[*Gamar* et al., 4(9): September, 2017*] ISSN: 234-5197
Impact Factor: 2.715

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

TEMPORAL EVOLUTION OF THE PHYSICO-CHEMICAL AND BIOLOGICAL LEACHATE QUALITY FROM THE DISCHARGE PUBLIC OF EL HAJEB TOWN (MOROCCO)

Abderrahmane Gamar*[1,2], Zakaria Khiya[1,2], Touria Zair[1,2], Mohammed El Kabriti[3], Abdelaziz Bouhlal[4], Fatima El Hilali[1,2]

[1]Research team of Chemistry of the Bioactive Molecules and the Environment. Department of Chemistry. Moulay Ismail University, Faculty of Sciences, Meknes, Morocco
[2]Laboratory of Chemistry of Materials and Biotechnology of Natural Products (Chima-Bio). Department of Chemistry. Moulay Ismail University, Faculty of Sciences, Meknes, Morocco
[3]National Laboratory of the Studies and the Surveillance of the Pollution (NLSSP), Rabat, Morocco
[4]Laboratory of the National Office of Electricity and Drinking Water (LNOEW)-drinking water branch, Meknes, Morocco
DOI: 10.5281/zenodo.904964

Keywords: physicochemical, biological, climate, parameter, leachate, evolution.

Abstract
The wild public landfill of the city of El Hajeb (Morocco) constitutes the central installation of storage and solid waste disposal (domestic, hospitable and other). Enormous quantities of putrescible waste rejected in this discharge, generate very polluting leachates constituting a danger for the environment and in particular for the groundwater which circulates in low depth. This work aims to study the temporal variation of this discharge leachate quality. In this study, sampling was carried out on a monthly step during a hydrological cycle, which spread from May-2015 to January-2017. The climatic data revealed that the climate of the zone of study could be classified as a semi-continental climate in a semi-arid to arid bioclimatic level between temperate and warm. Statistical study by the principal components analysis (PCA) of temporal monitoring of various physicochemical and biological parameters revealed a dry episode was characterized by a maximum increase in biochemical oxygen demand (BOD5 max = 17000 mgO2/L), in salts (EC max = 27.19 mS/cm), nitrate (NO3- max = 78.09 mg/L), in total Kjeldahl nitrogen (TKN max = 968.11 mg-N/L), in total phosphorus (TP max = 157.12 mg-P/L), in metallic load (Fe max = 1069.54 mg/L, As max = 2.79 mg/L and Cd max = 0.61 mg/L) and in microorganisms (total coliform max = 4.37e+7 CFU/100mL); and a significant decrease in dissolved oxygen (DO min = 0.65 mg/L), in sulfate (SO4 min = 943.32 mg/L), in suspended matter (TSS min = 671.56 mg/l) and in turbidity (Turb min = 1983.67 NTU). This phenomenon was reversed in wet period. The dilution by rain and low temperatures contributed strongly to this change in the quality of the leachates. In deed the study revealed the significant correlations between temperature and report BOD5/COD (r = 0.88), between temperature and chlorides (r = 0.82), between temperature and sulfates (r = -0.88) and between precipitation (P) and Zn (r = 0.91), between (P) and Ni (r = 0.70) and between (P) and Al (r = 0.83). It resulted from it of this study that the combined effect of precipitation and temperature was an important factor among others that governed the evolution of the quality of the leachate generated.

Introduction
Landfills have been identified as one of the major threats to groundwater resources [1]. In Morocco, waste production does not cease increasing, in quantity and in quality, engendering enormous environmental risks. Indeed, as of their setting in discharge, wastes are subjected to either groundwater underflow or infiltration from precipitation. The dumped solid wastes gradually release its initial interstitial water and some of its decomposition by-products get into water moving through the waste deposit. Such liquid containing innumerable organic and inorganic compounds is called 'leachate'. This leachate accumulates at the bottom of the landfill and percolates through the soil. This leachate is the seat of the degradation process related to complex physicochemical and biological reactions, what presents, potential risks of environment degradation by

emanation of foul odors (H_2S, NH_3, …), emission of poison gases and to greenhouse effect (CO_2, CH_4, ...). The effluent physicochemical quality is very diverse and variable in time and space [2].

The chemical composition of leachates is specific to each landfill. It depends on certain parameters such as nature, the age of the landfill, the type of waste, the method of depositing, the nature of the site, the climatic conditions, etc. [3]. Inside discharge (Fig. 1), by crossing waste, rain water loads in pathogenic germs, in pollutants organic and mineral [4]. With content of waste initial water, pluviometry represents the main contribution in hydric balance sheet. Knowledge of precipitation, temperatures, humidity and evapotranspiration mode is thus a crucial element for the study. Moreover the evaluation of volumes of produced leachates can be obtained by making a hydric balance sheet of the site, by means of a formula which entered parameters relative to the natural conditions and to the exploitation [5]: $P + ED + R1 = I + E + ETR + R2$

where:

- P: precipitation volume;
- ED: volume of water brought by waste;
- R1: water volume brought by streaming;
- I: leachates volume infiltrated in the basement through the discharge bottom;
- E: collected leachates volume;
- ETR: water volume eliminated by real evapotranspiration;
- R2: exported water volume of the discharge by streaming. [6].

Consequently, we propose to study the seasonal evolution of various parameters characterizing the leachate of a wild dump that serves the town of El Hajeb (Morocco) and to identify their interactions with temperature and precipitation whose intention is to be able to assess, in another work, the impact of leachate on the adjacent groundwater.

Materials and methods

Geographical situation of the study area

Located at the junction of Sais rich plain and Middle Atlas foothills (Fig. 1), El Hajeb city is to 30 km from south of Meknes (the nearest city), to 200 km as crow flies from east of Casablanca (The economic capital of Morocco). Altitude relative to sea level is of 1054 m. Study region characterized by an intensive agricultural development where all of lands are cultivated.

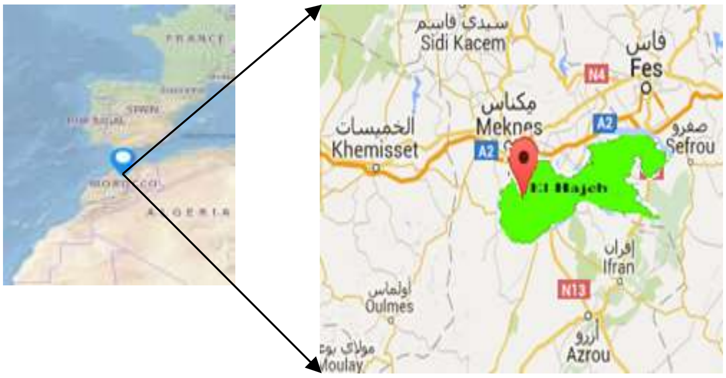

Figure 1: Map showing the study site of the city of El Hajeb (Morocco).

Particularity climatic

Ombrothermic diagram: Figure 2 showed diagram ombrothermic of the station relating to the study area. It emerges from it that dry period was increasingly important and long, it extended of in the beginning of May at mid-January. While humid period was short and extended of in the mid-January at the end of April.

De Martonne's index: This index is a function of temperature and precipitation; it is calculated by the following relationship:

$I = \frac{P}{T+10}$ .Where: P = 335.72 mm; T = 18.70 °C and so I = 11.69

We concluded that from it the climate of study area was semi-arid. Concerning precipitation, this climate stage was characterized by a pluviometry varying between 200 and 500 mm, while the number of dry months varies

ISSN: 234-5197
Impact Factor: 2.715

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

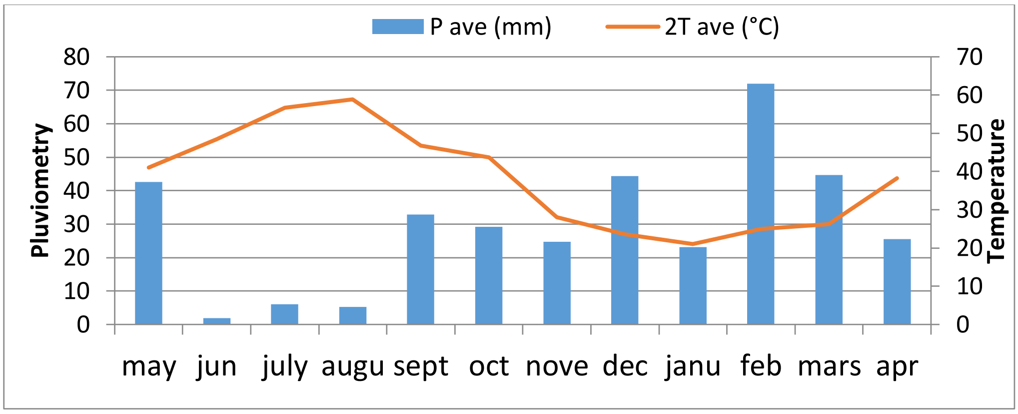

Figure 2: Ombrothermic diagram period May 2015 – January 2017
P ave: average monthly rainfall; T ave: average monthly of temperature

between 5 and 7.

Thermal amplitude (M-m): It's the difference between maxima average (M) of hottest month and minima average (m) of coldest month. M - m = 36.48 – 4.55 = 31.93 °C

Following Debrach [7] the climate of the area could be classified as semi-continental. It's a climate rather changeable because of its temperatures which vary ceaselessly from a season to the other one. Under this climate, summers are there hot and winters are there rather rough. Temperatures are less cold than in mountain, but they remain all the same colder than everywhere else. Rains in summer are often stormy.

Pluviometric quotient of Amberger: This index's given by formula:

$$Q2 = \frac{2000*P}{M2-m2}$$

Where:

P: annual pluviometry in mm;

M2: The square of maximal temperature of hottest month (Tmax + 273.15°K);

m2: The square of minimal temperature of coldest month (Tmin + 273.15°K).

During period 2015-2017 Emberger rainfall quotient for the study area is Q2 = 35.80 with m = 4.55 °C, what allows us to place the area, against any expectation, in arid bioclimatic level enters temperate and warm (Fig. 3).

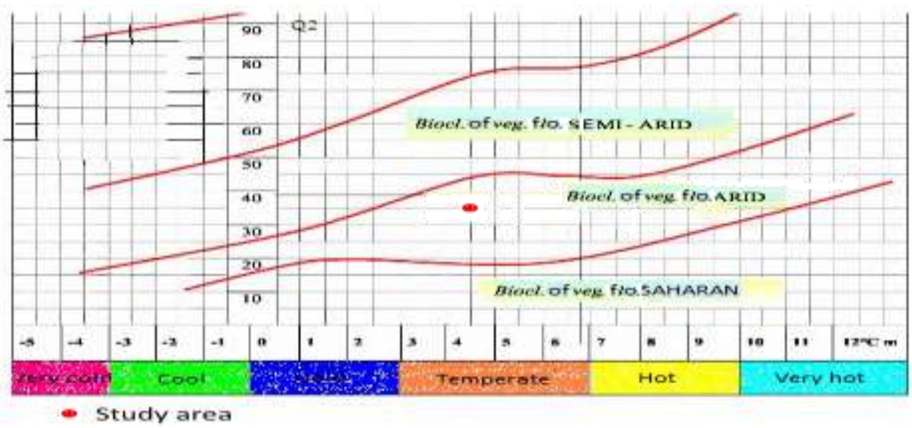

Figure 3: Projection of study area in the EMBERGER climagram.

The result could be explained by the climatic peculiarity "drought" that has marked the last two years. This level is characterized by a low pluviometry of 150 to 350 mm (our zone in registered an accumulation of 348.8 mm rains). Number of dry months is situated between 8 and 11. The variants concerning minimal temperature of the coldest month are rather bound to the continental character by going of «very hot» variant situated on the coast

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

of the Atlantic Ocean and the Mediterranean Sea towards that « very cold » located around mountains of the High Atlas. Climatic vegetation of this floor consists of species adapted well to water lack but denser and less heterogeneous.

Evapotranspiration: Average annual evaporation totaled 570.57 mm at a rate of 1.56 mm/day (Fig. 4). Six months of the period 2015-2017 (May, June, July, August, November and December) represent 62 % of annual sum of the evaporation. Maximum was in July-16 and minimum in Janu-17.

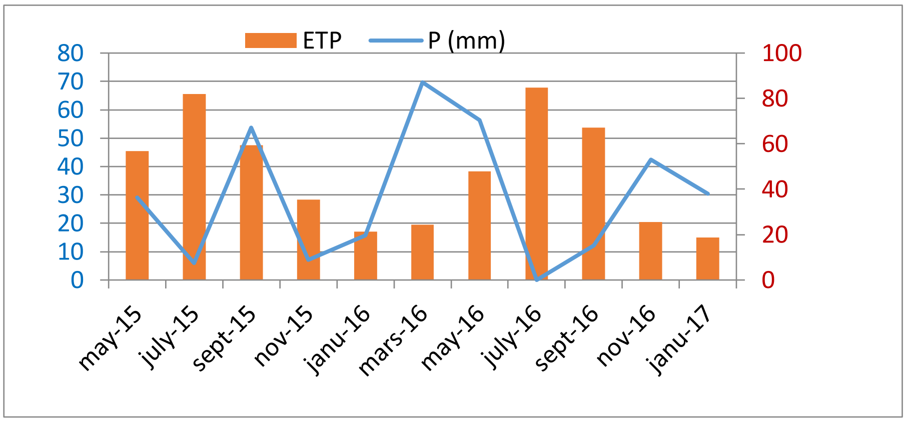

Figure 4: Pluviometry and evaporation in the study area (Period 2015-2017)

Relative humidity of the air: Relative humidity is expressed in percentage and is defines as report of the quantity of water actually contained in the air and absorption capacity in a given temperature. Monthly average relative humidity (2015-2017) at level of the study area (Fig. 5) varied between 42.25% (in July-16) and 69.84% (in Nov-16).

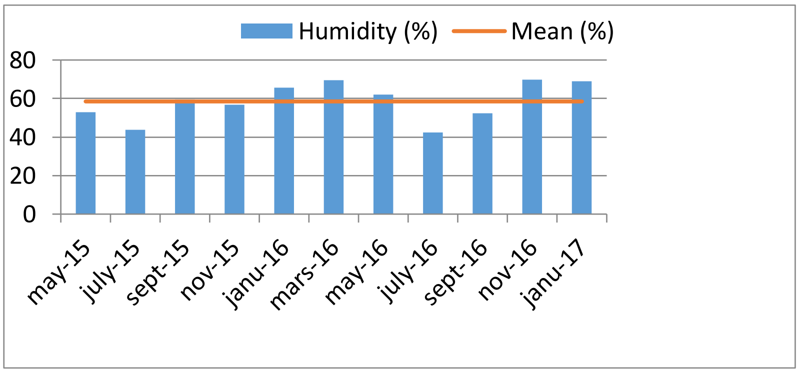

Figure 5: Humidity compared with the average of the study area (Period 2015-2017)

Relative humidity was generally lower than 70 % and varied relatively a lot during the year. Climate of El Hajeb city was less wet. However the monthly variations of the relative humidity corresponding to period 2015-2017 showed that in this region (Fig. 5), relative humidity was superior to monthly average (58.50%) during the cold period. While she is lower than monthly average (58.50%) during the hot episode.

Sampling and analysis: Leachate sampling was carried out on a monthly were monthly made in sixteen different places within the landfill during the period from May 2015 to January 2017 according to the method of Rodier et al [8]. Their analyses were carried out in two different and complementary laboratories according to standard methods.

Results and discussion

Seasonal evolution of the physicochemical and bacteriological quality of leachate

Temperature (T) and potential of hydrogen (pH): Temperature variations within leachates were widely dependent on the outside temperature. Those of discharge's leachates of El Hajeb city varied between 7°C and 23°C (Fig. 6-A). The pH was slightly acid, its values oscillated between 6.21 and 7.48 (Fig. 6-B). Minimal values spotted during the summer period correspond to the first phases of anaerobic degradation of organic matter. Maximal values of pH were recorded during wet season (7.48 in febr-16) and coincided with strong rainfall recorded for same period of the year. Wintry decrease in pH recorded during January was bound to slowing down of consumer photosynthetic activity of proton H+ in agreement with result found by Khattabi [9] in the household waste landfill of Etueffont (Belfort, France). The volume of the Leachates was at the peak in Apri-16, where the cumulative rainfall is maximal (P = 95 mm), while in July-16 (P = 0 mm) and Decem-15 (P = 0 mm), where the rain was non-existent (Fig. 6-C), this volume was shrinks and was taking the shape of a small swamp. Their reduced level could be due to the solar effect on the leachate and/or the infiltration in the ground.

A B C

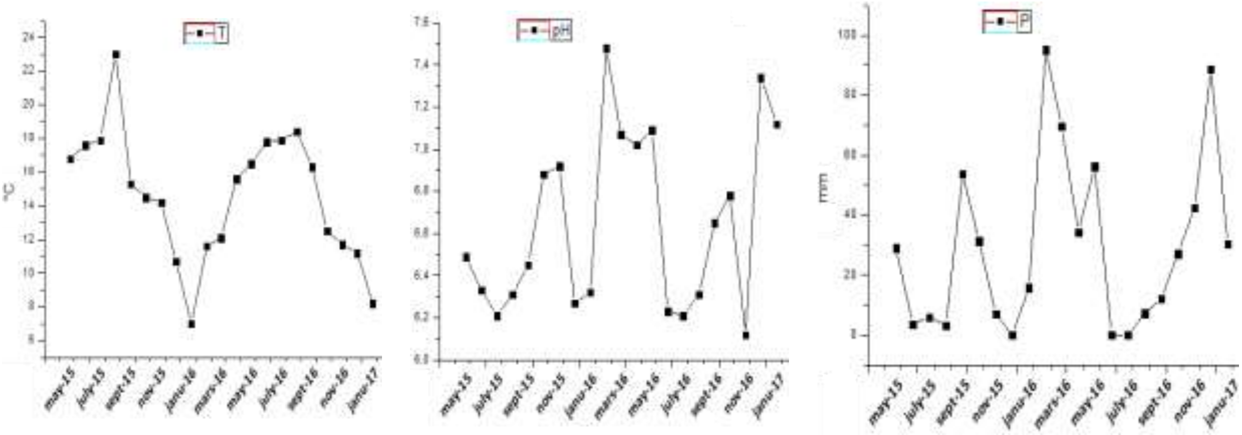

Figure 6: Monthly evolution of T (A) and pH (B) of the leachate and pluviometry (C) of the study area.

Potential redox (Eh), dissolved oxygen (DO) and salinity: Many factors or parameters which they're biotic or abiotic influence the contents in dissolved oxygen as the wind, the temperature and the salinity, but the most important is the biological activity (plants, animals and microorganisms respiration, and with the oxidation of the senescent organizations and their degradation by the heterotrophic bacteria), and the balance photosynthesis-respiration which results from it. Thus, the interpretation of the evolution of this parameter is rather complex [10]. The DO varied in content from 0.65 to 1.49 mgO2/L (Fig. 7-A). We noted very important deoxygenation during the dry season which succeeded immediately the summer plankton blooms, and was most probably attributable to the bacterial heterotrophic activity. It seemed that the reheating of waters was at the origin of an intensification of the bacterial heterotrophic activity. In winter, the permanent rains and the decrease of the bacterial activity ensured a strong and continuous oxygenation of the leachates [9]. The Eh passed from - 66.32 mV during August-16 when the conditions were very reducing (absence of oxygen) to -27.9 mV during May-15 when the contribution in oxygen was maximal (Fig. 7-B). Salinity often varied in saw teeth and showed peaks in the summer season in the order of 6.81 g/L (Fig. 7-C), which was not high enough to inhibit anaerobic digestion.
Turbidity (Turb), matter in suspension (TSS) and total dissolved solids (TDS): The contents in total dissolved solids (TDS) were between 4761.35 mg/L recorded in Febr-16 linked to the dilution phenomena. The contents of the matter in suspension (TSS) went from 671.56 mg/L recorded in August-15 to 1238.54 mg/L spotted in Febr-16 (Fig. 8-B). In the same sense turbidity values varied from 1983.67 NTU measured in July-16 to 2678.31 NTU found in Febr-16 (Fig. 8-C). The strong concentrations were due to the mechanical effects of the rain and the wind (leachates agitation, soil erosion, fragments and microorganisms input …)
Chlorides (Cl-), sulfates (SO4) and Electrical conductivity (EC): Electrical conductivity's also a parameter characteristic of effluents quality. During the monthly follow-up 2015-2016 the conductivity showed an

important variation. The strong values of electrical conductivity were observed in summer of about 8.7 mS/cm in order of27.19 mS/cm in August-15 and 27.12 mS/cm in August-16 what was explained the strong

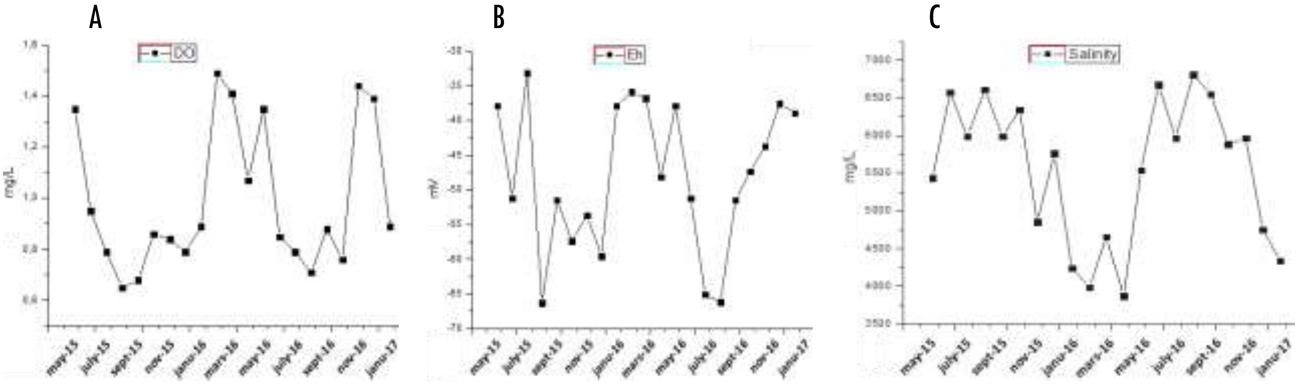

Figure 7: Monthly evolutions of DO (A), Eh (B) and Salinity (C) of the leachate

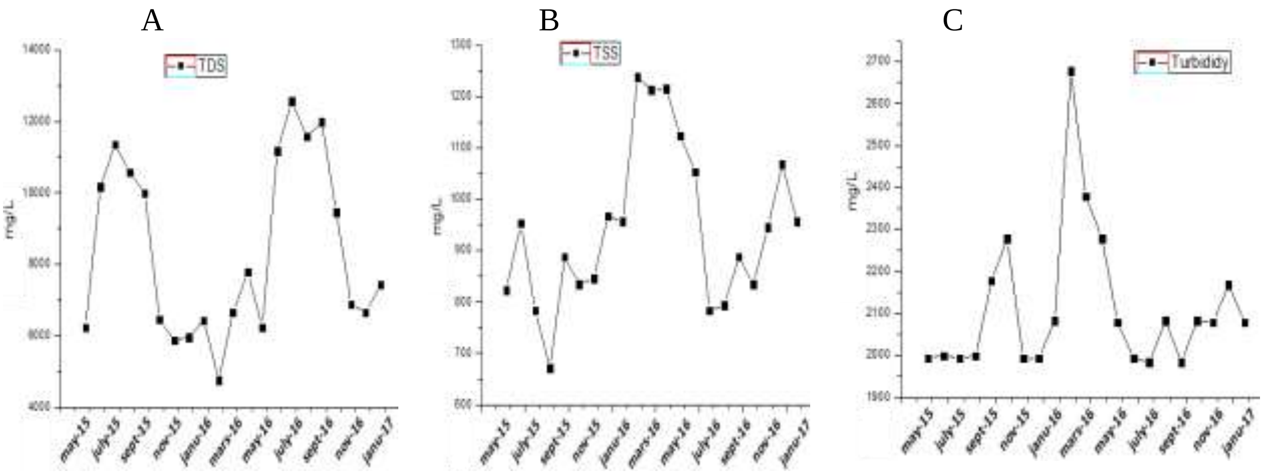

Figure 8: Monthly evolutions of the TDS (A), the TSS (B) and the turbidity (C) of the leachate.

mineralization of the leachate for this period. However, it was during the winter and spring season that one obtained low conductivities of about 8.23 mS/cm in Nov-16 and 8.64 mS/cm in March-16 (Fig. 9-A). The conductivity is largely determined by the chloride ions, in the same sense, the contents chlorides varied between 1543.76 and 2387.18 mg/L (Fig. 9-B) with maximum concentrations during the dry season (2.38 g/L in August-15 and 2.18 mg/L in August-16), where there was a near-total absence of precipitation origin of the dilution phenomena of the discharge juice, from which the leachates became more and more rich in chlorides.

Contrary to chlorides, the evolution of the sulfate concentrations (Fig. 9-C) showed that they oscillated between 993.56 and 1453.19 mg/L. In winter, its concentrations were maximal of the order of 1453.19 mg/L found in Febr-16, however in summer the contents in sulfates were low of the order of 993.56 mg/L measured in Sept-15 and 965.89 mg/L registered in August-15 when the bacterial biodegradation phenomena are very intense (leachates reheating) and the environment conditions are very reducing [11]. Sulfates are reduced to sulfides (H2S) which are among gases responsible for bad odors released by the discharge [9; 12] and are often associated to the metallic ions.

Biochemical oxygen demand (BOD5) and chemical oxygen demand (COD): The behavior of the trend curves of the BOD5 and COD can be attributed to the initial contents raised in organic matters and rates in humidity leading to an important biological activity and at the request of oxygen at this stage. The seasonal evolution of BOD5 and COD was similar. In summer and in autumn we attended a maximal increase of the BOD5 values of the order of 17000 mgO2/L in August-15 and 16987 mgO2/L in Sept-16 (Fig. 10-A) and COD values of the order of 32000 mgO2/L in August-15 and 22578 mgO2/L in Sept-16. In winter period we noted a reduction in the BOD5 until 12000 mgO2/L, registered in January-16 (Fig. 10-A) and of the DCO until 17000 mgO2/L

ISSN: 234-5197
Impact Factor: 2.715

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

recorded in janu-17 (Fig.10-B) which coincided with the minimum of the contribution in waste and the minimum temperature so constituting a factor limiting for the bacteria which become more and more incapable

A B C

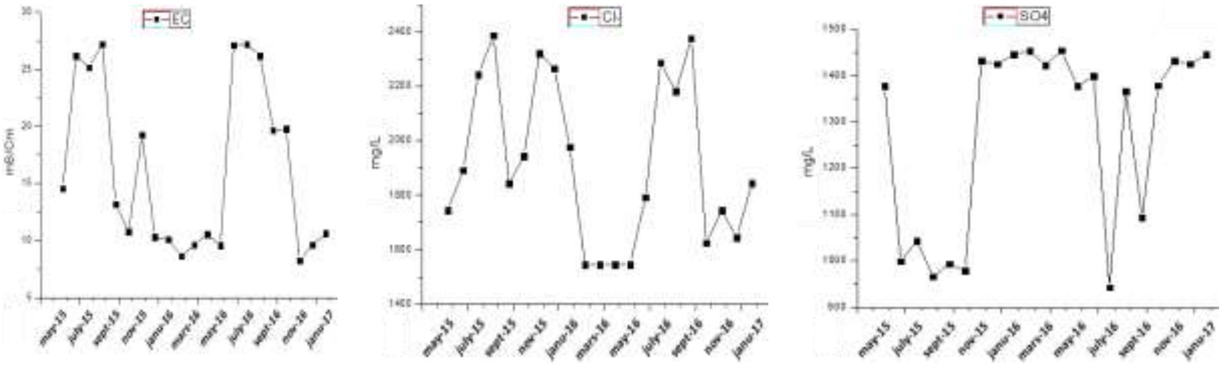

Figure 9: Monthly evolutions of EC (A), Cl-(B) and SO4 (C) in the leachate.

to transform the organic matter. In spring, both parameters increased but the dilution phenomenon was imperative and involved their decrease. During the dry season, on the one hand, a reheating of the leaching water was noted and a maximum amount of waste so allowing an intensification of the activity of the bacteria and the degradation of the organic matter. Besides, the report BOD5/COD is an indicator of the organic matter biodegradability and the leachates maturation [13; 14]. The follow-up of the temporal variation of the report BOD5/COD (Fig. 10-C), during this study, showed that it varied around 0.62 what allows us to classify these leachates as moderately biodegradable. The high value of the order of 0.71 was recorded in August-15, while the minimum value of the order of 0.31 was recorded in Janu-17.

A B C

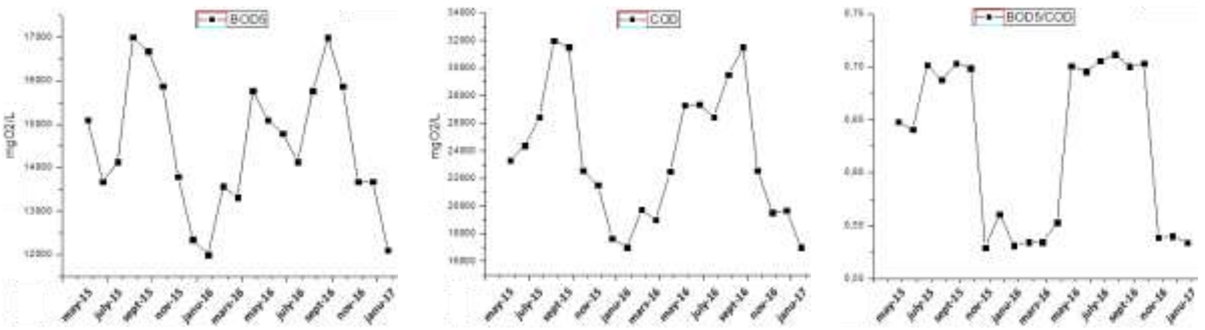

Figure 10: Monthly evolutions of organic parameters (A and B) and of report BOD5/COD (C) of the leachate.

Minor elements: Concentrations obtained in landfill leachates range from 589.31 mg/L to 1643.12 mg/L for calcium (Fig. 11-A), between 201.34 mg/L and 653.27 mg/L for magnesium (Fig. 11-B) and between 567.12 mg/L and 1194.23 mg/L for sodium (Fig. 11-C). The concentrations of these ions are very dependent on the content in dissolved organic substances and on the season [15]. The seasonal evolutions showed strong values in summer, presumably due to the low organic matter content that complexed these cations, these results corroborate those of the work of Khattabi [9].

Orthophosphates (PO4), total phosphor (TP) and potassium (K): The figure 12 showed that leachates in summer were richer in phosphate and in potassium. The contents of orthophosphates (PO4) varied between 94.73 mg-P/L registered in Mars-16 and 132.84 mg-P/L spotted in August-16 (Fig. 12-A). While the contents in total phosphor (TP) ranged from 98.35 mg-P/l found in April-16 to 157.12 mg-P/l measured in August-15 (Fig. 12-B), whereas those in K+ fluctuated between 1091.66 and 2693.52 mg/L (Fig. 12-C). The low concentrations were noted during the wet period when the contribution of waste was minimal and the elevation of precipitation induced a dilution effect. These results were in agreement with the work of Khattabi [9] in the site of Etuiffont (France). Nitrogen compounds: During the study cycle, It emerged from the figure 13 that the leachates of the discharge of the city of El Hajeb (Morocco) presented contents in nitrate (NO3-) which varied from 54.71 to 78.09 mg-N/L (Fig. 13-A). Nitrite (NO2) concentrations varied between 0.65 and 3.21 mg-N/L (Fig. 13-B).

A B C

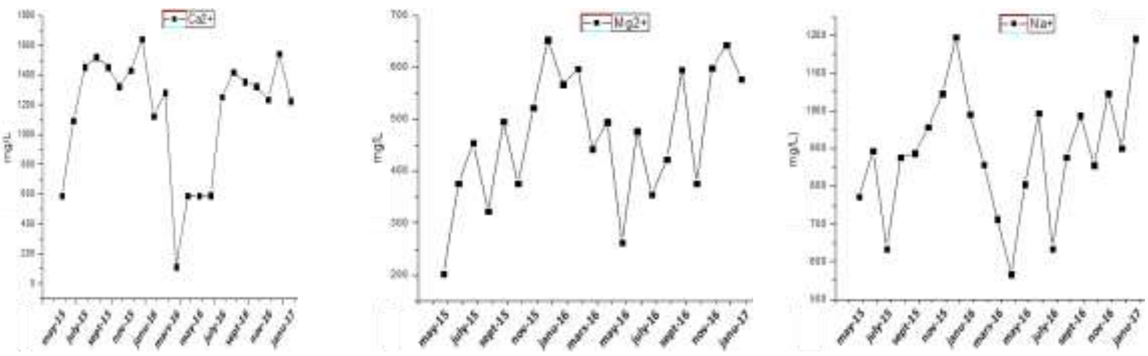

Figure 11: Monthly evolutions of Ca (A) and Mg (B) and of Na (C) in the leachate.

A B C

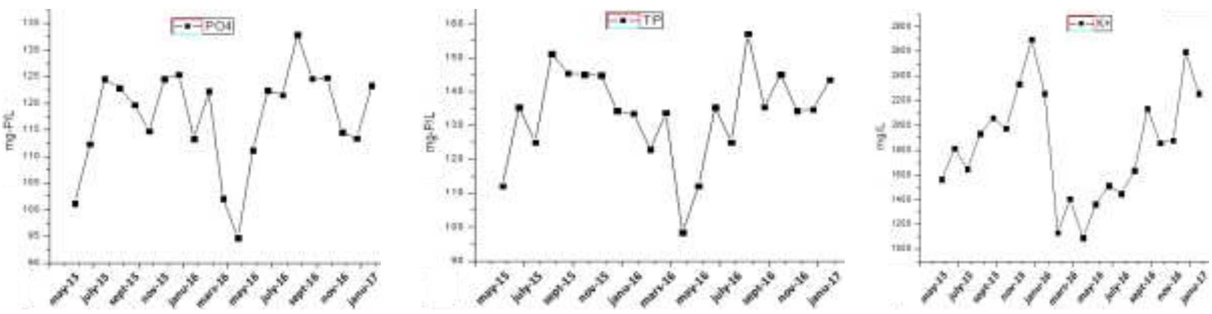

Figure 12: Seasonal evolutions of orthophosphate (A), of total phosphor (B) and of potassium (C) in the leachate.

Those of ammoniacal nitrogen (NH4+) fluctuated between 263.56 and 529.02 mg-N/L (Fig. 13-C). The comparative study of these three nitrogenous forms indicated a quasi-similar seasonal evolution, characterized by high summer values, most probably due to an excessive contribution of waste and to a strong activity anaerobic bacterial. As for the low wintry values, they were in relation to the small quantity of waste rejection and to the dilution effect. The nitrogen emanation was also more important in the sites of recent deposits. Indeed, waste has a big capacity to convert nitrate or nitrite in gaseous nitrogen (denitrification) under the microorganism's effect, what could explain the weak concentrations of nitrites obtained in leachates. In most of the reactions, nitrites have a fast denitrification and more complete than nitrates [16]. On the other hand the ammonia nitrogen concentration was very high in the leachates, in relation to the process of deamination of amino acids when decomposing organic compounds. Total nitrogen (TN) concentrations of the leachate fluctuated between 805.41 and 1005.67 mg-N/L (Fig. 13-D); those of total Kjeldhal nitrogen (TKN) were ranged from 673.54 to 968.11 mg-N/L (Fig. 13-E). While those some organic nitrogen ranged from 310.04 to 660.86 mg-N/L (Fig. 13-F). The comparative study of these three nitrogenous forms indicated a similar seasonal evolution characterized by high summer values and low winter values.

Heavy metals: Measurements of heavy metal levels showed a significant fluctuation from one month to the next. This is due to the activity of the landfill and the quantity and variation of the composition of the deposited waste (mobile phones, computers, appliances of medical devices, accumulators ...) as well as environmental and climatic conditions. It should be noted that some wastes contained small quantities of precious metals (gold and silver…) or rare (Lithium) as well as primary metals (Copper and Ferrous metals…) and ores (cadmium, lead and mercury…). The most plentiful metallic elements in the leachate of El Hajeb discharge are iron, copper, zinc and nickel. The study of the evolution of metals trace in leachates showed that the Zn (Fig. 14-B), Al (Fig.

ISSN: 234-5197
Impact Factor: 2.715

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

14- B) and Ni (Fig. 14-A) were more leachable in a fresh waste, indeed their minimum concentrations were recorded in the summer season of the respective order of 3.83 mg/L in August-16, 1.23 mg/L in Jul-16 and 3.02

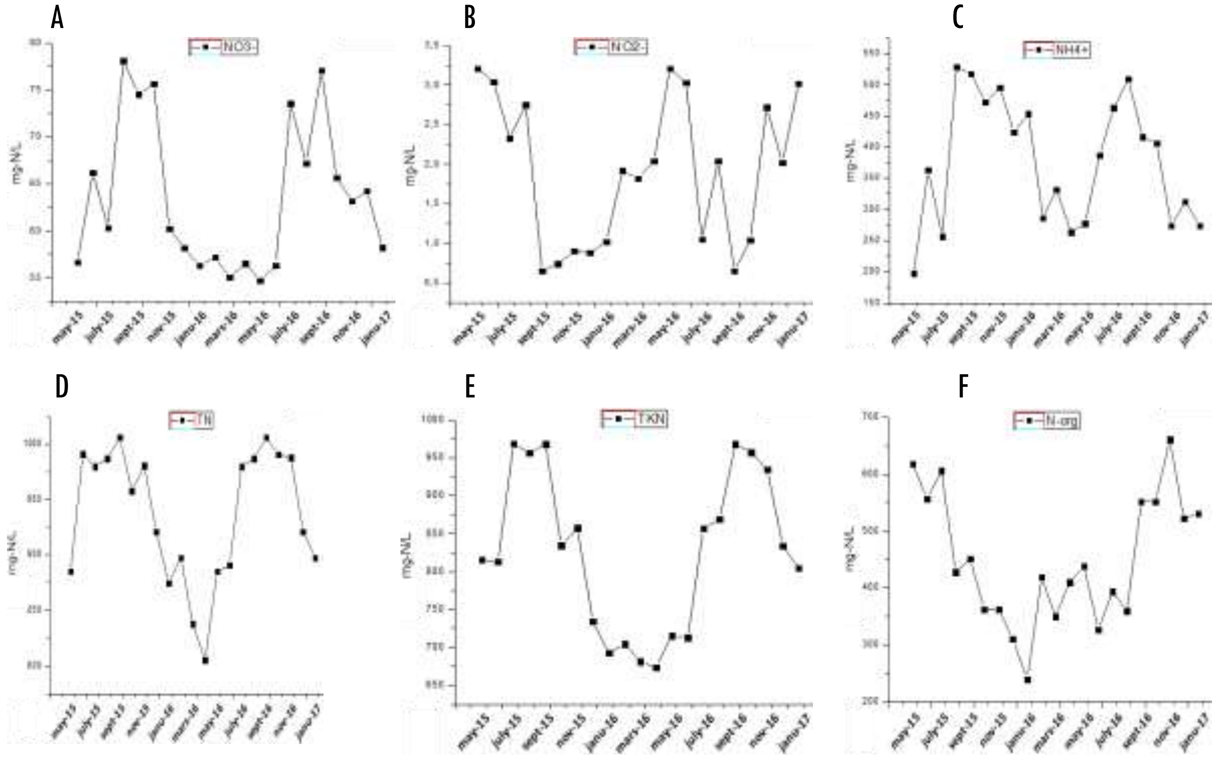

Figure 13: Seasonal evolutions of NO3 (A), of NO2 (B), of NH4 (C), of TN (D), of TKN (E) and of N-org (F) in the leachate.

mg/L in August-15. The Cr varied from 0.69 to 11.14 mg/L (Fig. 14-A), Pb ranged from 1.36 to 4.37 mg/L (Fig. 14-C), the Cu went from 1.31 to 3.48 mg/L (Fig. 14-E). As varied between 0 and 2.79 mg/L (Fig. 14-C) while the Cd ranged from 0.2 to 0.61 mg/L (Fig. 14-F), Hg varied from 0.007 to 0.012 mg/L (Fig. 17-F), the Co concentrations fluctuated between 0.02 and 1.73 mg/L (Fig. 14-E), and the Fe fluctuated in saw teeth between 518.29 and 1069.54 mg/L (Fig. 14-G).

Bacteriological parameters: In the case of this discharge, bacteriological analyses showed that the results of variation in bacterial content depended on the seasons of the year. The TC exhibited a high concentration lobe that persisted from early summer to early winter with a maxima of 4.37e+7 CFU/100mL (Fig. 15-A). The evolution of the concentrations of coliforms faecal (FC) presented fluctuations of saw-toothed shape very salient and very-acute with a maximum of 7.13e+6 CFU/100mL registered in August-15 and a minimum of 2.68e+2 CFU/100mL spotted in April-16 (Fig. 15-B). Fecal streptococci (FS) was less salient and less acute with a maximum of 6.48e+7 CFU/100 mL recorded in August-15 and a minimum of 2.9e+4 CFU/100 mL in Feb-16 (Fig. 15-C). The effect of temperature and rain was noticeable.

Statistical study

Correlations between physicochemical, biological and climatically parameters: The analysis of Pearson allowed establishing the correlation matrix of the various parameters in the alpha threshold 0.050 (Table 4). The examination of this matrix showed a significant positive correlation between the COD and the BOD5 ($r = 0.88$), between conductivity and chlorides ($r = 0.79$), between temperature and BOD5 ($r = 0.86$), between temperature and Cl-($r = 0.82$), and to a lesser degree between temperature and EC ($r = 0.67$) and between temperature with COD ($r = 0.61$). On the other hand the temperature was strongly correlated but negatively with SO4 ($r = -0.88$) and between the temperature and the ratio BOD5/COD ($r = 0.88$), this could be explained by the important role of temperature in the processes of oxidation, waste hydrolysis and sulfate reduction. It was to note also the existence of the statistically significant positive correlations enter total suspended solids (TSS) and the turbidity ($r = 0.85$), between total of dissolved solids (TDS) and the conductivity ($r = 0.74$), between the TDS and the salinity (r = 0.9), between the DO and the redox potential (r = 0.86), between the DO and the pH (r = 0.81). Indeed, the fall of the dissolved oxygen concentration (OD) observed during the summer period appeared to be

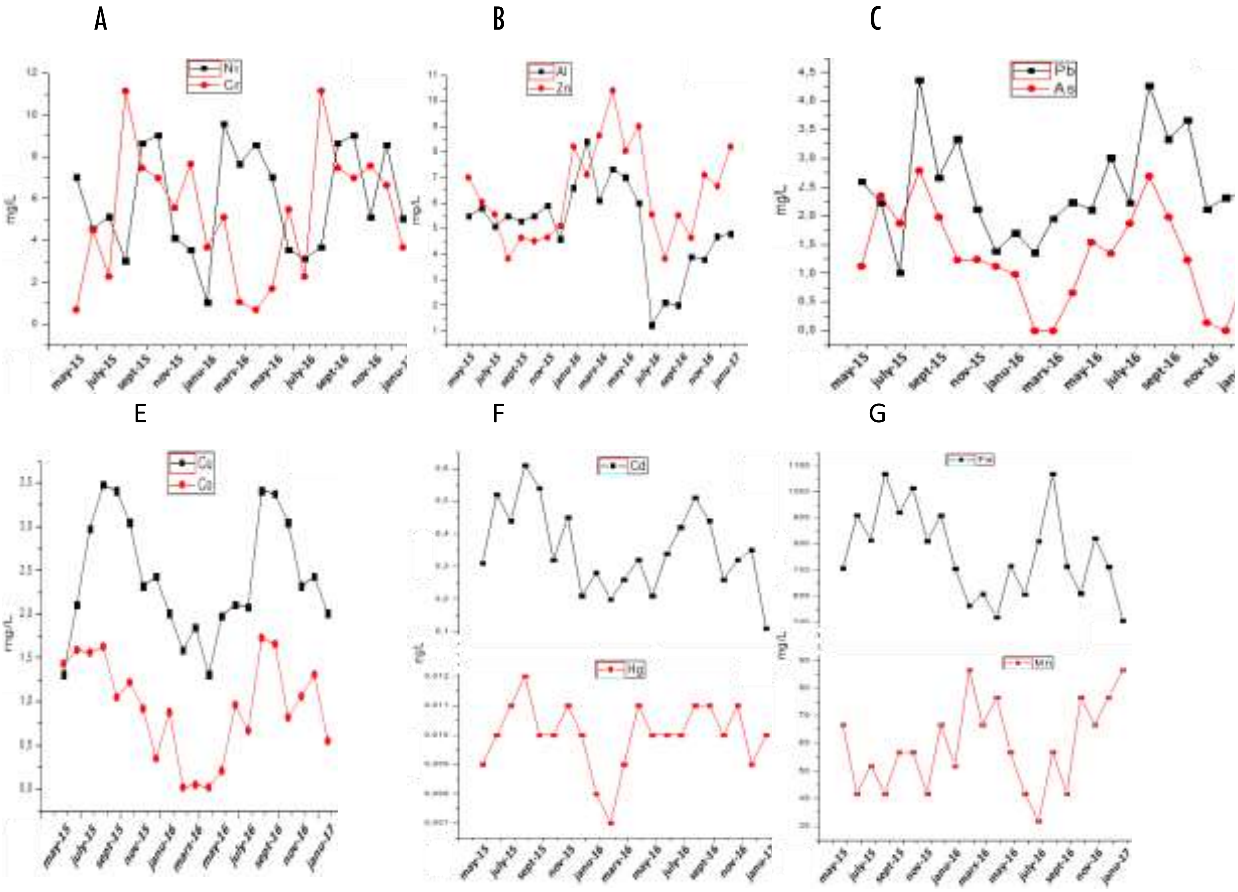

Figure 14: Seasonal evolutions of Ni and Cr (A), of Al and Zn (B), of Pb and As (C), of Cu and Co (D), of Cd and Hg (E) and of Fe and Mn (F) in the leachate.

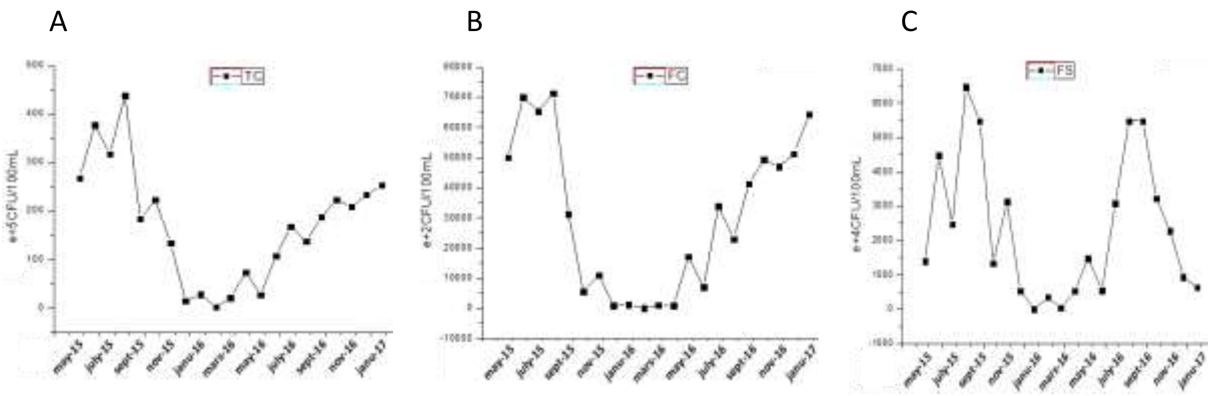

Figure 15 Seasonal evolutions of bacteria: TC (A), FC (B) and SF (C) in the leachate.

due to the elevation of aerobic microbial activity in the landfill, who by consuming oxygen by decomposers, generated a slight decrease in pH and a fall in the redox potential (Eh). These variations were in accordance with

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

the observations of Ragle et al. [17]. This study also showed the existence of a correlation between total phosphate and total nitrogen (r = 0.81) between TN and TKN (r = 0.78), between total phosphorus and orthophosphate (r = 0.85) and in the same vein between phosphates and nitrates (r = 0.73) on the one hand and between phosphates and NH4 (r = 0.84) on the other hand, which indicated that they probably had the same origin and that could be only the waste from agricultural activities. There was also a fairly strong positive correlation between calcium and Phosphate (r = 0.60) and between calcium and Sodium (r = 0.75). These correlations showed, to some extent, the favoritism between calcium and sodium with respect to their origin namely chemical fertilizers and obsolete plant protection products, but also the fate of phosphate and calcium that can form complexes and precipitate in the form of calcium phosphate. For trace metals only Zn, Ni, and Al that were statistically positively and strongly related to precipitation (P) with respective correlation coefficients of r = 0.91, r = 0.70 and r = 0.83. The As was strongly correlated with Pb (r = 0.952) and Cd (r = 0.958), suggesting that these three metals probably have the same origin as hospital waste or electronic waste. We also noted a significant but negative correlation of pH evolution with that of TC (r =-0.80), to a lesser extent with that of FC (r =-0.64) and finally with that of FS (r =-0.51). A decrease of the pH favored strongly the development of these germs. The joint analysis of the physicochemical and biological parameters: Temporal evolution of the various physicochemical and biological parameters measured during the study period, were evaluated by points clouds dispersed in factorial plan F1-F2. by principal components analysis (P.C.A.) of these parameters whose principal components F1 and F2 absorbed 84.92% of global inertia and their individuals “the corresponding months” whose principal components F1 and F2 absorbed 73.32% of global inertia (Fig. 16-A and 16-B).

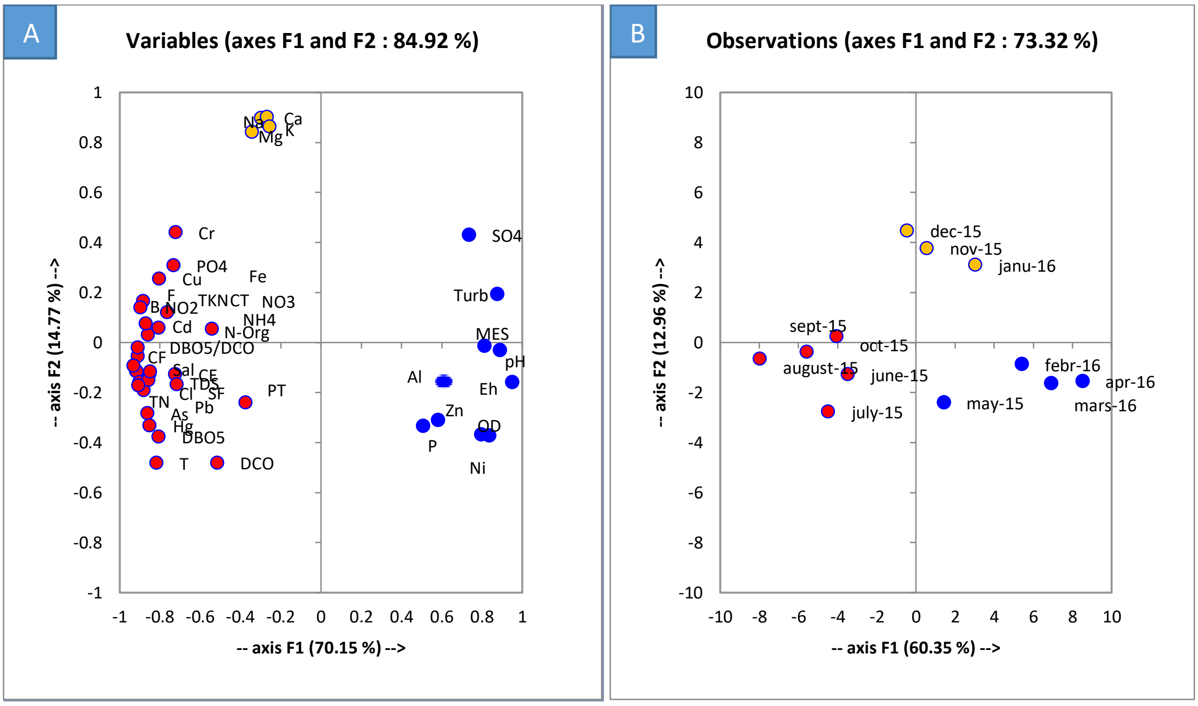

Figure 16: Projection of the different parameters on the factorial plan (1 x 2) (A) and projection of the corresponding months on the factorial plan (1 x 2) (B) given by the principal component analysis.

It emerged that sampling months were grouped in three great groups:

Group 1 (red points): this group was negatively coordinated with the axis F1, and formed by the least rainy months or the dry season (June, July, August, September, October, November and December), it was characterized by high rates there, TDS, nitrogenous and phosphate drifting, Cl, BOD5, COD, BOD5/COD, Cr, Ni, Cu, As, Pb, Cd, Hg, TC, FC, FS.

Group 2 (blue points): this group was coordinated positively with the axis F1, and was formed by the rainiest months or wet season (January, March, April, February and May). The group's individuals were characterized by a strong load in SO4, Turb, TSS, pH, Eh, DO, Zn and Fe.

Group 3 (orange points): constituted by December November and January, this period, considered as intermediary between dry and wet season, was positively correlated with the axis F2 and was characterized by strong contents of K, Mg, Ca, and Na.

Conclusion

Landfill site of El Hajeb-City is open dump. It has neither a collection system nor a leachate treatment system. Consequently, all this generated percolate is in the surrounding environment.

It was concluded that leachate samples collected and analyzed in all seasons contain a high concentration of organic and inorganic constituents beyond the authorized limits and indicated that the composition of the leachate is dependent on the seasonal variation (the leachate in summer is more toxic compared to the winter season), most of these variations seem to be bound to the precipitation and to the temperature besides the quantity of waste. Minor parameters including calcium, magnesium, trace metals and biological parameters BOD5 and COD suggest that the dominant control of leachate chemistry is the temperature, leaching, and dilution with precipitation. The present study confirms that landfill leachate can act as an agent that conveys organic and inorganic substances, thus contaminating the aquatic environment near the landfill even at diluted concentrations if leachates are released without treatment, which could present a risk to exposed organisms. As a result, the implementation of the most suitable technology for the treatment of landfill leachate should be considered after fully understanding the composition and concentration of leachate in various seasons to guarantee an adequate management of landfill sites.

This research is an initial glimpse into the long-term temporal changes that leachate undergoes in a landfill site and represents a logical first step toward the formulation and calibration of quantitative models for the prediction of changes in leachate chemistry with time.

References

[1] D. Fatta, A. Papadopoulos and M. Loizidou, "A study on the landfill leachate and its impact on the groundwater quality of the greater area", Environ. Geochem. Health, vol.21, n°2, pp. 175-190, 1999.
[2] A. Baun, S.D. Jensen, L. Bjeg, T. H. Christensen, N. Nyholm, "Environmental and Technology", pp. 34 647-652, 2000.
[3] M.S. Bilgili, A. Demir, M. Ince, B. Ozkaya, "Metal concentrations to simulated aerobic and anaerobic pilot scale landfill reactors," J. Hazard. Mater, Vol. 145, n°1, pp. 186, 2007.
[4] F. Ozane, " Les lixiviats de décharge, le point des connaissances", Techniques sciences et méthodes -l'Eau, pp. 298-312, 1990.
[5] Barres et al., "Les lixiviats de décharges", Le point des connaissances en. T.S.M.-L'eau, vol. 85, n°6, pp. 289-313, 1990.
[6] S. Glandier - Légende pour la composition des lixiviats ; Déchet de centre de stockage de déchets ménagers et assimilés. Mémoire de l'Ecole Nationale de la Santé Publique, 2002.
[7] J. Debrach, " Notes sur les climats du Maroc occidental", Maroc médical, vol. 342 pp. 1122-1134, 1953.
[8] J. Rodier, B. Legube, N. Merlet, "L'Analyse de l'Eau", Ed. 9, Dunod : Paris. pp. 1579, 2009.
[9] H. Khattabi, Intérêts de 1'étude des paramètres hydrogéologiques et hydrobiologiques pour la compréhension du fonctionnement de la station de traitement des lixiviats de la décharge d'ordures ménagères d'Etueffont (Belfort, France). Thèse de Doctorat, Université Franche Comté, France, pp.171, 2002.
[10] B. Émilien, Évolution de l'impact environnemental de lixiviats d'ordures ménagères sur les eaux superficielles et souterraines, approche hydrobiologique et hydrogéologique. Site d'étude : décharge d'Étueffont (Territoire de Belfort - France), Thèse de doctorat, Université de Franche-Comté, Besançon, 2008.
[11] A. Chofqi, Mise en évidence des mécanismes de contamination des eaux souterraines par les lixiviats d'une décharge incontrôlée (El Jadida Maroc) : Géologie, hydrogéologie, Géo- électrique, Géochimie et Epidémiologie. Univ-Chouaib Doukkai Fac des sci.El Jadida, 2004.
[12] H. TAZI, "Déchets solides : Étude d'impact sur l'Environnement (sol, eaux souterraines) et traitement par voie de compostage ", Thèse Univ. El Jadida, Maroc, pp. 224, 2001.
[13] T.A. Kurniawan, W. Lo, G. Chan, "Physico-chemical treatments for removal of recalcitrant contaminants from landfill leachate". J. Hazard. Mater; vol. 129 Issue 1-3, pp. 80-100, Feb 2006
[14] R. Kerbachi, M. Belkacemi, "Caractérisation et évolution des lixiviats de la décharge de Oued Smar à Alger ", T.S.M- L'eau, N°11, p.615-618, 1994.
[15] P. Christensen, "Biogeochemistry of landfill leachate plumes", Application Geochemistry vol.16, pp. 659–718, 2001.
[16] V. Vassilia, M. Ponthieu, B. Giulia, A. Jean-Marc, D. Christian, M. Laurent, B. Nicolas, B. Theodore, Nitrate and nitrite injection during municipal solid waste anaerobic biodegradation. Was. Man. pp. 14, 2006.
[17] N. Ragle, J. Kissel, J.E. Ongerth, F.B. Dewalle, "Composition and Variability of leachate from recent and aged areas within a municipal landfill", Water Environ. Res., 67, n°1, pp. 238-243, 1995