Landfill Soil Characterization: Tangier Case Study

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Abstract: ***Household refuse dumps, especially old ones that do not have an interface with the bedrock, pose a threat to the environment, especially to the underlying water table. Leachate that infiltrates is partly responsible for the degradation of water and soil quality. Since the landfill has neither technical installations for environmental protection, nor a controlled operating concept, polluting emissions constantly emanate from the landfill. Critical factors are uncontrolled surface runoff or subsoil infiltration of leachate, as well as the biogas produced by the decomposition of organic matter. In addition, the frequent fires and the development of smoke are still to be named, as well as general improper operation (theft of waste, ragpickers, grazing animals, hygienic aspects), which lead to significant risks and serious ecological damage.***

Keywords: Household, Environment, Landfill, Leachate, Risks

1. Introduction

Solid waste because it is the most extensively utilized waste disposal strategy in the world, it is simple to apply and relatively inexpensive, a significant portion of the waste is still land filled. [**1**].

This constitutes a real and permanent threat to the environment [**2; 3; 4; 5; 6; 7; 8**].

These are primarily unregulated and open-air landfills in underdeveloped nations, where all forms of waste (urban, industrial, hospital, and agricultural) are released in their raw or mixed state.

Only very rarely is the trash so discharged fully inert, and multiple physicochemical and biological reactions occur both between the waste and the environment in which it is found (rocks, soil, groundwater, percolation water), as well as inside waste of varied origins [**9**].

Indeed, waste is susceptible to degrading processes involving complicated biological and physicochemical reactions beginning with the disposal phase. The dissolution of contaminating materials in the percolation fluids by physicochemical and biological processes produces liquid effluents rich in organic and mineral matter called leachate or often "discharge juice" as a result of the waste's fermentation and contact with rainwater.

One of the major constraints for the management of public landfills is leachate from urban garbage. They are, in fact, a menace to the environment and human health due to their high polluting burden. Each landfill's chemical composition is distinct. It is highly dependent on the landfill's nature and age, the type of garbage and its degree of decomposition, the land filling process, the nature of the landfill site, and meteorological conditions, among other factors. [**10; 11**]. The infiltration of these pollutants into and their contact with soil can lead to the insidious degradation of the soil quality.

2. Study Area

2.1 Geographic location

The public dump of Tangier was put into operation in the early 1970s. It stretches over 30 ha 5 km from the city center on the road to Tetouan. The coordinates of the location are: latitude 35°44'35.32 "N and longitude 5°45'17.39". The site belongs to the private domain of the State. It serves the following boroughs: Charf Mghogha, Souani, Tangier Médina and Beni Makada plus waste from industrial zones.

2.2 Hydrographic network

The landfill is marked by an average slope of 40% on the northern slopes and increasing towards the east and west. The hydraulic network consists of two Wadis around the landfill: Mghogha and M'laleh. The surface water and the leachate flowing over the area of the Tangier landfill flow into the WadiAynAtTaleb Ahmed of Wadi Mghogha, which leads to the bay of Tangier in the immediate vicinity of the residence Sanaa Beach.

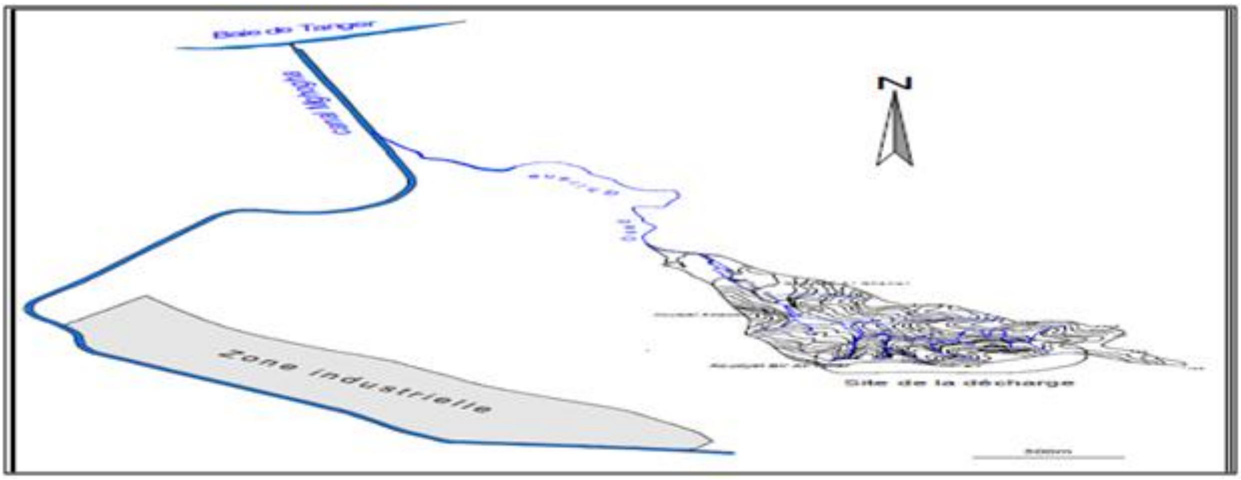

Figure 1: Hydraulic network of Tangier landfill

2.3 Field Geology

The landfill is located on the hills that form the eastern limit of the area where the Tangier unit outcrops.

The unit is characterized by a vast marly schist or clayey schist complex of the Upper Cretaceous. The hills are surrounded by the valleys of wadiMoghogha and Ghir Boudra to the south and those of wadis of Mlaleh and Khandak Bou Hajjar to the east [12]. The marl-schist formations which predominate in the facies of the site are characterized by their impermeability. The soil around the landfill is mostly clay. The geological map indicates two faults at the landfill site; at least one of these two crosses the landfill site [12].

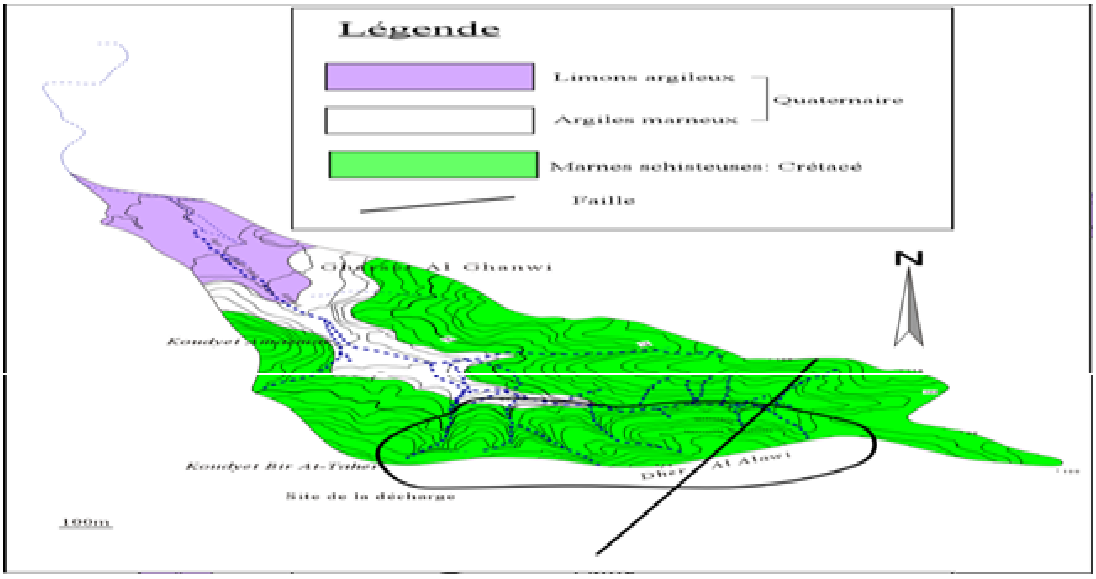

Figure 2: Geology of the Tangier landfill

2.4 Waste quantities

The annual production of household waste in Morocco is estimated at 7, 433, 045 tons per year, which represents the equivalent of a ratio of 0.78 kg / inhabitant / day in urban areas against 0.33 kg in rural areas. The amount of household and similar waste produced reaches approximately 5.3 million tons per year in urban [13].

The problem of solid waste in Tangier appears to be one of the major aspects of the urban environment. A city like Tangier has to face a continuous increase in the volume of waste it produces; The production ratio (0.86 kg / inhabitant / day) is high compared to the national average 0.75. This increase, due not only to the steady growth in the number of inhabitants, is generated by the economic growth of the city, but it is also due to the change in production and consumption patterns.

Table 1: Tonnage of waste collected 2014-2020

Month	Collection 2014	Collection 2015	Collection 2016	Collection 2017	Collection 2018	Collection 2019	Collection 2020
January	*	13 258, 76	14 887, 88	15 433, 42	15 906, 04	18 756, 30	17 091, 20
February	*	12 418, 97	13 739, 01	14 360, 64	14 654, 84	17 069, 43	16 690, 90
March	*	15 082, 41	14 773, 58	16 776, 34	17 516, 49	19 164, 94	17 122, 84

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April	*	15 401, 69	15 226, 32	16 028, 80	18 077, 02	19 092, 18	16 048, 28
May	14 877, 00	15 720, 59	16 940, 62	17 589, 08	19 765, 11	22 619, 08	17 771, 48
June	15 108, 60	16 981, 30	17 910, 40	19 503, 26	18 652, 18	20 018, 73	17 518, 38
July	17 500, 22	18 204, 01	18 979, 14	19 998, 92	21 477, 02	22 052, 68	23 035, 21
August	16 090, 90	17149, 72	18 933, 72	20 639, 34	25 485, 62	26 148, 22	20 238, 95
September	14 218, 40	17 533, 90	19 207, 12	19 044, 38	18 693, 12	20 712, 58	17 805, 04
October	15 246, 10	14 642, 44	15 658, 18	16 718, 82	19 005, 38	19 002, 08	16 651, 58
November	13 433, 96	14 222, 52	14 999, 50	15 583, 62	18 699, 43	16 723, 32	16 127, 00
December	13 964, 50	13 940, 68	15 621, 96	16 137, 70	19 171, 08	17 838, 34	17 131, 98
Total collected (Tons)	120	184	196	207	227	239	213
	439, 68	**556, 99**	**877, 43**	**814, 32**	**103, 33**	197, 88	**232, 83**

3. Materials and Methods

3.1 Sampling points

Five samples were taken from the surface layer of soil (0-20 cm) of the uncontrolled landfill in Tangier. These samples were manually sorted to remove metal, plastic, glass and stone. Residual samples were crushed and sieved particles less than 2mm in diameter were used for analyzes.

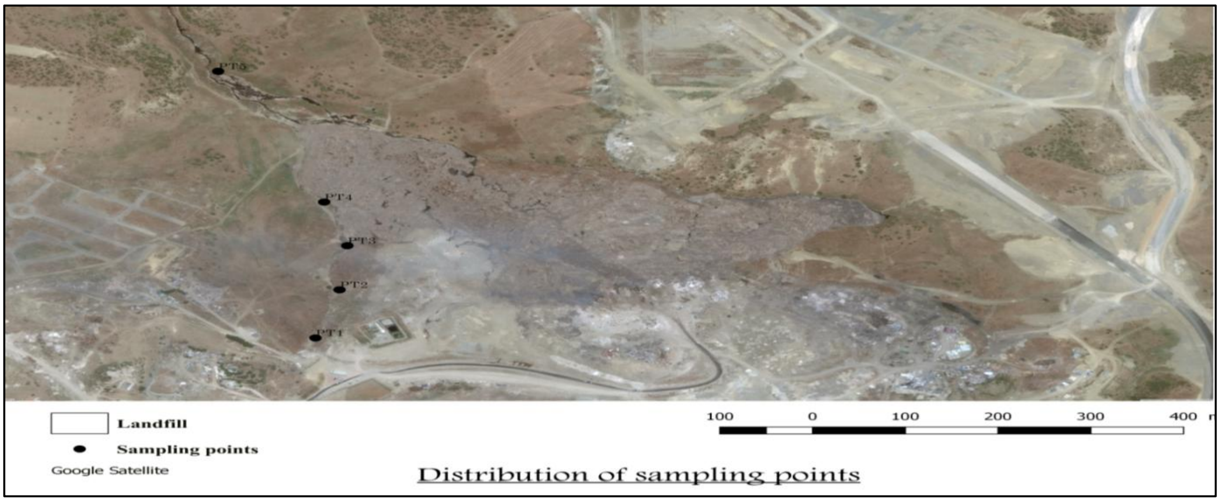


Figure 3: Distribution of sampling points

3.2 Soil analysis

3.2.1 Particle size analysis

The particle size of a soil corresponds to the distribution of minerals by size category (diameter), regardless of the nature and composition of these minerals. The purpose of particle size analysis is to determine the weight distribution of the different textural fractions of the mineral part of a soil.

The soil samples were dried at room temperature and out of direct sunlight, then sieved or through a vertical vibrating laboratory sieve for separation and exact pulling of the size fractions.

3.2.2 Organic Matter and Moisture Level

Dry matter (DM) is what you get when you remove water from a product. The percentage of dry matter is the ratio between the mass of dry matter and the mass of non-dry (hydrated) matter. Immediately after sampling, an aliquot of each of the samples sieved at 2 mm was dried in an oven at 105 C. The whole is weighed before and after passage in the oven. Drying is considered complete when the mass is constant (approximately 48 hours). The total organic matter content (OM in% DM) was determined by the loss in mass during the calcination of the sample at 550 C, for 5 hours.

Humidity level

The measurement of the humidity level consists in determining the mass of water removed by the drying of a humid material until a constant mass is obtained at a temperature of 105 ± 5 ° C for 24 hours of material after baking is taken as the mass of solid particles (ms). The moisture content determination was calculated from the ratio of the mass of water (mwater) to the mass of solid particles (ms).

This gives the water content of the sample analyzed as proposed by CALLAUD M. J.:

H (%) = (mwater / ms) * 100 = (mt-ms / ms) * 100

m water: body of water (g)

ms: mass of the dry sample (g)

mt: mass of the wet sample (g)

3.2.3 X fluorescence

X-ray fluorescence allows the chemical characterization of several materials such as ceramics, clays, alums, minerals, metals, oils. . . In the context of this work; we used this technique to determine the chemical composition of clays.

The elemental chemical analysis of the clay sample was carried out using an X-ray fluorescence spectrometer of the "Axion" type, with dispersion of wavelength 1 kW. This type of chemical analysis was carried out carried out at the CNRST laboratories.

3.2.4 Scanning Electron Microscope (SEM)

Observation with a Scanning Electron Microscope (SEM) has the advantage of allowing to visualize surfaces, and to highlight details of great finesse especially to characterize the inter and intra granular spaces (the first space between grains and within the binding phase, the second is in the constituent grains).

The sediment analysis by SEM was carried out at the laboratory of the Faculty of Sciences and Techniques of Tangier FSTT. The preparation of samples is restrictive. They must be dehydrated and then undergo treatment to become conductive (tissue fixation, cleaning). The sample is then placed on the slide. The beam is focused on the sample using magnetic lenses, interactions occur in the irradiated sample. This information is detected and transformed into images on a very small scale. The formed image is in 3D.

3.2.5 X-Ray Diffraction:

X-ray diffraction (XRD) is a powerful technique without destructive effects intended to characterize crystalline materials. It provides information on the structures, phases, preferred orientations of the crystal (texture) and other structural parameters such as average grain size, crystallinity, tension and crystal defects.

The samples were ground into powder were suspended in distilled deionized water, then spread on glass slides, air dried and analyzed with a diffractometer system (X-ray diffractometer D8 ADVANCE ECO).

4. Results and discussion

4.1 Practical size analysis

Table 2: Distribution of particle size fractions and porosity rate of soil samples

Samples	S1	S2	S3	S4	S5	s6
Clays	21	29	20	31	22	23
Limons	55	36	45	42	48	48
Silts	24	35	35	27	30	29
Porosity%	41, 29	32, 45	35, 45	32, 5	38, 2	40, 75

Particle size fractionations are regularly used to measure the structural stability of a soil and to study the organic matter bound to stable aggregates. The granulometry study shows that the samples are taken from fairly coarse soils, with a predominantly silty-clay-sandy texture. This study is carried out by the vertical vibration sieving method.

4.2 Organic Matter and Moisture Level

Table 3: Organic and dry matter of discharge soil

	Organic material %	Dry matter %
Sample 1	4	98, 1
Sample 2	3, 57	90, 62
Sample 3	13	95, 4
Sample 4	0.2	96, 3
Sample 5	9, 8	85, 9

Organic matter (OM) is the material produced by living things (plants, animals, fungi and other decomposers including microorganisms).

The organic matter content is the parameter which shows a very good correlation with the retention capacity of organic and metallic pollutants by the soil **[14]**.

The percentage of organic matter varies point to point from 0.2% to 13% with an average of 7.53%.

The value of the calculated moisture content is of the order of 1.9%, this explains the non-hygroscopic character which means that the humidity in this case is not a role, and it does not facilitate the clay particles to be compressed.

4.3 X fluorescence

Table 4: Elemental chemical composition of the sample

Element	SiO2	Al2O3	CaO	Fe2O3	MgO	K2O	Na2O
% Mass	64, 5	17, 9	7, 64	4, 4	2, 15	0, 926	0, 771
Element	ZnO	SrO	MnO2	ZrO2	HgO	Cr2O3	I
% Mass	0, 05888	0, 0403	0, 0356	0, 0257	0, 0246	0, 0233	0, 0159
Element	P2O5	TiO2	SO3	Cl	Nb2O5	Y2O3	Rb
% Mass	0, 651	0, 447	0, 269	0, 0916	0, 0157	0, 012	0, 00873

The percentage of Silica and Aluminum is very high; this indicates the presence of Kaolinite (Al2Si2O5 (OH) 4). As well as for Calcium which is relatively high, therefore this material is rich in Calcite (CaCO3). The **Alumina / Silica** ratio provides information on the permeability of the material with respect to humidity, the greater this ratio the greater the permeability **[15]**. In our case, this ratio is small Al2O3 / SiO2=0.27 %. This low value agrees with the low humidity percentage (1.9%). The SiO2 / Al2O3 molar ratio = 3.6 (maximum substitution of Si4 + by Al3 +) is greater than the conventional value for bentonites which is 2.7%. This difference indicates the presence of free Quartz in the clay fraction in large proportion **[16]**.

The overall composition of the other oxides (Fe2O3, MgO, K2O and Na2O) reaches a percentage of 8.24 which shows that our clay is not pure.

4.4 X-ray diffraction

The X-ray diagram of the raw clay is shown in the figure. The results indicate that the predominant constituents are quartz and silica, the high proportion of these two constituents is present in almost all of the diffractograms of the soil samples from the landfill.

The soil is composed in addition to quartz and calcite, Muscovite, Kaolinite, Hematite, and Alumohydrocalcite. So others composed but in low proportions like VanadianBassanite and Mica. (Fig 4)

These results are confirmed by scanning electron microscope analyzes. The results of MEB show that they are mainly made up of many alloys based on Si, Al, Fe, Mg, Ca, Cu. .

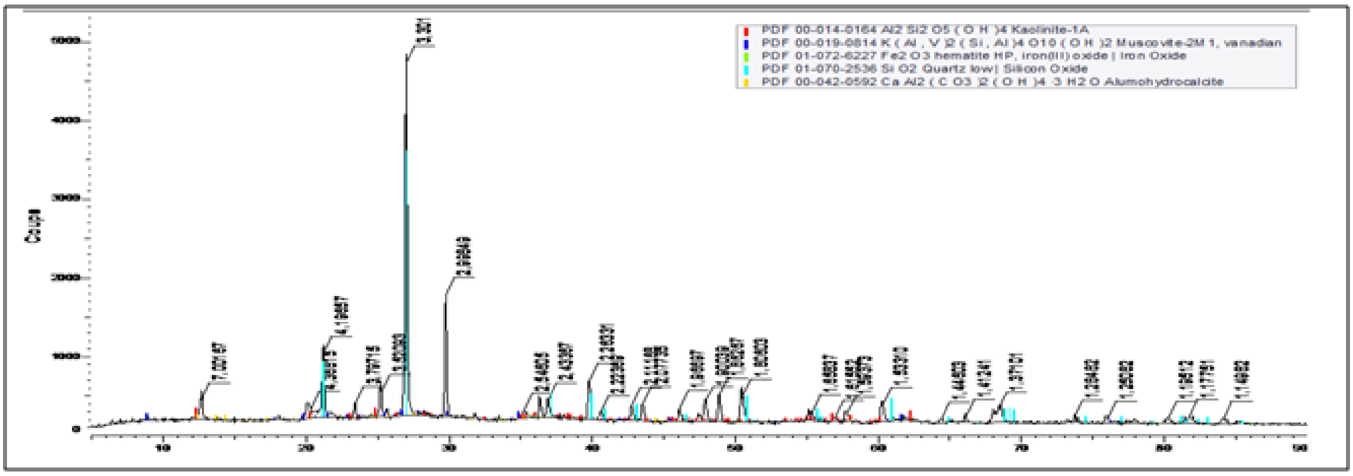
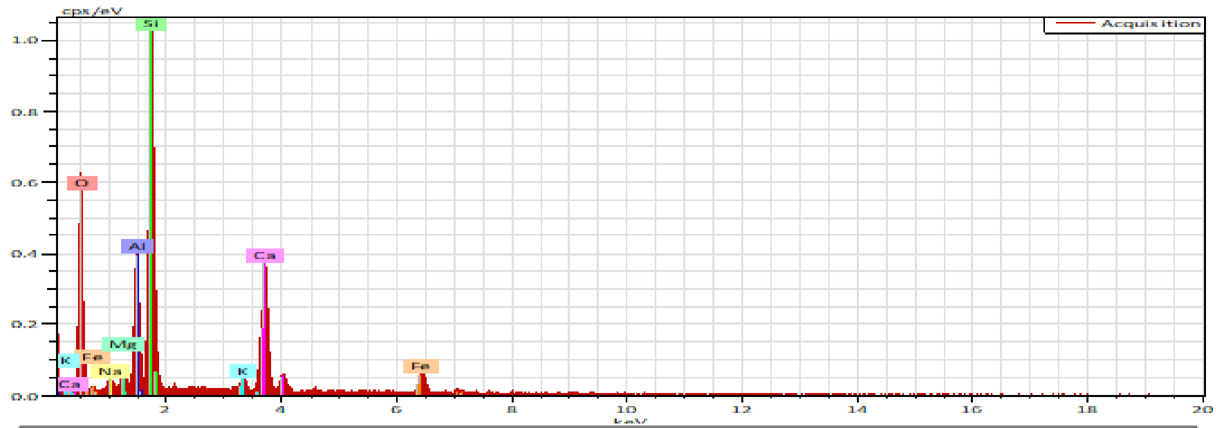


Figure 4: X-ray diffraction patterns of a soil sample (S3)

4.5 Scanning electron microscope (SEM)

Scanning microscopy makes it possible to observe the texture of the clay sample and to characterize mineralogical assemblages. The images obtained by scanning electron microscopy of the clay sample with different magnifications are shown in Figure 3. The clay particles appear in the form of clusters of fine aggregates and platelets in the form of rods with irregular outlines as has been shown by the MET. This is a morphology encountered both for poorly crystallized Kaolinites and for Illites as observed by Konan The image of the figure and in agreement with what we obtained in XRD, there is no doubt on the presence of carbonates and Quartz in the sample. Carbonates (Calcite) are in the form of conspicuous aggregates and Quartz is in the form of small grains.

The results of MEB show that they are mainly made up of Quartz and many alloys based on Silicon, Aluminum, Calcium, Iron, Manganese ……



Elément	Séries	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (3 Sigma) [wt.%]
oxygène	K-series	78.05	60.28	73.76	45.59
silicium	K-series	21.90	16.91	11.79	3.26
aluminium	K-series	12.80	9.88	7.17	2.37
calcium	K-series	8.32	6.43	3.14	1.17
sodium	K-series	2.56	1.98	1.69	1.15
Fer	K-séries	2.57	1.99	0.70	0.67
Magnésium	K-séries	2.09	1.61	1.30	0.79
Potassium	K-séries	1.19	0.92	0.46	0.37

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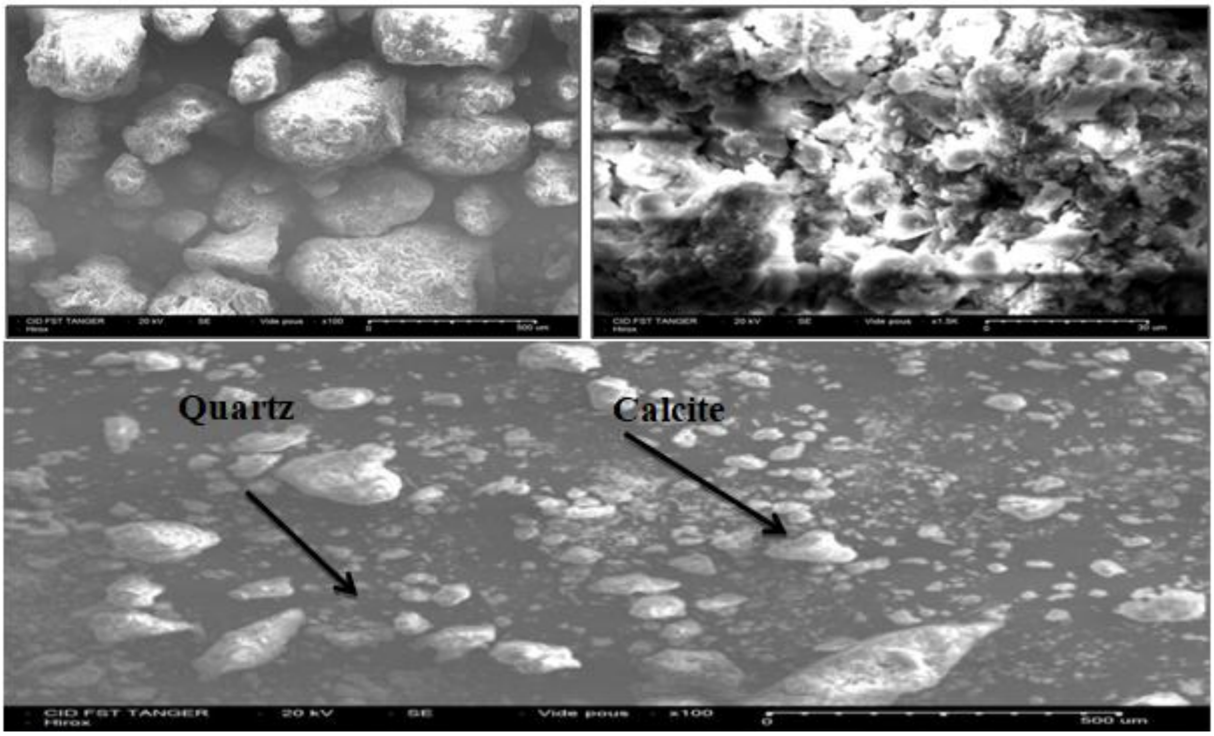

Figure 5: SEM image with an example of EDS (Energy Dispersive x-ray Spectroscopy) spectrum of the tangier discharge soil

5. Conclusion

This study was carried out on a soil profile of the public landfill of the city of Tangier with a sampling covering 5 positions of depth varying between 0-10 cm.

Analyzes by DRX; SEM and Fluorescence X also make it possible to define the composition of the mineral fraction of these soils, they are essentially composed in addition to quartz and calcite, Kaolinite, halite; Muscovite and vanadium. In addition, the in-depth analyzes of SEM have shown the presence of intra-granular porosities in the grains of these soils. The results of X-fluorescence analysis indicate the presence of Silica, Calcium and Aluminum.

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