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Study of the physicochemical parameters of urban waste of the landfill of Bikarane, town of Agadir (Morocco) for a durable rehabilitation

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Abstract
The landfill of Large Agadir, named Bikarrane, exploited since 1978 until April 2010, is a not controlled wild landfill. The diagnosis of this landfill and its surrounding medium reveals several negative impacts related mainly to the absence of measurements of the lixiviats and biogas management. Some of these impacts will be removed once the site is closed and the others which are durable will be compensated by some rehabilitation measurements. For better studying the success conditions of the rehabilitation, the study of the physicochemical parameters of landfilled waste was undertaken emphasizing a majority earthy fraction (between an average of 40 and 50% in means) with a light texture and an average stony load for the whole of the profiles carried out. This fraction posts an high rate of salinity which remains bearable and no prejudicial for certain plants. The pH of this fraction was slightly alkaline and its content of organic matter and fertilizing elements is considered to be good for all profiles.

Keywords: urban waste, landfill, physicochemical parameters, lixiviats, biogas, durable rehabilitation.

I- Introduction:
Despite its proximity to the city of Agadir, the site of Bikarrane receives waste solid municipal of Agadir since 1978. This was an uncontrolled landfill that began receiving since 1996 whole municipal waste generated at level the Grand Agadir (Agadir with six other neighboring urban municipalities) [9,21]. Currently the average total tonnage of waste landfilled is estimated at 500 t/d and storage area covers a total area of nearly 24 ha with an average height of Waste of 12 m .This surface is divided into two zones operated largely by of lockers tumulus following the method landfills by "onion hide» [2,20].

The environmental impact study reveals several negative impacts related to the lack of management measures leachate and biogas [15], at method of landfills by "onion hide ", to fledge plastic bags, at the presence the ragpickers [6] and animals on the site, and traffic the level of access point to the site Bikarrane via the PR 41. Some of these impacts will be deleted from the site closure, and others that are sustainable will be offset for rehabilitation measures in site proposed by this study. Thus, it is proposed that an emergency action plan aimed the remodeling of this discharge, with temporary cover, giving it a dome shape favoring the stability of massif waste, and storm water runoff toward the interception ditch which serve for draining until watercourse [3,17].

After stabilization of the differential settlements major, it is proposed to set up a final cover adaptable to the local context [1,8,18], it will constituted mainly a layer semi-waterproof limiting water infiltration and production of leachate [10], a layer of loose soil that is intended for drainage of water feeding the plants, of pockets of vegetale land filling out holes planting of a vegetation having shown adapting in the middle in the pilot test is performed on parcel disused the site [16] and who should allow the reinstatement landscaped of Bikarrane discharge.

For better studying the conditions of success of the rehabilitation, this work aimed mainly:
1. To analyze of the risks related to the durable impacts of the landfill on the environment, particularly in cases where the choice of revegetation is that of roots plants vertical proliferating in the interior of massif waste.
2. To establish the optimal conditions for the rehabilitation concerning the installation of the final cover and the revegetalisation [9].

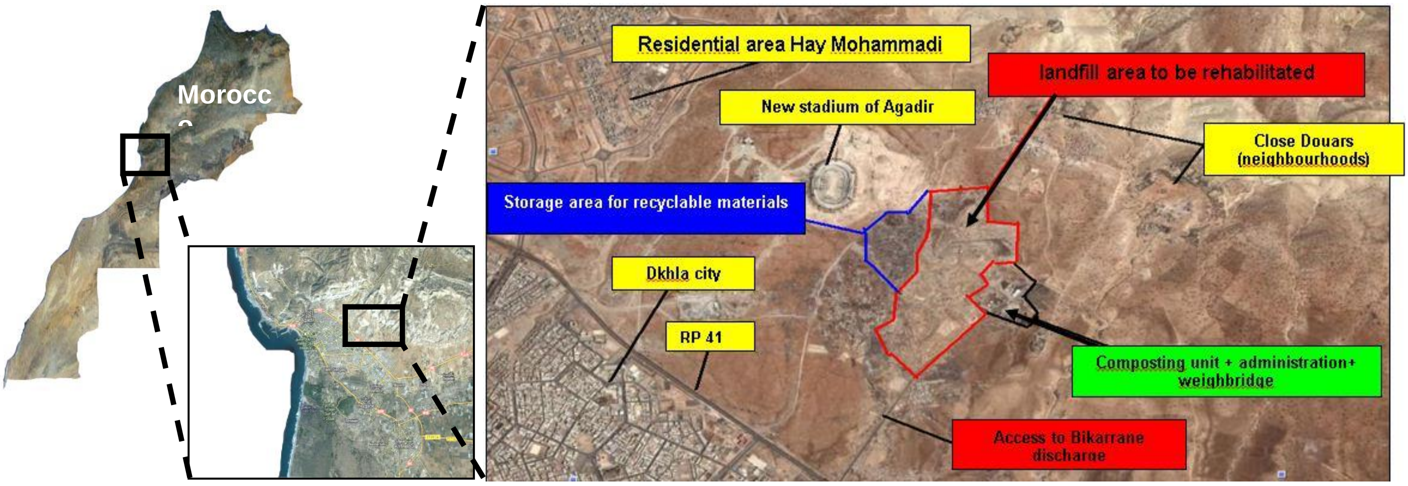

Fig. 1: Plan of the landfill of Bikarrane.

2 - Materials and methods:

2.1. Situation and presentation of the landfill of Bikarrane:

The landfill of Bikarane is at the foot of the High Atlas at the East of the Town of Agadir 800 m away of the city of Dakhla and the university residence.

The storage section of waste is divided into three zones; two zones are dedicated to the exploitation and are the subject of our study of rehabilitation (Fig 2).

Zone I: extends on a surface of approximately 16 ha

Zone II: extends on a surface of approximately 8 ha

The third zone is out of exploitation currently, it is about old landfilled waste before 1996 and put in cover before being levelled. It is relatively punt and the height of the landfilled waste in this zone does not exceed 1 m is a very low thickness of waste not requiring work of rehabilitation.

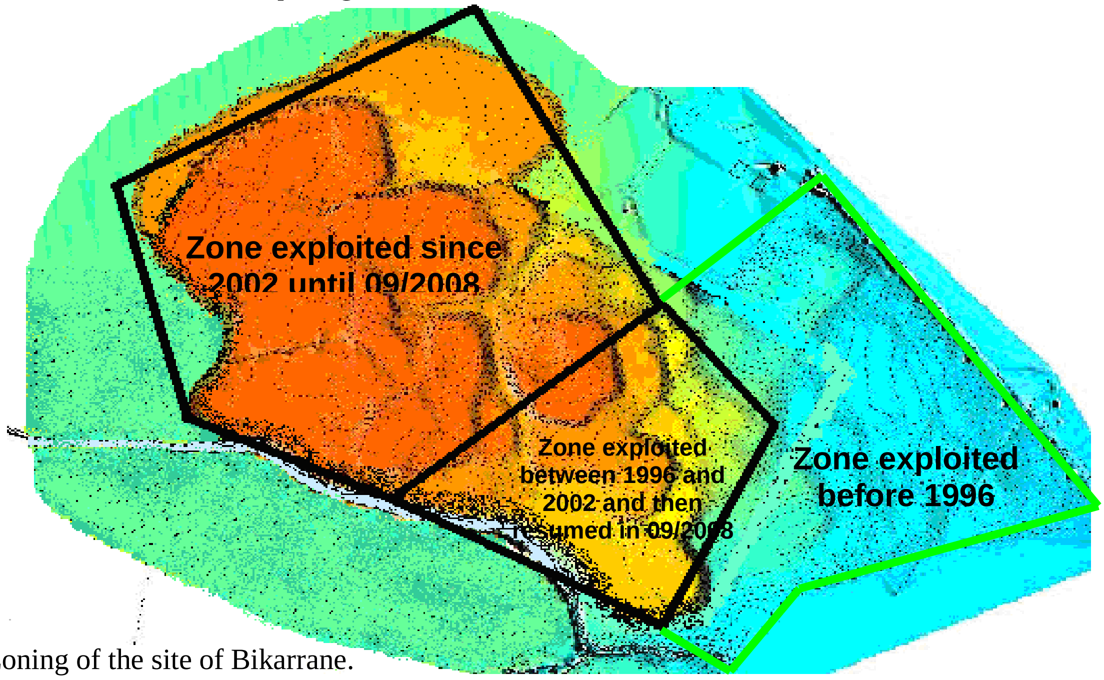

Fig. 2: Zoning of the site of Bikarrane.

2.2 Strategy of sampling

The characterization of the landfilled waste with the landfill of Bikarrane requires a strategy of sampling making it possible qualitatively to describe this waste which will be sorted in several components in particular the earthy fraction which will be analyzed (bacteriological and physicochemical analyzes) [3,4,14].

Let us recall that potential sources of problems of sampling of waste as indicated in table hereafter [12] relate to the temporal variation, the sampling, their preparation and their handling like their storage and their safeguarding.

Table 1: Problems of sampling which can affect the analytical results according [12]

Major problems of sampling	Soil/ sediments	Subterranean water	Superf. Water	Air	Waste/ products
Migration of dangerous substances	♦♦	/	♦	♦	♦♦
Temporal variations	♦	♦	♦♦	♦♦	♦
Spatial variation	♦♦	/	♦♦	♦	♦♦
topographic and geological characteristics	♦♦	♦♦	/	♦	/
Point sources	♦♦	/	/	/	♦♦
Sampling levy	♦	♦	♦♦	♦♦	♦
Preparation and manipulation samplings	♦♦	♦♦	♦♦	♦♦	♦
Storage of samplings	♦	♦♦	♦♦	♦♦	♦
Preservation of samplings	♦	♦♦	♦♦	/	♦

♦♦ Probable sources of significant problems of sampling
♦ Potential source of sampling problems
/ Not object.

By making the connection between the characterization of landfilled waste and their temporal variation [5,11], one understands the interest which stirs up the age of this waste in the determination of the intake points of the samples (Table 2).

Following the investigations carried out on the spot in zone I of the landfill, we could work out a zoning allowing to distinguish between three types from the zones; those concerning of the landfilled waste recently in 2008, those of the landfilled waste before 2007et those in excavation where there is a scouring of the roadbases of waste and where it is difficult thus to determine the age of the waste exposed (without cover).

To conclude better these investigations and supporting the results of zoning obtained, a partner of in situ recognition concerning the detection of methane was carried out in zone I to give itself an idea of how old this landfilled waste is.

This strategy of sampling is that known as of the judgment which is the technique most adapted had regard to the objectives of evaluation of the risk and of identification of the sources of pollution (case of this study of characterization of landfilled waste) which corresponds to a selection of the intake points on the basis of historical study carried out and of the visual inspection of the site (see results of in situ recognition campaigns).

Table 2: Evaluation of the strategies of sampling for the sites polluted depending on the objective [13]

Strategy	Random	Systematic	System.	Search	Stratified	Profile	Judgment
Risk evaluation	4	2^A	3	3	3	2	1
Identification of	4	2^A	3	2	2	3	1
Delimitation of	3	1^B	1	1	3	1	4
Prospects for	3	2	2	4	1	2	3
Control	1^C	1^B	1	1	3	1^D	4

Strategy:
1: the most adapted
2: possible
3: little adapted
4: the least adapted

Comments:
A: to be applied with a screening technique analytical field.
B: adapted only if the trends are known.
C: statistical validation if the whole site is covered.
D: possible if the site is supposed to own (more technical).

2.3. Sampling procedure

The quality of sampling largely conditions the interpretability of the analytical results.

More particularly in the case of waste, the disparity between the importance of the masses of waste and that which will be implemented for the analysis and the characterization (specimen test) are such as the operation cannot be under consideration in only one stage (Fig 3). Indeed, it proves to be necessary to proceed:

- Initially, with a taking away representative of the heterogeneity of materials met on the site
- Then with the reduction of this first taking away to a size allowing its sorting or separation in several fractions of the secondary sample established.
- Lastly, at the laboratory, with the constitution of a sample, generally of very low mass, concerning the fraction studied and which will be directly subjected to the analysis.

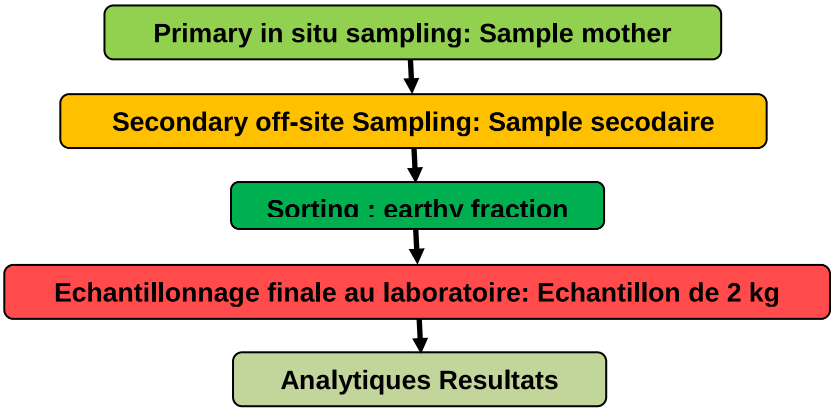

Fig. 3: Diagram showing the sampling methodology.

2.3.1. Primary sampling:

Failing to lay out itself of a drill which is appropriate for the case of the landfill of Bikarrane of which the average depth of waste reaches 12 m, the sampling mother is made by trench carried out in zone I where the exploitation stopped since the end of September 2008, with a cup machine which makes it possible to reach a depth of 5 M.

2.3.2. Secondary sampling:

Landfilled waste is received in a cleaned hall where they are homogenized and put in heap. For each profile one takes 4 wheelbarrows (approximately 200 L) of waste with the help of a manual shovel in order to constitute a representative secondary sample (Fig 4). In total 3 secondary samples are made up for each profile (Table 3).

Fig. 4: Photo of landfilled waste piled in a hall reserved for the secondary sampling.

2.4. Sorting of landfilled waste

Once the secondary sample made up, one proceeds to the sorting of waste while separating between the earthy fraction made up from the broken up organic matter (to be noted that the fermentable matter is completely degraded for the three profiles considered) and from the ground with noncoarse granulometry (mesh of release d80 < 2cm), the plastic, paper, stones and the little ones, and the other elements (wood, fabrics, metals, glass, bone….etc) (Fig 5)

Table 3: Recapulatif of the sampling of the landfilled waste carried out on the site of Bikarrane.

Profile	Old landfilled waste before 2007			landfilled Waste in summer 2008			Zone in excavation without cover		
Thickness of the ground of cover	2			1,60			No cover		
Total depth (m)	5			3,60			2,70		
Volume of removed waste (m3)	18			18			28		
Weight of removed waste (T)	28			21			19		
Volume of the secondary sample	≈200 l (4 wheelbarrows)			≈200 l (4 wheelbarrows)			≈200 l (4 wheelbarrows)		
Number of the sample	Ech 1	Ech2	Ech3 400 L	Ech 1	Ech 2	Ech 3	Ech1	Ech 2	Ech 3
Weight of the secondary sample	99	123.4	235.6	129	118.2	115	153.8	113	123

Fig. 5 Sorting of landfilled waste, into different components.

2.5. Agronomic analyzes of the earthy fraction:

After having carried out the description of the three studied profiles, the earthy fraction was the target of the granulometric and physicochemical analysis.

For this purpose, we took a final sample of 2 kg for each earthy fraction concerning the 9 samples carried out for the three profiles (Fig 6).

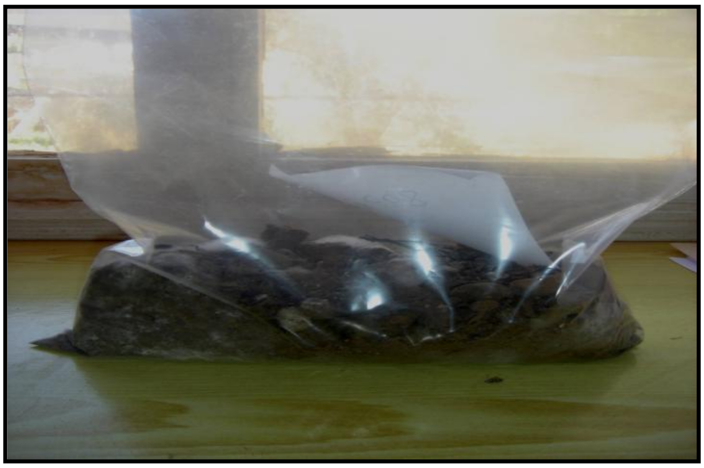

Fig. 6: Sample of the earthy fraction.

3 - Results and discussion:

3.1. Sorting of landfilled waste:

As soon as the final sorting starts, one will separate the particles <2 cm to constitute the earthy fraction and the remainder will be distributed by nature to form the group of the plastic, Paper and paperboards and the others (Table 4 and Fig 7).

Table 4: Quantitative description of the three profiles of waste carried out.

		Earthy fraction (<2 cm) %	Stones and stones %	Plastic %	Papieret paperboards %	Different	Total
Profile before 2007	**Sample 1**	46	16	16	9	13	100
	Sample 2	62	12	11	5	10	100
	Sample 3	37	22	16	12	13	100
	Average	49	17	14	8	12	100
	Standard deviation	12.66	5.03	2.88	3.51	1.73	
Profile summer 2009	**Sample 1**	41	23	15	10	11	100
	Sample 2	37	26	12	16	9	100
	Sample 3	41	22	18	11	8	100
	Average	40	24	15	12	9	100
	Standard deviation	2.3	2.08	3	3.21	1.52	
Profile in excavation	**Sample 1**	45	31	12	7	5	100
	Sample 2	55	24	12	7	2	100
	Sample 3	45	28	10	10	7	100
	Average	49	28	11	8	4	100
	Standard deviation	5.77	3.51	1.15	1.73	2.51	

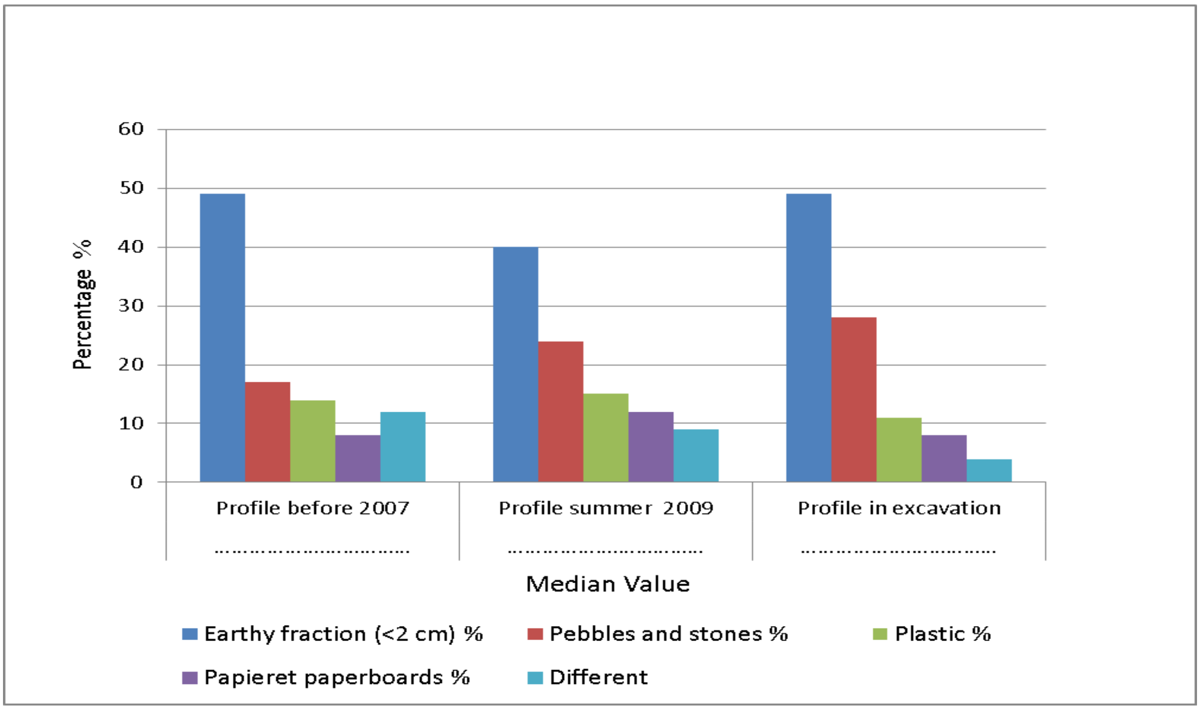

Fig. 7: Result of the quantitative analysis of the profiles carried out.

According to quantitative descriptions above one notes the prevalence of the earthy fraction followed by the fraction of stones and the little ones, with a small distinction characterizing the second fraction, considered to be higher in both cases of the profiles in summer 2008 and excavation. This could be explained by the increase in the quantity of inert waste (of construction and demolition) which flows in growth on the landfill of Bikarrane because in particular of the consecutive operations of demolition of the shantytowns that the town of Agadir had known for almost two years.

In addition, it is important to note, as we noticed on the level of the profiles carried out, that the fraction of the plastics is important; between 11 and 15% in average for the three profiles considered. The presence of the plastic bags with such quantities could constitute a constraint in front of the development of the plants with major rooting, but considering these plastic materials do not form a true impermeable layer, the plants will probably manage to exceed this obstacle.

Concerning cellulosic feedstock (papers and paperboards), one notes that this fraction is less important in the case of the profile of the landfilled waste before 2007, which can be justified by the fact that a share of this fraction is in phase of advanced degradation and that it is found in the earthy fraction [6,19].

3.2. Granulometry analysiss of the earthy fraction

In order to determine the texture of the earthy fraction on the level of each profile, we studied the fine granulometry (< 2 mm) of the 9 final samples sent to the Analysis laboratory of the ground to the horticultural complex of Agadir (Table 5 and Fig 8).

Table 5: Results of the grain size analysiss of the three profiles.

		coarse sand 200µ-2mm(%)	fine sand 50µ-200µ(%)	coarse silt 20µ-50µ(%)	fine silt 2µ-20µ(%)	clay <2µ(%)
Profile before 2007	**Sample 1**	26.02	38.43	11.65	10.9	13
	Sample 2	29.03	34.04	15.62	10.35	10.95
	Sample 3	33.55	30.04	12.67	11	12.75
	Average	29.53	34.17	13.31	10.75	12.23
	Standard deviation	3.79	4.19	2.06	0.35	1.11
Profile summer 2009	**Sample 1**	38.31	21.43	19.66	2.95	10.65
	Sample 2	40.82	25.79	15.79	8.5	9.1
	Sample 3	36.65	24	15.39	15.15	8.81
	Average	38.59	23.74	16.94	8.86	9.52
	Standard deviation	2.09	2.19	2.35	6.1	1
Profile in excavation	**Sample 1**	36.05	26.31	14.5	12.15	11
	Sample 2	38.66	20.05	15.99	11.8	13.6
	Sample 3	36.18	33.6	13.78	8.7	7.75
	Average	36.96	26.65	14.75	10.88	10.78
	Standard deviation	1.47	6.78	1.12	1.89	2.93

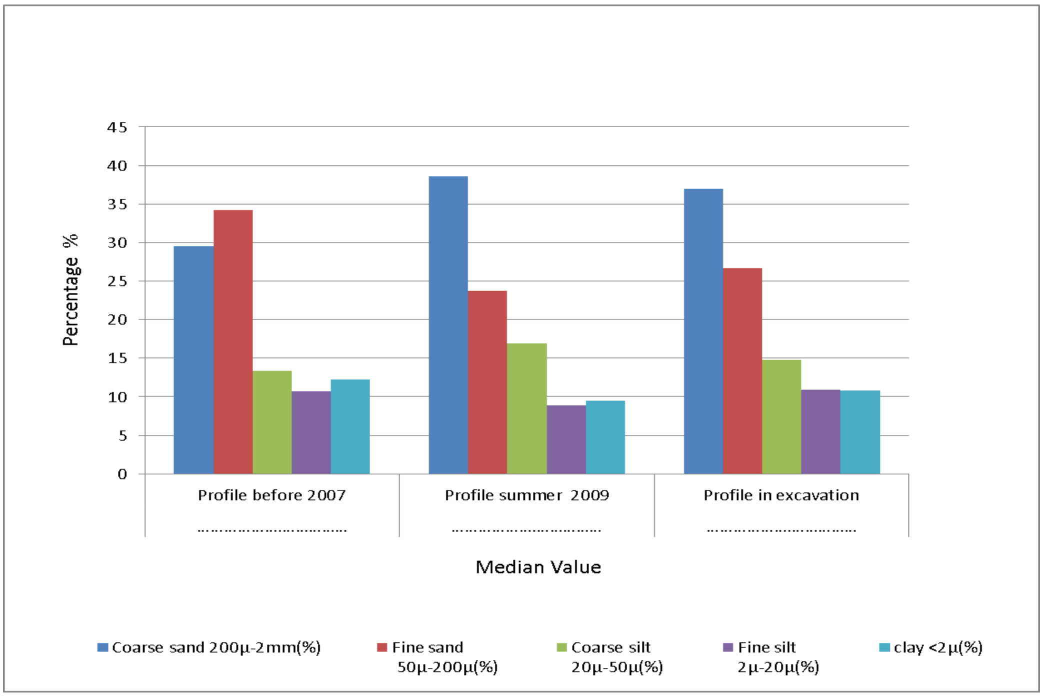

Fig. 8: Result of the granulometric analysis of the profiles carried out.

While referring to the triangle textural one can say that for the whole of the samples taken for the three profiles, the texture of the earthy fraction is of the sand spreader type is a light texture. By considering the work completed by khouildi 2007 and Belahcen 2003, the earthy fraction is fairly stony for all three profiles.

3.3. Physicochemical analyzes of the earthy fraction:

Following the physicochemical analyzes of the 9 final samples of the earthy fraction sent to the Analysis laboratory of the ground (Fig 9), the first notices it is the concentration high of Fe in the three profile and of NO3 on the level of profiles before 2007

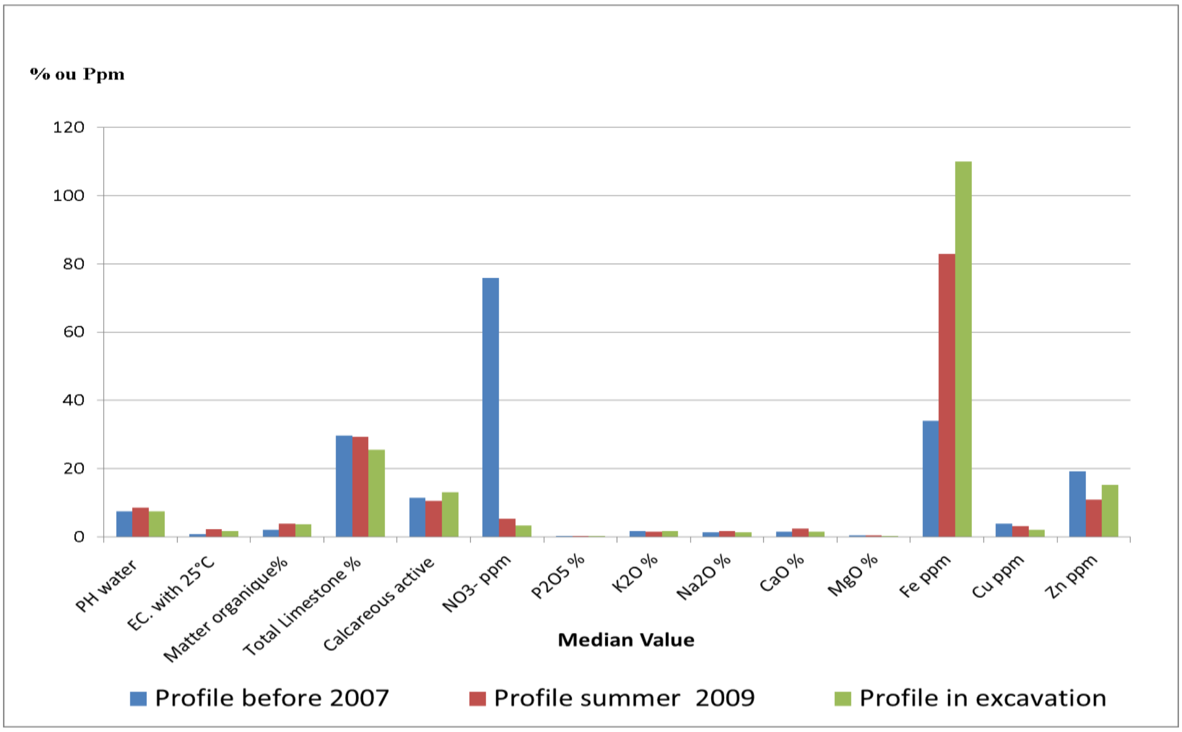

Fig. 9: Result of the physicochemical analyzes of the profiles carried out

- <u>pH :</u>

The average pH for the three studied profiles is fairly basic (between 7,43 and 8,53) what makes it possible to qualify the earthy fractions of slightly alkaline.

- <u>Electric Conductivity :</u>

The average electric conductivity of the earthy fractions of the three profiles considered are respectively 0,78,2,31 and 3,71 mmhos/cm. Thus the earthy fractions are classified in the category of the saline grounds.

- <u>Calcareous total and active limestone :</u>
  - The total limestone average content in the earthy fractions of the three profiles is very high with respectively 29,76,29,29 and 25,51%.
  - The active limestone average content is fairly high for the whole of the samples between 10,57 and 13,02%.
- <u>Organic matter :</u>
  - The percentage out of organic matter reveals that the earthy fraction of the first profile is fairly rich in organic matter with an average percentage of 2%.
  - The other profiles have a good average content of organic matter with respectively 3,88 and 3,79%
- <u>Mineral Nitrogen :</u>

The average content nitric nitrogen for the earthy fraction of the first profile is fairly high (75,9%). For the two other profiles, it is relatively weak with respectively 5,3 and 3,4%.

- <u>Assimilable Phosphorus :</u>

The average content assimilable phosphorus for the earthy fraction of the first profile is regarded as high (0,23%). For the other profiles, it is fairly high with respectively 0,18 and 0,14%.

- <u>Exchangeable Bases :</u>

All the earthy fractions of the three profiles considered present a high percentage of all the exchangeable bases without exception

- <u>Trace elements :</u>

All the earthy fractions of the three profiles considered present a high percentage of iron, zinc, copper and manganese.

3.4. Analyzes of heavy metals:
One takes again those obtained during a work carried out per [7] carried out in 2003 concerning the earthy fraction of the landfill of Bikarrane (Table 7).

Table 7 : Total concentrations in heavy metals of the analyzed samples of the earthy fraction (mg/kg) (Benlahcen, 2003).

Element	**Ech 1**	**Ech 2**	**Ech 3**	Average	acceptable Concentration max *****
Cd	001.1	0.9	000.7	000.9	15
Pb	120.9	120.5	119.1	120.2	2000
Cu	235.6	155.4	195.6	195.5	130
Zn	300.3	285.3	352.2	312.6	300
Hg	000.2	000.2	000.2	000.2	20
As	008.3	007.5	009.2	008.3	40
Cr	030.0	030.0	030.1	30.03	1000
Ni	017.8	015.1	016.2	016.4	70
Se	000.1	000.1	000.1	000.1	6

* Maximum content reserve by the Environmental analysis laboratory of the university of Derby

These analyzes revealed that the contents of heavy metals in the analyzed substrate are very below the thresholds of contamination except for the copper whose concentration remains to be controlled (195,5µg/L) because it is likely to be dangerous for the ground water and the plants. It remains to be specified that the edaphic conditions of Morocco and these alkaline grounds will most probably reduce the mobility of the elements metal traces and will make it possible to avoid the toxicity of the plants and the pollution of subterranean water.

One can conclude that the metal elements traces do not present an obstacle in front of the project of revegetalisation of the site of Bikarrane.

Conclusion

From the agronomic point of view, the earthy fraction obtained after the sorting of the landfilled waste in zone I of the landfill, is fairly stony, with a light texture. The content of organic matter is moderately fine, or rather good. This will allow an improvement of the retention of water and an optimal root extension of the plants.

But in parallel, this fraction has a high salinity which will be perhaps a handicap for the development of the plants. This salinity is due, probably, to waste coming from the fish industry, which can also explain the high percentage of sodium and chlorine as well as the high percentages of phosphorus and calcium.

To evaluate the gravity of the problem of salinity, the value of electric conductivity is not enough, other parameters must be taken into account. They are the values of the SAR =$Na+/[(Ca^{3+}$ $Mg^{2+}]1/2)$ and of the ESP= 3 (0,01475 SAR -0,0126)/(0,01475 SAR + 0,9874) X 100 (%) which measures the percentage of sodium fixed by the argilo-humic complex. According to the calculations made starting from the results of the analyzes of the earthy fraction on the level of the three profiles, the SAR is respectively equal to 1,4. 1,35 and 1,36% and ESP are respectively equal to 2,3. 2,1 and 2,16%. This last is enough far from the limiting value which is of 15% defined like being able to influence on the productivity of the plants. Thus one can say that the studied earthy fraction is nonsodic.

Considering relatively high salinity, two solutions are then to propose: either to make a scrubbing of the substrate of the landfill by abundant irrigations, before the plantation, or to make a choice of tolerant plants to salinity, or to combine the two solutions.

The content total limestone is also regarded as very high. This can be explained by the nature of the substratum of the area of Agadir, constituted of an alternation of marnes and white limestones.

Phosphorus, potassium and magnesium are present in high quantity and make it possible to exempt fertilizer contributions.

The trace element contents are also raised and make it possible to exempt external contributions.

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