Physico-chemical characterization of the landfill of Mohammedia (Morocco)

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ABSTRACT

This study focuses on assessment of waste metal (leaden, chromium, iron. etc...) in leachates from the landfill of the city of Mohammedia. Leachate have a high concentration of heavy metals, sediment collected at the landfill are high concentrations of Cr, Pb and Fe. Moreover, the concentrations of these metals detected in sediments collected near to river el Maleh have significant traces of Fe, Cr, Pb and Cd. This is evidence of heavy metal pollution from the discharge near the river. In addition, the analysis and treatment of all physico-chemical data (temperature, pH, salinity, conductivity, dissolved oxygen, suspended matter, total organic carbon), have identified some clues reflect organic pollution. And for the potential damage caused by the landfill of Mohammedia on the environment and its proximity to the dam el Maleh hence the need to identify a plan to rehabilitate the old quarry. It is the object of our study.

Keywords - Morocco, landfill, leachates, physic-chemical, characterization, rehabilitation.

I. INTRODUCTION

Morocco has a set of areas of quarries, with their materials and their operating locations, are of interest both economic and environmental.

As part of the identification and redevelopment of areas of quarries, the clay quarry of Mohammedia, is located in proximity of the river El Maleh; of an area of 26 hectares.

It extends between the golf course and the edge of the plateau of part and other one of the valley of Oued and separate the old city with its industrial district and its new extensions, the industrial zone of the first category includes the SAMIR refinery, thermal central and the SNEP.

The city of Mohammedia, however, although it is characterized by a highly developed water system, its water resources are facing problems of quantity and quality. They are limited because of the half dried climate of the region and experience a deterioration in their quality by intense activities urban, industrial, craft and agricultural facing this area [3].

This work, executed in the laboratory "of Geotechnical Engineering, Applied Geophysics, Geology Engineering and Environment, from the Mohammedia School of Engineers of Rabat, Had for objective to evaluate the quality and the quantity physico-chimical of superficial waters of river El Maleh in relation with the effects of leachate emanating of the transformation of the old quarry of clay in public landfill and to identify a plan of rehabilitation of this landfill.

II. MATERIELS AND METHODS

II.1. Study site

The quarry of clay is situated near the river el Maleh, in the city of Mohammedia (33°33’N ; 7°23’W), city of Moroccan Atlantic coast 65 km south of Rabat and 20 km north of Casablanca.

The peculiarity of this area is that it is marked by an important aspect reddish clay formation elongated along the valley of river el Maleh at Southwest; the career show sometimes silty clay formations whose plasticity differs from one place to another [7].

The quarry site is located in an area not under cultivation in complex topography, its neighborhood consists essentially by reliefs covered by vegetation. The population are far from the quarry site approximately 1200m. On the hydrological plan, the site of the quarry is characterized by the existence of river el Maleh and its dam upstream. In the region there are two types of groundwater :

The superficial groundwater which assures the drinkable water supply of douars almost along the year. It is fed by the hydrological network which is represented in the region by some small effluents (chaabas). The site topography is very rugged and the water is very deep; it can reach on the site deeper than 150m. This is a free groundwater [7].

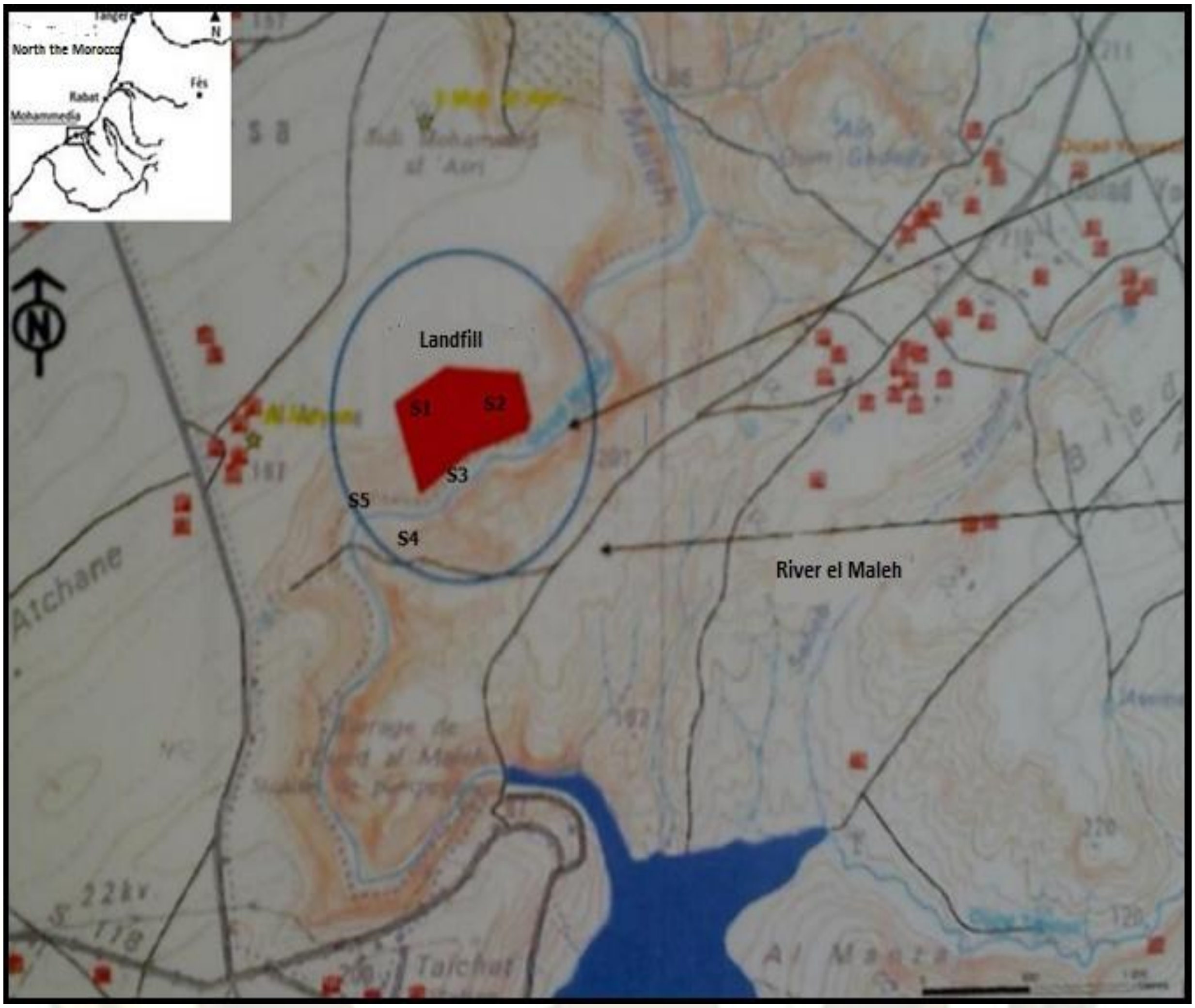


Figure 1 : Geographic position and location of the different stations of study In the quarry of clay of Mohammedia.

II.2. Regional geological framework

The study area belongs to the field of coastal Meseta, limited on the west by the Atlantic Ocean, in the South of the plain Guantours and in the East by the Central Massif of Morocco [3].

It consists essentially of layers of primary age surmounted by a major unconformity layers of tertiary or quaternary age.

This regional area has an area of about 720km, secondary and tertiary movements have made deposits more or less powerful in their successive transgressions which have accumulated during the Quaternary sandy clay silt.

This plain is limited by the tray of Settat to the Southeast, by river el Maleh in the Northeast, in the Southwest there is a primary of Souk Jamaâ, Finally coastal sahel in the Northwest which constitutes the outlet downstream of the plain towards the ocean.

The secondary consists of Permo-Trais facies enough under his usual pelitic clay and red sandstone, conglomerate and basalt flows otherwise, we note the presence of levels important gypsiferous; the whole ground appear only on borders, in particular in the North in the valley of river el Maleh [3].

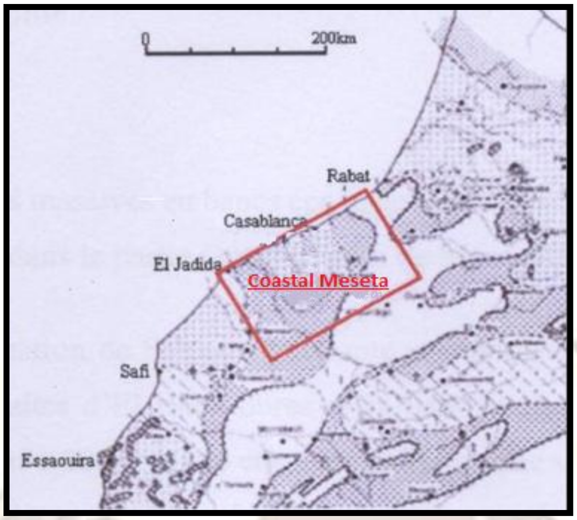


Figure n° 2 : Structural outline [3]

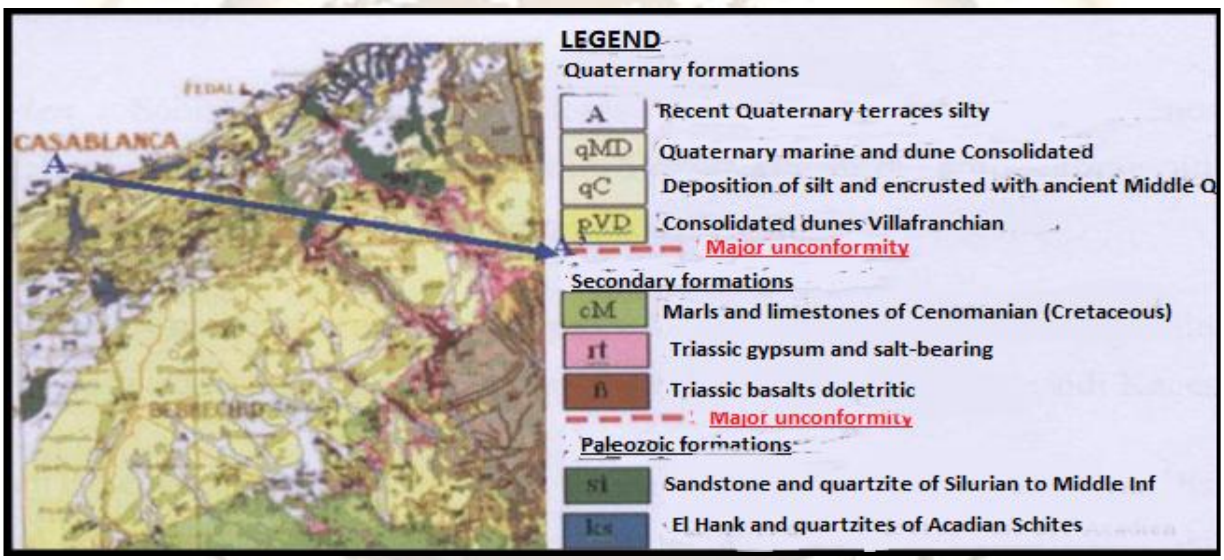


Figure 3 : Excerpt from a geological map 1/500 000 (N et Mn° 70 : paper Rabat).

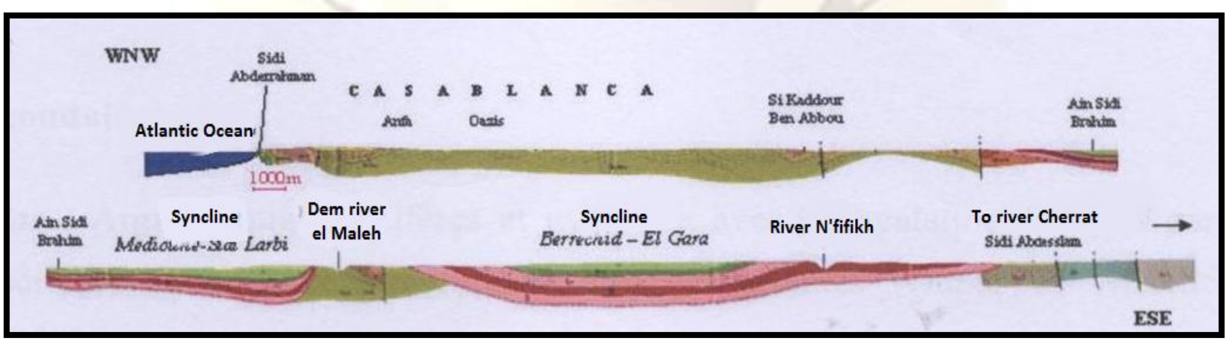


Figure n° 4 : Synthetic geological cutting through the Coastal Meseta [3].

II.3. Choice of stations

Five stations of sampling are distributed on the landfill were chosen so that they are representative, accessible, witnesses of the actual characteristics of these waters taken from wells at the various sites explored and to determine their overall physical and chemical processes defining the problem of contamination by the leaden and chromium (Figure. 1). They are distributed as follows:

– the stations S1 and S2, are located at the landfill;
- the station S3 is between the quarry and the river el Maleh;
– the stations S4 and S5 are located downstream of the river el Maleh.

II.4. Sampling

Les échantillons d'eau de surface ont été prélevés à l'aide de flacons en polyéthylène de 250 ml, previously washed in the distilled water and transported in portable iceboxes (+4 °C).

II.5. Physico-chemical analysis of water

The physico-chemical determinism of waters of the landfill and rievr el Maleh were realized by the analysis of 11 physical and chemical parameters of the water at the level of 5 stations. Five of these variables were measured on the ground:

The temperature, the pH, the salinity, the conductivity and the dissolved oxygen. The biological demand in oxygen, the nitrates, the sulfates, the metallic analysis in Cr and Pb, the suspension material and the total organic carbon (COT), were measured in the laboratory. The techniques of analysis appear in the table 1.

Table 1 : Methods of analysis of the various physico-chemical parameters [3].

Parameters	Methods of analysis	Units	Sources
Temperature	Mercury thermometer, precision in 1/10	°C	
pH	pHmètre ORION Research, Ionalyser Model 607 with specific electrode O2 electrode ORION Research model 91-05		
Salinity	Salinometre YSI (model 33); S.C.T meter	g/l	
Conductivity	Conductimetre, YSI (modèle 33); S-C-T meter	µS/cm	
Dissolved oxygen	Oxymetre, ORION Research, Ionalyser model 607, With specific electrod O2 electrod ORION Research model 91-05	mg/l O2	
D.B.O5	Dilution method		Norme AFNOR T 90-103
Nitrates	Conversion of nitrates derived nitro-phenol-sulfuric colored, Then dosage with spectrophotometry of this derivative¯	mg/l NO3	Norme AFNOR NF 90-012
Sulfates	Nephelometric method; sulphates are precipitated In hydrochloric middle in the state of sulfate of barium. The obtained precipitate is stabilized by the "tween20". The homogeneous suspensions are measured in the spectrophotomètre	mg/l de SO4¯¯	Rodier (1996)
Total Phosphor	The fractions of the inorganic phosphor Are mineralized in the form of orthophosphates. The mineralization is made in acid medium in the presence of Hour persulfate of potassium (K2ZH2O8) in 120 °C during 2. After neutralization of PH and adjustment in a given volume, we proceed to the dosage of the phosphor, Mineralized as for orthophosphates.	mg/l de Pt	Rodier (1996)

III. RESULTS AND DISCUSSION

III.1. Spatial evaluation of the quality of waters of taking

The parameters are represented by the profile of its spatial evolution (Figure.5). This profile allows to make a global and spatial approach of the contamination of waters of the landfill and at the level of river el Maleh. The results of analyses realized at the level of the stations of taking are represented in the table. 2 and the figure 5.

Table 2 : Hydrological characteristics of the landfill water and river el Maleh (mean ± standard deviation limits).

	S1	S2	S3	S4	S5
Ta (°C)	22,40±3,92 (27,78–5,10)	22,25±3,24 (26,80–16,80)	22,87±3,96 (26,90–15,40)	21,31±2,72 (25,40–17,00)	20,31±2,65 (24,70–16,50)
Te (°C)	23,17±4,63 (28,30–4,30)	23,00±4,53 (29,70–14,80)	23,50±4,40 (28,90–15,01)	22,05±4,12 (27,50–15,00)	21,09±4,03 (27,00–15,02)
pH	7,76±0,45 (8,44–7,22)	7,65±0,40 (8,52–7,25)	7,58±0,27 (7,83–7,10)	7,81±0,38 (8,30–7,02)	7,82±0,23 (8,02–7,40)
Sa ‰	6,08±2,05 (8,70–2,60)	12,27±3,55 (18,50–8,20)	21,58±6,42 (31,00–12,50)	27,21±3,94 (34,10–22,20)	33,54±1,12 (34,80–31,70)
Ce (mS/cm)	0,84±0,27 (1,49–0,59)	10,64±8,38 (27,50–0,79)	19,84±11,80 (48,10–10,51)	30,23±12,62 (52,20–13,10)	44,58±7,29 (54,70–36,40)
OD (mg/l)	6,43±2,86 (11,1–2,17)	7,33±3,34 (12,30–4)	8,21±3,87 (13,60–3,5)	8,75±4,39 (15,00–2,5)	7,68±4,56 (15,40–2,95)
MS (mg/l)	73,27±29,14 (108,00–31,20)	55,49±25,26 (86,00–12,85)	53,79±19,26 (80,00–29,45)	55,59±26,65 (82,00–10,56)	42,28±28,57 (81,00–14,30)
CO (mg/l)	8,33±1,56 (10,50–6,30)	8,88±2,54 (12,14–5,20)	9,06±5,08 (15,40–3,10)	11,83±8,48 (24,60–3,70)	19,96±10,55 (33,40–3,50)
NO (mg/l)	2,40±4,24 (12,80–0,38)	2,19±1,93 (5,70–0,67)	2,98±4,23 (12,40–0,13)	5,04±5,25 (13,80–0,80)	4,89±5,88 (13,50–0,27)
DC (mg/l)	20,28±9,34 (38,40–10,00)	20,91±7,34 (30,50–11,60)	36,31±36,22 (98,20–10,50)	26,60±14,49 (50,00–9,70)	25,76±12,30 (46,70–12,30)
DB (mg/l)	8,47±4,08 (13,10–2,29)	9,86±4,26 (16,90–3,71)	10,82±7,85 (24,40–3,90)	5,75±2,87 (11,50–2,78)	10,67±7,81 (23,50–2,80)

Do : dissolved oxygen; SM : suspended matter; TOC : total organic carbon; NO3- : nitrate ; COD : Chemical demand in oxygen; BOD : Biological demand in oxygen ; S : station

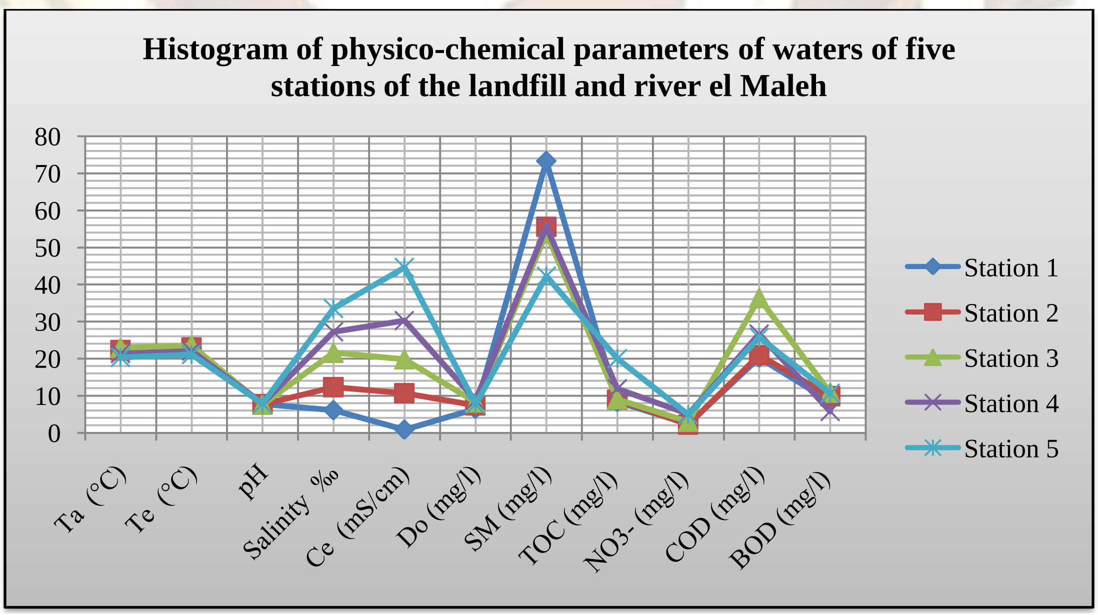


Figure 5 : Evolution of the physico-chemical parameters of water sampling stations mentioned before.

Stations S1 and S2

The waters of the landfill brought by ground-water sheets at the level of stations S1 and S2 are characterized by a high mineralization (5,74 mS / cm conductivity), owed not only to the contents of the ions chlorides, but especially to those of sulphate ions . The situation is relatively good in both stations S1 and S2. It is translated by a reduction in the content of most part of the chemical parameters (BOD5, COD, NO3-) and an ascent of the oxygen compared with the other stations.

Stations S3

The waters of the station S3 represent the transition between the waters of the two stations S1 and S2 taken at landfill and those levied at river el maleh S4 and S5, The contents of the majority of the physical and chemical parameters mainly those in connection with the nature of the substratum remain high in absolute values (conductivity, salinity, nitrates).

However a light decrease is noted. The content of NO3-does not know a big variation thanks to the availability of the oxygen, the presence of which favors the active admixture of these waters. We note the presence of urban and industrial discharges at this level, hence the persistence of the load conveyed upstream of the discharge to the river, which is reflected by a value of BOD5 on 10 , 82 mg / l). For COD, there is an increase of 36.31 mg / l. This can be explained by the presence of minerals such as chlorides, sulphates, calcium and abundant in S3, The discount in suspension of numerous décantables elements under the effect of the admixture, can also contribute to the increase of the values of the COD.

Table. 3 : Concentrations of metals in different sediment samples from different stations expressed in mg / g dry weight except Fe in mg / g (mean ± standard deviation limits)

	S1	S2	S3	S4	S5
Fe	28,52±9,13 (39,82−15,69)	28,51±8,15 (40,28−21,40)	23,07±8,82 (36,69−12,22)	26,61±10,59 (37,91−12,20)	29,29±8,81 (40,57−13,83)
Zn	129,36±22,85 (159,90−105,20)	130,13±15,35 (154,60−115,2)	109,78±8,80 (121,40−98,69)	102,00±6,85 (111,20−93,70)	105,80±4,88 (112,10−98,90)
Cu	14,63±12,39 (29,80−2,04)	14,04±8,55 (24,67−5,05)	13,50±11,27 (28,50−2,310)	19,07±5,21 (25,40−10,62)	23,03±7,71 (29,30−12,50)
Pb	70,13±30,64 (99,87−22,64)	50,78±24,27 (78,40−20,57)	21,87±34,91 (92,90−2,10)	83,23±29,50 (111,70−30,28)	45,88±52,31 (113,10−3,60)
Cr	64,24±41,71 (103,50−8,87)	63,18±42,16 (95,96−4,41)	59,37±51,75 (119,80 −1,20)	97,23±41,68 (122,10−13,51)	72,29±53,88 (124,30−5,66)
Cd	0,91±0,87 (2,30−0,09)	1,09±1,01 (2,57−0,06)	1,08±1,13 (2,89−0,05)	1,28±1,39 (3,40−0,01)	1,18±1,26 (3,10−0,09)

Stations S4 and S5

We are witnessing at the S4 and S5 to a significant increase especially in the COD reaching the average value of 26.18 mg / l, together with a sharp drop in the average level of dissolved oxygen 8.21 mg / l. This matter load is accompanied by an oxidizable chemical pollution marked by increased levels of total organic carbon (11,83 mg/l, in table. 1).

Moreover, in S4 the values of COD (26.60 mg / l) far exceed those of BOD5 (5,76 mg/l). This established fact testifies of the ascendancy of a pollution of excessive industrial origin at this level there, where from results a critical situation which is mostly translated by a strong fish mortality further to an asphyxiation of fishes.

Indeed, these relatively high levels of COD compared to those of BOD5 at this level could certainly translate the presence of a load dominated by a few biodegradable micropollution (heavy metals) may be masked by the organic load.

III.2. Evaluation of the spatial variation of heavy metal contamination of samples analyzed

The results of the various samples analyzed are presented in Table. 3, 4 and Figure 6.

Table 4 : Order of enrichment of sediments of stations.

Metallic elements	Orders of enrichment
Fe	S2 > S1 > S3 > S5 > S4
Cu	S4 > S1 > S2 > S5 > S3
Pb	S4 > S5 > S2 > S3 > S1
Fe	S2 > S1 > S3 > S5 > S4
Cu	S4 > S1 > S2 > S5 > S3
Pb	S4 > S5 > S2 > S3 > S1

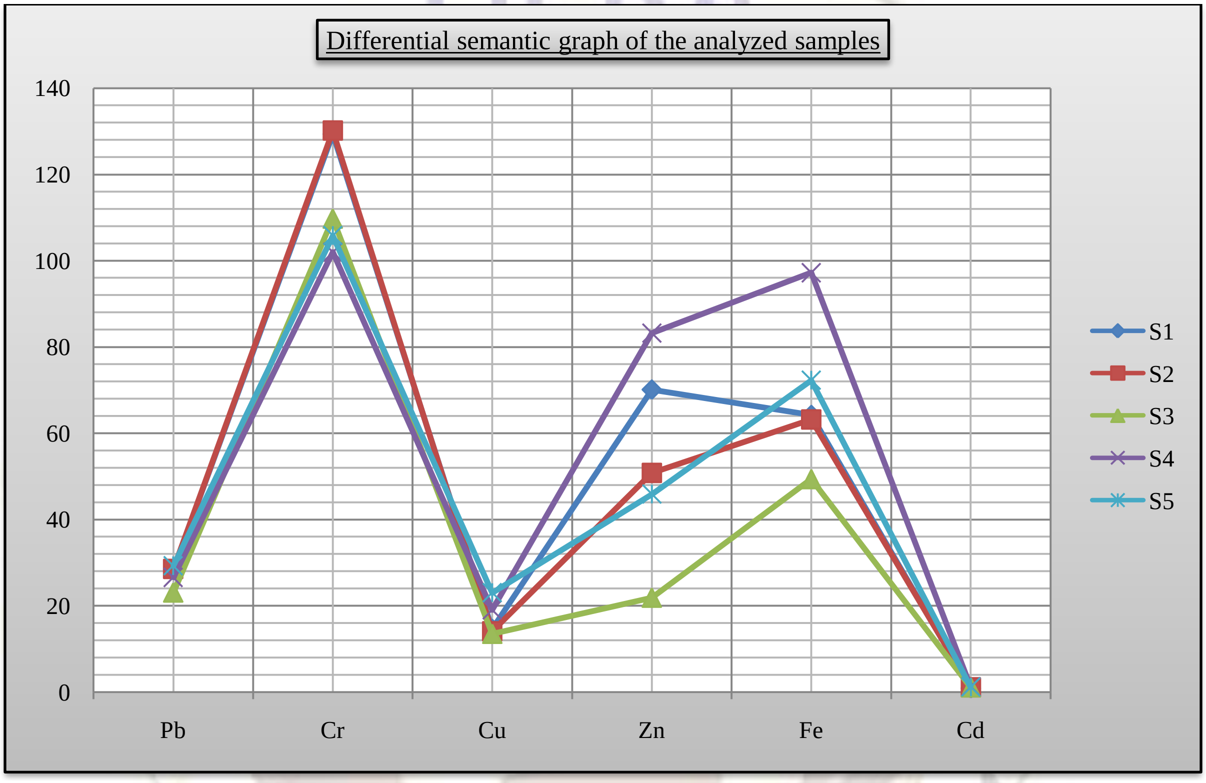


Figure 6 : Differential semantic graphs of the metallic elements in the analyzed samples.

The figure 6 shows the graph of semantic differential metallic elements in the samples analyzed. Indeed, Pb and Cr concentrations show the most important of all metallic elements of our study with a maximum of up to 40.28 mg / g recorded in the station S5 and 159.90 mg / g recorded in the station S1.

III.3. Assessment of metal contamination of the samples analyzed

The highest average concentrations are those of Fe (27.20 mg / g) followed by Zn (115.41 mg / g), Pb (69.26 mg / g), Cr (54.38 mg / g), Cu (16.85 mg / g) and Cd (1.11 mg / g). Stations S1 and S4 have the highest rates of metallic elements, especially in the case of Fe, Cu, Cr and Zn in comparison with those of the S3 station located further releases.
This enrichment in metallic elements is to be put in connection with the contributions of lixiviats produced by the landfill of Mohammedia.

In all the stations, the average content in Fe (27,20 mg / g) exceeds that some not polluted sediment (13,20 mg/g) (Nicolaidou et Nott, 1998). The excess of Fe could result from contributions of waste water of factories near the landfill.

As well as for Zn (115,41 µg / g), the contents are Superior to the reference contents (90 µg / g) [18].so underlining a pollution moderated by Zn. On the

other hand for Cu (16,85 µg / g), the contents are lower than the reference contents [13].which are 30 µg / g.
Sediments of the zone of all the stations exceed the references of the table. 2 [10] concerning the contents in Pb, Cd and Zn and is contaminated thus significantly in metals.
The level of contamination is considered low to moderately above stations with values lying above the guideline values proposed by metal contents [18]. It is upper to 0,15 µg / g for Cd, 30 µg / g for Pb and 90 µg / g for Zn which represent the concentrations considered as natural in coastal sediments [13].

A significant contamination was noted for Cr, Pb and Cd. Indeed, the average contents of Cr (54,38 µg / g) raised exceed those of reference. Moreover, the spatial evolution of the contamination revealed an average content of Cr at station S3 (located near the landfill).

Table 5 : Results of microbiological analyzes [12]

ug/l	Waters of surface between the discharge(dump) and the river	River of Maleh/ml	Juice of the landfill /ml
Total coliform	180	150 000	700 000
Fecal coli-	780	120 000	400 000
Fecal streptococci	1500	80 000	520 000
Staphylococcal pathogenesis	0	60 000	270 000
Salmonella	0	0	0

On the other hand for Pb, the high concentrations were registered at the level of stations S4 and S5 (sediments taken at the level of river el Maleh). This testifies of a pollution in heavy metals resulting from the landfill.

For Cd, the contents of the studied stations exceed the limit value of 0,15 µg / g which is presented by [13] and thus stations are significantly contaminated. The global rate of this metal in fine sediments is far from being unimportant in the studied stations compared with the natural contents. Sediments of these stations are difficult to interpretThe results of these analyses indicate a strong pollution of Oued el Maleh by the lixiviats of the discharge. To note the presence of pathogenic Staphilocoques, in high concentration; this water has to serve, neither to the Human food, nor to the irrigation, nor even to the bathing [12].
As regards waters of the surface between thedischarge(dump) and the Oued el Maleh, the results(profits) of analysis indicate the presence of this Coliforme as well as faecal Stréptocoques: this water is thus unfit of the consumption [12].

III.4. Rehabilitation of quarries

The implementation of the on-site waste

This one (after pouring) consists at first in spreading. The waste will regularly be arranged by coats from 1 to 3 m weakly compacted, piled on the height of the rack by moving forward gradually the forehead of the deposit. The lands of covers must be put according to the exploitation. This technique ' in skin of onion ' in for advantage the limitation of the size of zones in exploitation and this with the aim of limiting the flights, the presence of animals and the infiltrations of water in the waste. It is necessary to assure a slope from 3 to 6 % on all the surface of waste to assure a streaming of rainwater.

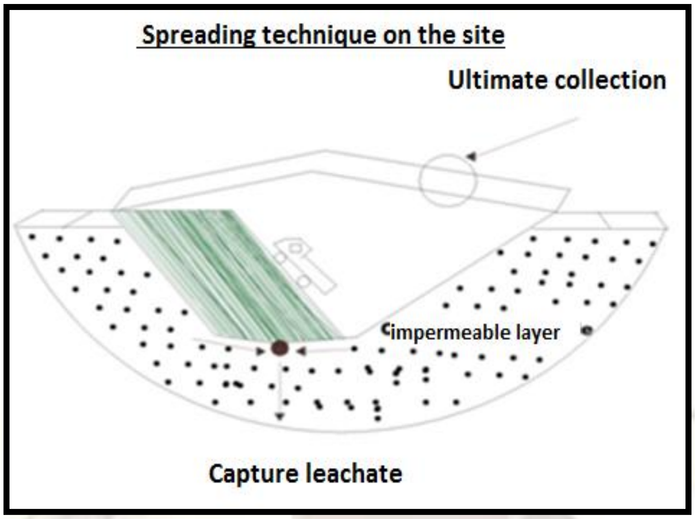
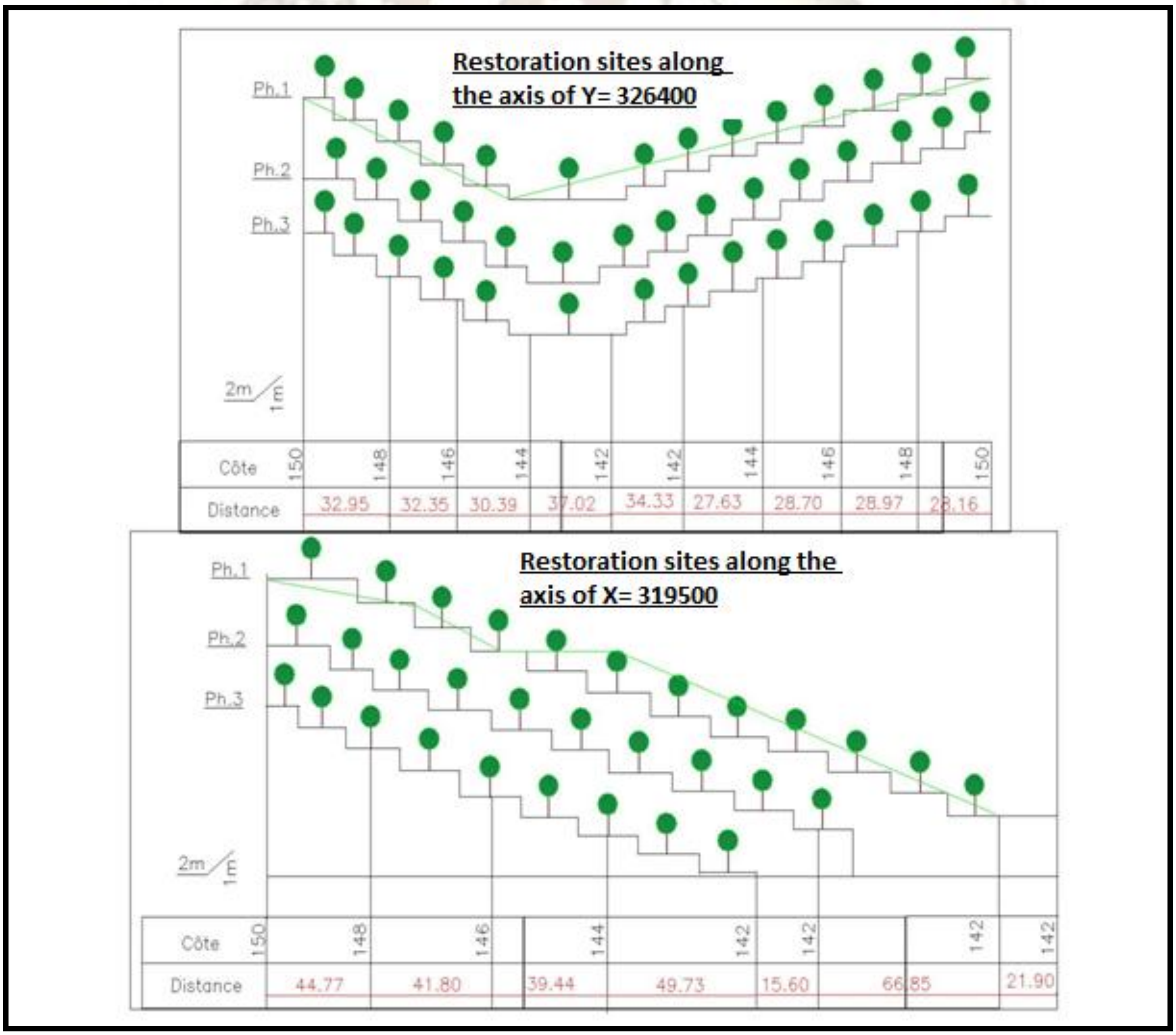


Figure 7 : Rehabilitation plan of the quarry



System of covering and drainage of the lixiviat

Afterward waste will be covered by a clayey cover from 1.5 to 2.5 meters in thickness, that could allow rainwater to percoler through the cover and to accumulate in the discharge, and that waters of lixiviat migrated in the immediate environment of the discharge and seen the nearness of the dam el Maleh that allows to contaminate the restraint of water of the dam.

And to avoid any risk of instability of the landfill body and reduce infiltration as quickly as possible, the water level will be lowered leachate using a pumping system which consists of the first phase of the work of sanitation consists of installing a drainage system in the dump body, looks control and discharge lines. In addition, a water purification plant to be built downstream in the example concise discharge Oued Nfifikh in 2003.

The 2nd phase of purification corresponds to the implementation of a device of waterproofness which is constituted by several coats of different grading and mineralogical natures. From top to bottom, we can distinguish:

- A plant cover, the lower coat of which is constituted by materials of excavation,
- A zone rhizosphérique ' muddy clays with sands and gravels, containing some stones and blocks),
- A coat of waterproofness (compacted clays),
- A drainage layer capillary (sandy, siliceous),
- A capillary barrier (gravel).

Water-treatment plant

The installation of leachate water treatment comprises the following steps:

An anaerobic purification (filter size),
An aerobic treatment (activated sludge plant with aeration),
An additional aerobic treatment (activated carbon and sand),
A treatment plant denitrification (two ponds).

IV. CONCLUSION

The diagnosis revealed the presence of an organic and mineral important points downstream of discharges from the landfill. It gives the classic image of a high pollution reflecting the impact of the landfill on the environment. However, this total load is not constant, it fluctuates in time and space.

The results of the analysis of physico-chemical parameters of samples of the river el Maleh who are exposed to before we were used to assess water quality and degradation of this quality at stations S4 and S5. These results showed globally that the physico-chemical parameters recorded at the specimens showed high levels of heavy metals.

For suspended solids, we note that the water content increases in sediment when these materials are increasing.

The leachate that drains by gravity into the river el Maleh which seep into the ground to reach the groundwater a few meters deep.

The analysis and treatment of all physico-chemical data indicate highly polluted waters, taken at river el Maleh and at landfill from the leachate. View and the proximity of the landfill of the water retention dam el Maleh, it could contaminated water retention which will later will not help either for human consumption or irrigation, or even for swimming.

Therefore, the rehabilitation of the landfill has become a necessity instead of a simple reinstatement of the old quarry in the environment.

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