 6%).

Then a characterization according to model MODECOM (Mode of Characterization of Household Refuse) suggested by the ADEME, was carried out, (French Agency for Environment and Energy). [8]

Table III: categories and under categories

Categories	Comments
1 - Putrescible	Kitchen organics, vegetable, meat, yard wastes
2 - Papers	packing papers, newspapers, magazines and re-examined
3 - Cardboard	packing flat paperboards and packing corrugated cardboards
4 - Complexes	Composite (tetra pack)
5 - Clothing textiles	textiles
6 - Sanitary textiles	textiles hygienic fraction (baby wipe)
7a - plastic, bags	polyethylene (PE)
7b - recyclable plastic	package (PE, PC)
7c - no recyclable plastic	polystyrene
7d - plastic-polystyrene	(pots of yoghourts and fresh cream)
8 - NCC	NCC, no classified combustibles: leather, rubber, wood, etc.
9 - Glass	no color sorting
10a - Metals	iron
10b - Metals	aluminium
11 - NCI	no classified incombustibles: stones, gravel, sand, ceramic
12 Hazardous	various toxic waste
13a - Fine elements	<0-20mm>
13b - Super fine elements	<10mm

2.2 Principles of MSW management

- Characterization of MSW production
- Generalization of the traditional waste collect and establishment of a separate collect of household hazardous waste.
- Recycling of waste materials (glass, metals, plastics, paper-cardboard), the composting or the anaerobic digestion of the organic fraction of waste
- Landfilling of final residues in the respect of environment
Since 2006, five campaigns expertise over a period of 12 months were conducted on two landfills. They showed errors in design and sizing, including drainage of leachate and biogas. [9][10] [11]
Collection of potentially infectious waste from the activities of healthcare centers and hospitals: Protocols for collecting and sorting in hospitals before blanketing (disinfection by autoclaving or by chlorination) and their transfer to incineration plant must be established. [12]

2.3 Design of management schemes

For Oran, we must consider alternative management schemes which incorporate several management concepts.
The approach will be carried out gradually according to several levels (see Table IV)

Table IV: Proposed management schemes

Scheme 1	Collection	*Actors*	Pre-treatment	*Actors*	Landfilling	*Actors*
Residential waste	Door to door	*EPIC+Private*	-	-	Class II landfill	*EPIC+Private*
	Voluntary drop-off	*User/private*	-	-	Class II landfill	*EPIC+Private*
Commercial waste	Door to door	*EPIC+Private*	Sorting	*SME/NGO*	Class II landfill	*EPIC+Private*
	Voluntary drop-off	*User/private*	Sorting	*SME/NGO*	Class II landfill	*EPIC+Private*
Street cleaning waste	Deposit and transport	*EPIC+Private*	-	-	Class II landfill	*EPIC+Private*

Scheme 2	Collection	*Actors*	Pre-Treatment	*Actors*	Landfilling	*Actors*
RHW, Residual household waste	door to door	*EPIC+Private*	-	-	Class II landfill	*EPIC+Private*
	Voluntary drop-off	*User/private*	-	-	Class II landfill	*EPIC+Private*
Recyclable waste	Door to door	*EPIC+Private*	Sorting	*SME/NGO*		
	Voluntary drop-off	*User/private*	Sorting	*SME/NGO*		
Commercial waste	Door to door	*EPIC+Private*	Sorting	*Private*		
	Voluntary drop-off	*EPIC+Private*	Sorting	*Private*		
Street cleaning waste	Collected	*EPIC+Private*	-	-	Class II landfill	*EPIC+Private*

Scheme 3	Collection	*Actors*	Pre-Treatment	*Actors*	Landfilling	*Actors*
Residential waste	Door to door	*EPIC+Private*	Mechanic-Biological treatment	*Private*	Class II Recycled/ Landfill agriculture	*EPIC+Private*
	Voluntary drop-off	*EPIC+Private*	Mechanic-Biological treatment	*Private*	Class II Recycled/ landfill Agriculture	*EPIC+Private*
Dangerous waste	Voluntary drop-off	*User*	Treatment	*EPIC +Private*	Class II landfill	*EPIC+Private*
Large bulky waste	Voluntary drop-off	*User*	Recuperation recycled	*EPIC +Private*		
Commercial	Door to door	*EPIC+Private*	Sorting	*Private*		

waste	Voluntary drop-off	*EPIC+Private*	Sorting	*Private*		
Street cleaning waste	Collected	*EPIC+Private*	-		Class II landfill	*EPIC+Private*

EPIC: public institution with industrial and commercial vocations
NGO: Non-Governmental Organisation
SME: Small and Medium-sized Enterprise

3. Results and discussion

3.1 Composition of MSW in Oran district

The sampling campaign was carried out on July 20th, 2010 in center of the company in the industrial Es-Senia park in very wet climatic conditions and temperatures between 33 and 35°C. The characterization according to the Mode of Characterization of Household refuse [12] was also done.

One can notice that putrescible constitute the principal category (52.3%) that the average density of waste is of 0.59 T/m^3. It is strongly higher than that of waste of the developed countries, which is about 0.15 T/m3 because of the great proportion of organics and weak behalf of packaging (papers, paperboard, plastics, etc.). The average production ratio is around 0.75 kg/inh/day

Results, even if they are obtained from a unique sample allow these comments (table V)

The greatest part of the MSW is constituted to putrescibles (52%) and plastics (25%), followed by sanitary textiles (layers, paper towel, baby wipe) (more than 6%) and glass, present in significant amount, and finally metals .

Table V: Composition of MSW in Oran

Categories	kg	% wet
1 - Putrescible	132.20	52.3
2 - Papers	8.60	3.4
3 - Cardboard	8.00	3.2
4 - Complexes (tetra pack)	1.20	0.5
5 - Clothing textiles	8.30	3.3
6 - Sanitary textiles	15.90	6.3
7a - Plastic, bags	47.70	18.8
7b - Recyclable plastics	9.50	3.8
7c - No recyclable plastics	4.80	1.9
7d - Plastic polystyrene	0.80	0.3
8 - NCC	3.00	1.2
9 - Glasses	3.10	1.2
10a - Metals	4.20	1.7
10b – Metals aluminum	0.00	0.0
11 - NCI	0.00	0.0
12 - Hazardous	0.00	0.0
13a - Fine Elements	5.30	2.1
13b - Super fine Elements	0.00	0.0
Total	**252.60**	**100**

3.2 Comparison with Algiers, Biskra,

Table VI: Composition of urban waste of cities of the South and North Algeria

Categories	Oran %wet	Alger [a] % wet	Biskra[a] % wet
Putrescible	52.3	53.2	37.2
Paper-cardboard	6.6	8.8	10
Plastics	24.8	11.6	12.5
Metals	1.7	1.3	2
Textiles	10.1	9.1	11.4
Other	2.4	3	5.8
Hazardous	0	0.2	0.3
Fines <30mm	2.1	12.8	20.8
Total	**100**	**100**	**100**

(a) Average values of 4 campaigns conducted over the expertise from 2007 to 2008
Algiers: the capital is located in sea area
Biskra: town of 200,000 inhabitants is located in Sahara.

The comparison shows that the composition of household waste of Oran area in 2010 (El-Othmania sector) is in the range of values presented in the table VI, of some Algerian cities. However the results presented in this study (El-Othmania zone), offer a good overview of the spectrum of waste compositions such as are found in Algeria (Biskra, Algiers). [14]

It may be noted that the rate of putrescible always prevails over the other categories of putrescible. The proportion is still higher in northern cities than in southern Algeria, which shows the significant effect of the factors of food and climate regimes. Consumption of dry vegetables, rice and pasta is higher in the South than in the North of Algeria.

The proportion of paper and cardboard has increased sharply for the majority of the Algerian cities (8.8% in Algiers and 10% at Biskra in 2009). This proportion could increase in the coming years by their use as packaging material.

A sharp increase in paper, cardboard, and tetra-pack occurred during the last ten years. That is due to changes in consumer behaviour. In addition, the plastic was introduced in all business sectors.

Plastic bags have increased, whereas in the 80's, people used baskets. Soft drinks and water are packaged in plastic bottles, whereas in the 80's and early 2000's, it prevailed glass bottles. There is also an increase in textiles, mainly sanitary textiles (textiles hygienic fraction babies layers etc.).This growth is the characteristic of consumer societies in the last century, abandonment of washable and reusable and disposal adoption. This consumption pattern deviates from the principles of sustainable development, nowadays recommended

3.3 Proposals of MSW Management Schemes

In order to conceive different scenarios of waste management in Oran City, this study focused on data collected on site, supplemented where necessary by surveys, estimations or extrapolations such as:
- Patterns of movement of household garbage OM.
- Volumes of waste involved.

The purpose of scenarios is to provide guidelines for the organization of waste management for all of the Wilaya. The majority of solutions for the collection and the treatment may be under considered in each group.

The objective of the scenario is to propose orientations for the management engineering of waste for the whole Wilaya. The major part of the solutions for the collection and the treatment can be under consideration on the level of each grouping

It is important to recall that the scenario propose are bases on estimates. real quantities not being available, this one were estimated starting from the data on the various cities Algerian

Table VII: Selected data for the assessment of diagram flow for two scenarios

General data on waste		Scenario A1		Scenario B1	
Population		**996809 inh**		**256065 inh**	
		Tons/days	**Tons/year**	**Tons/days**	**Tons/year**
Household waste ration kg/hab/days	0,57	568,2	207386,1	146	53274,3
Bulky waste kg/inh/year	15	41,0	14952,1	10,5	3841,0
Commercial waste ration kg/inh/days	-	0,0	0,0	0,0	0,0
Street cleaning waste kg/inh/year	-	0,0	0,0	0,0	0,0
Green waste + waste of the market kg/inh/year	18	49,2	17942,6	12,6	4609,2
Total		**658,3**	**240280,8**	**169,1**	**61724,5**

- **Scenario A1,** with the MBT (mechanical biological treatment) process, for the urban area

A1 is a scenario for the urban sector, composed of the following cities Oran, Bir el Djir, Es-senia, El-Kerma and Hassi Bounif for a population of 996,809 inhabitants. in this scenario considers some a mechanic-biological treatment (MBT) before hiding of urban waste. This scenario also makes it possible to evaluate the potential of recovery of materials, which can be recycled, paper, paperboard, plastic, metals and glass. This scenario considers also the die of hazardous waste
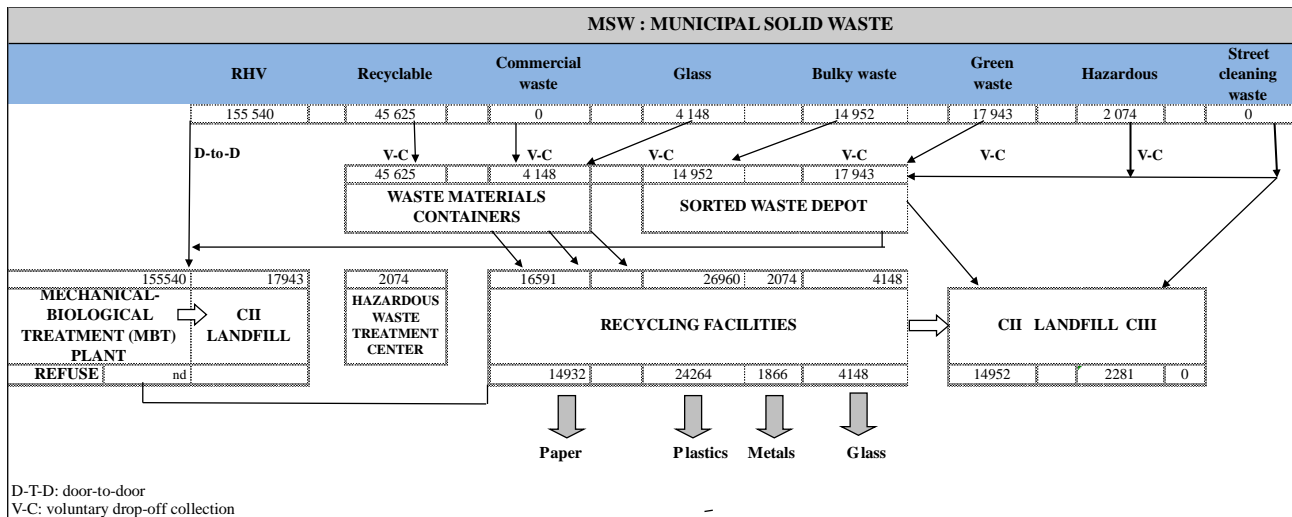

Figure 5: Scenario A1 with MBT process, with diagram flow
*: Quantities of waste, recyclables compost and refuse in Ton/year

- **Scenario B1,** with the sorting -composting process, for the rural area

B1 is a scenario for the urban semi sector, composed of following cities Hassi benokba, Boufatis, Benfriha Gdyel and El-braya for a population of 256,065 inhabitants.

Treatment of the domestic household refuse residual resulting from sorting to the source them refuse in order to produce an organic soil conditioner, which may undergo beneficiation in agriculture
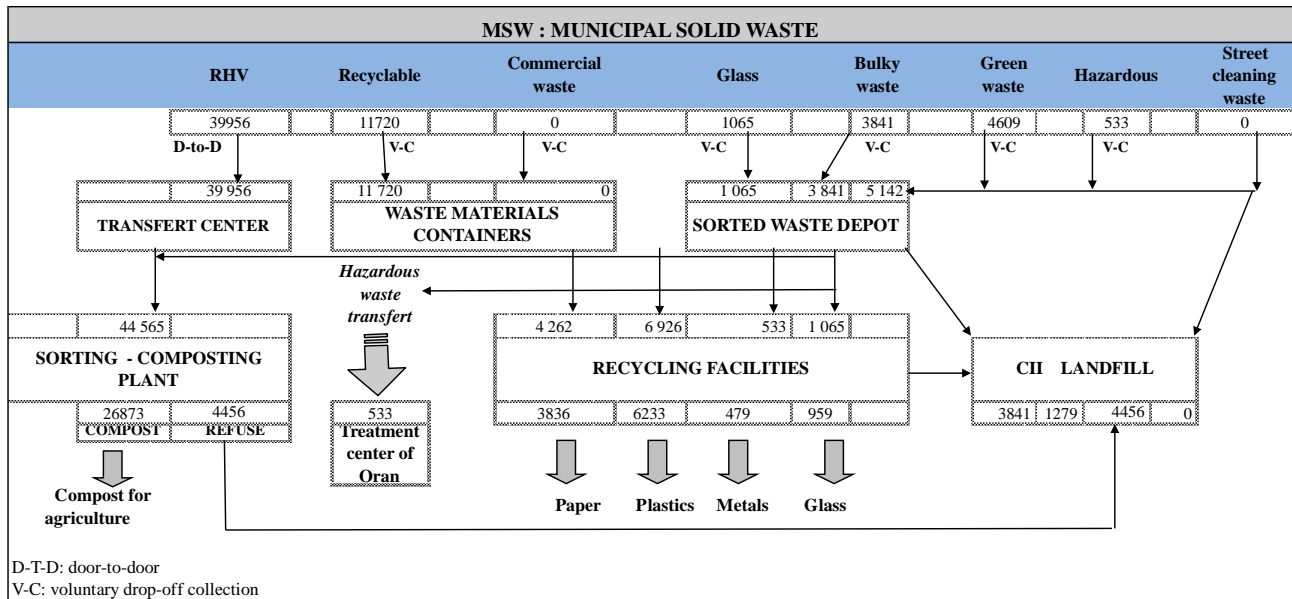
MSW : MUNICIPAL SOLID WASTE							
RHV	Recyclable	Commercial waste	Glass	Bulky waste	Green waste	Hazardous	Street cleaning waste
39956	11720	0	1065	3841	4609	533	0
D-to-D	V-C	V-C	V-C	V-C	V-C	V-C	

TRANSFERT CENTER: 39 956
WASTE MATERIALS CONTAINERS: 11 720 — 0
SORTED WASTE DEPOT: 1 065 — 3 841 — 5 142

SORTING - COMPOSTING PLANT: 44 565
Hazardous waste transfert
RECYCLING FACILITIES: 4 262 — 6 926 — 533 — 1 065
CII LANDFILL

COMPOST 26873 — REFUSE 4456
Treatment center of Oran: 533
RECYCLING FACILITIES outputs: 3836 — 6233 — 479 — 959
CII LANDFILL: 3841 — 1279 — 4456 — 0

Compost for agriculture
Paper — Plastics — Metals — Glass

D-T-D: door-to-door
V-C: voluntary drop-off collection

Figure. 6: Scenario B1 with sorting – composting process, with diagram flow
*: Quantities of waste, recyclables compost and refuse in Ton/year

Conclusion

This research work is proposed to carry out a study of the feasibility of the methodology to be applied to the management of urban waste, from base of scientific data updated and reliable This work is intended to be a tool for decision support to the management of waste of Oran city.

Its aim is to contribute to the establishment of a comprehensive strategy of sustained management of waste in the city by making available the quantitative and qualitative data on the generation of household waste in Oran:
- To propose a methodology for characterization of these waste adapted to the city of Oran.
- To propose schemes and guidelines for the organization of waste management for all the city of Oran.

The proposed schemes during this work, allow the local officials to choose the scenario of their locality with the most appropriate corresponding hypothesis.

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