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Impact of Municipal Rubbish dumps on major soil Nutrients in north of Tunisia

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Abstract

Technological progress and population growth have led to an evolution of municipal solid waste production. The management of these wastes has long been reduced to their mere burying or deposit on unprepared and/or inadequate land. In these rubbish dumps, bad smell resulting from the fermentation process of organic matter, as well as the presence of high concentrations of heavy metals (cadmium, zinc, copper, manganese) can create poisoning problems in the environment or to human health. The present study was to evaluate the impact of municipal rubbish dumps in the city of Tabarka (Tunisia) on the surrounding environment. The study considered three different municipal waste disposal sites respectively of 5, 10 and 20 years of age and compared them with pilot soil located about 500 m at the downstream and the upstream of the center of the dump. Samples of soil were taken from various stations. We noticed that the carbon content of the soil was multiplied by four inward from the area adjacent to the center of the waste disposal. Similarly, moving from an uncontaminated to a contaminated location (any station confused), the amount is multiplied by two for nitrogen and by eight for phosphorus. For these three minerals seasonal variation was not statistically significant. For calcium, potassium and sodium, the highest concentrations were recorded in the center of the rubbish dumps. Although these concentrations varied significantly between stations and localities, the highest values were always recorded in the contaminated areas.

Keywords: Soil, landfill site, macro-nutrients, waste.

Introduction

The human activity creates waste in the households, within the industry or in agriculture. The mass and the quality of this waste evolved with the improvement of the standard of living, the industrial growth, the agricultural evolution, the progress which the industry of packing as well as the short time life of the objects[1]. This waste was too often regarded as useless, non desired and thus rejected as being without value or below what was being recorded[2]. As a result, waste management has entered only lately the concerns of the decision makers and up to one very recent period that urban household wastes neither collected nor even identified. However, the always increasing load of solid waste has many effects on the environment and the public health such as the bad smells released after the process of fermentation of the organic matter, or of the explosions resulting from the fuel gases generated (CO^2 et CH^4) who also contribute to the greenhouse effect, as well the waters and the soil contamination by heavy metals[3].

In fact, the soil known as a non renewable natural resource, has several functions in the biosphere and humans with high rate of degradation and extremely slow rate of regeneration processes[4]. It represents biomass production: storage of water, nutrients and heat, natural filter, intoxication[5] and buffering system. Also, the soil is an important gene –reservoir and can reproduces past and present human activities[6-8].

In Africa, Hunger unhealthy people have been linked to unhealthy soils[9]. Now, the theory of soil quality has been gradually moving from a notion focused on yield potential and nutrient levels to one of environmental quality, food safety and human health[10].

In our study, we are going to represent the content in major nourishing element evolution in polluted soil coming from municipal solid waste and pilot soil.

Indeed, in Tunisia, the solid waste production has strongly evolved subsequent to the important progress observed in the industrial, tourist and agricultural levels. The standard of living improved and the dietary habits are not any more the same ones. Today, Tunisian eats more and diversified their food considerably. Thus, the cans, the bottles out of plastic are increasingly present in our dustbins. Moreover, Tunisian eats more meat, of fish and fruits and all that results in a slight increase of household wastes of which the quantities intended for the garbage dumps are extremely important and approach those recorded in the industrialized country. This waste has a high rate of organic material which border 70%.

Thus, the process of valuation of waste underwent a big evolution in time and one attends various processes created such as composting, recycling, the incineration and the setting in

municipal solid waste. The use of compost manufactured coming from municipal solid waste held an interest on a worldwide scale because of its high content in organic matter can improve the soil quality[11]. Nevertheless, the compost can be the origin of heavy metal accumulation which can contaminate the living beings[12].

Material and Methods

Choice of the sites: The selection of the sites rests exclusively on the municipal solid wastes which were successively selected by the municipality to deposit wastes there (figure-1). Thus, we retained three municipal solid wastes, of different ages: i. Municipal solid waste of El Khdairia, which is the most recent, located to 8 km from the center of Tabarka. It is being used for 5 years and is always in the course of employment. It is prepared by the municipality to become a controlled municipal solid waste. ii. Municipal solid waste of Bouterfès which was used for one ten year period and is now abandoned. iii. Municipal solid waste of the City El Morjène which is the oldest , going back to about 20 years, now given up and not used.

Figure-1
Location of the governorate of Jendouba (North of Tunisia)

Figure- 2
Location of the town of Tabarka

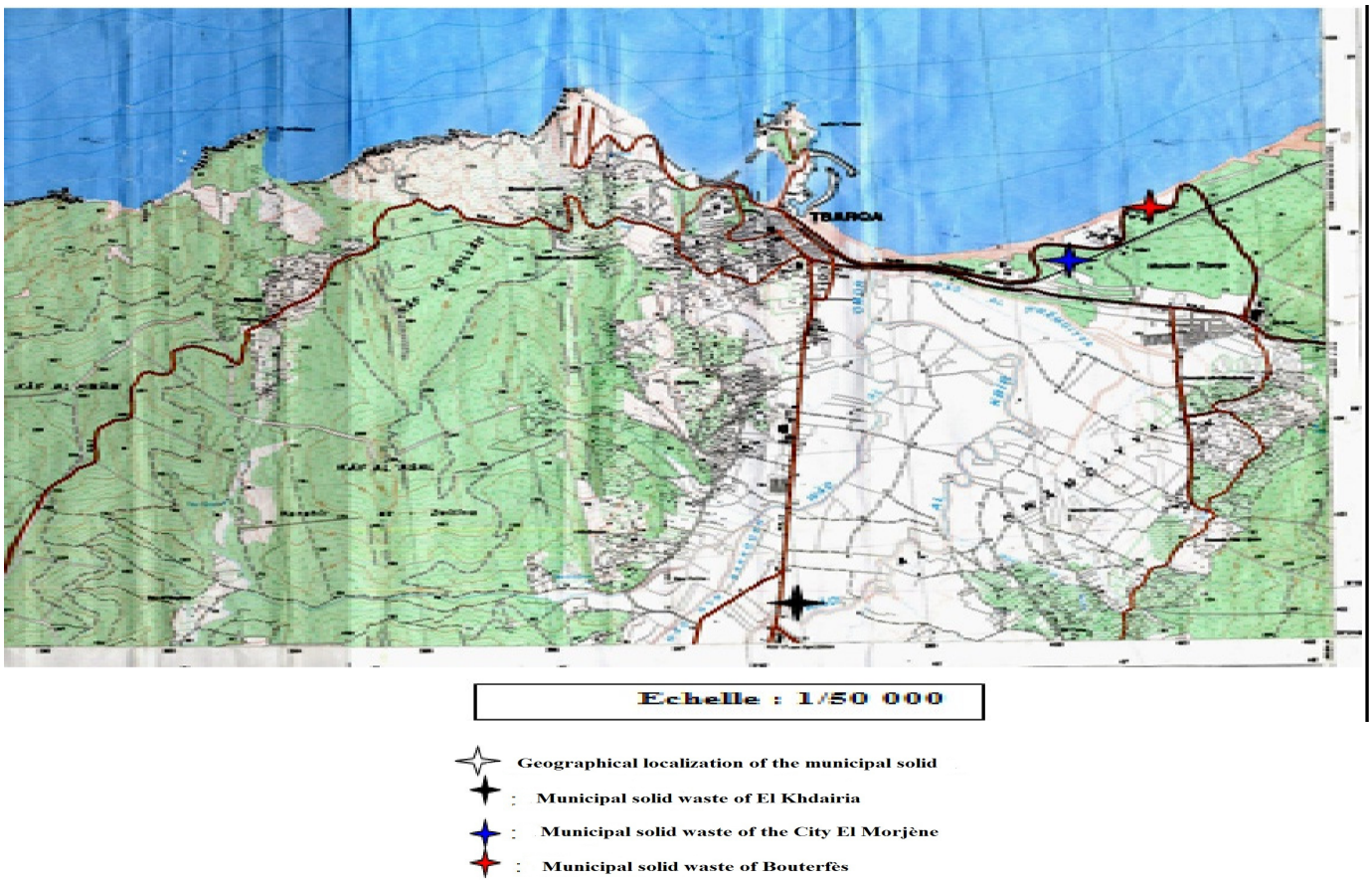

Figure-3
Geographical localization of the three municipals solids wastes in the region of Tabarka (Source: official card of Tabarka)

These two last municipal solid wastes represent the landfill site simply where the municipalities eliminated their wastes.

Although it is very important to keep the forest soils, not only for their aesthetic aspect but also for ecological reasons, the three municipal solid wastes were established in the middle of the forest of Tabarka.

In the two last municipal solid wastes, one discovered the presence of plants like *Cynoglossum pictum*, *Malva sylvestris*, *Marrubium vulgare*, and *Urtica dioica*, to which are added *Retama raetam* (municipal solid waste El Morjène) like *Ricinus communis* and *Arum italicum* (municipal solid waste of Bouterfès).

Sampling strategy and sample processing method: On the level of each municipal solid waste, known as stations, we delimited three small localities of 500 m2 variable forms, a first upstream, a second in the center and a third downstream (upstream and downstream compared to the road of flow of water), each locality being distant the different one from about 500 m. The upstream and downstream localities can show us the part played by the streaming of water in soil pollution and the plants. Along the site of the municipal solid waste, we systematically took 40 samples of soil to the Pedological drill. These samples were carried out in December and in July. They took place with regular intervals along a layout in a zigzag which crosses the entire site. They relate to the layer 0-20 cm of the soil where are concentrated the nutritive elements not or not very mobile in the soil such as phosphorus, potassium, calcium, iron, zinc, manganese and copper[12].

Analyses at the laboratory: Once the sample of soil arrived at the laboratory, it had dried in the free air (30°C) in order to reduce the microbial activity. Then, it had crushed then filtered with the sieve of 2 mm. Organic carbon had oxidized by dichromate of potassium in sulphuric medium. The proportioning of Olsen phosphorus had been carried out by the method modified Olsen. The total nitrogen had been taken out and proportioned according to the method of Kjeldahl[13]. The reading of elements nutritive content has carried out by spectrophotometer with atomic absorption (Shimadzu AA 6200) according to the procedure described by Ryan and al. (1996)[14].

Statistical analyses: Analyses (ANOVA) had carried out by using software (SAS). The significant differences between the averages of the various parameters were determined by tests of Student-Newman-Keuls (SNK).

Results and Discussion

Carbone: The percentage of the carbon found in the various municipal solid wastes showed a variation very highly significant between the stations and the localities. Various concentrations found are understandable by the fact that the carbon varies according to the soil types[15].

In the center of the municipal solid waste of El Khdairia, we registered the highest content of C (10%), for the 10 years municipal solid waste the content is about 0, 7 % and it is off 8% in the 20 years municipal solid waste (figure-4 and figure-5).

According to soil quality index values and associated soil property threshold values and interpretation[16], the contaminated soil of Tabarka present an excellent buildup of organic C with all associated benefits (>5%). Knowing that The dynamics of the carbon in the soil are dependent on two parameters: primary productions deducted from the exports and the possible external contributions) and the speeds of mineralization[17].

But, Our values are lower than those of François and al.[18] who found that, in the recent municipal solid waste and that three years, the percentage of carbon is about 30% where for 8 years municipal solid waste it is about 14,5% and to 16% in a 20 year municipal solid waste.

One can explain this variation by the fact that Tabarka is a small town of weak industrial and agricultural activity, which the organic mass contributes to the increase in the organic matter rate. This result is confirmed by work of Loué[19]. In this direction, Vilain[20] affirms that the organic matters present or built-in the soil exert effects on these properties by modifying its fertility. The difference is more visible in the station of Bouterfès for the reason that in sandy soil the organic matter losses by streaming or cheluviation are very important.

Nitrogen: The nitrogen concentration varied significantly between the various stations. The highest concentration had recorded in the oldest landfill waste (municipal solid waste of El Morjène: 0, 50%). The lowest value had recorded in the municipal solid waste of Bouterfès (0, 12%). In this station, the nitrogen contents did not show significant variations from a locality to another. For the other stations, the nitrogen concentration doubled while passing from not contaminated localities (0.14%) to the municipal solid wastes (0, 30%). This concentration did not show significant seasonal changes (figure-6 and figure-7).

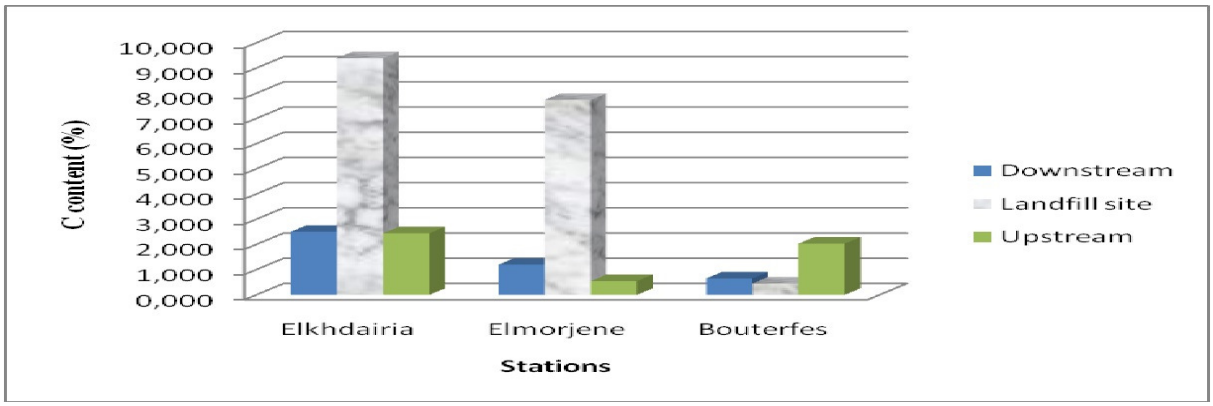

Figure-4
Variation of the C content according to stations

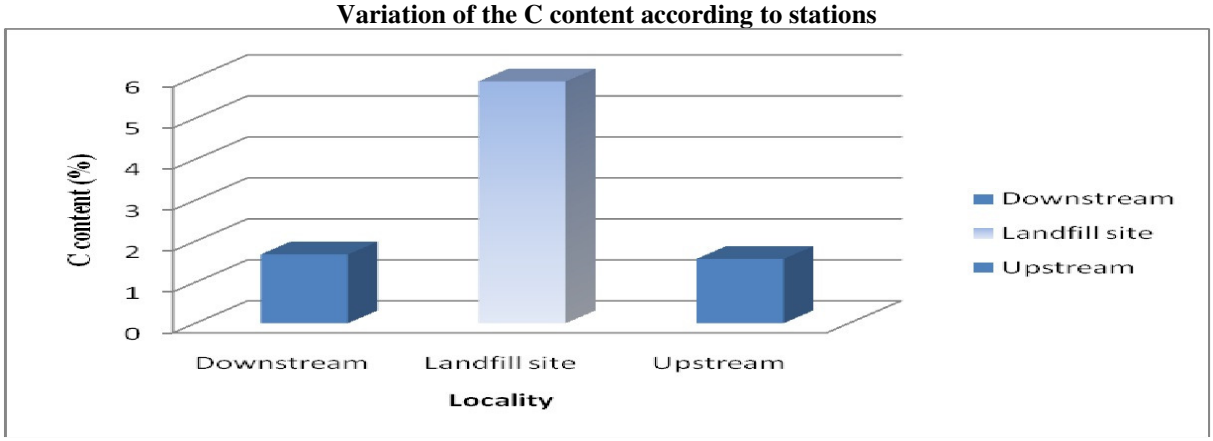

Figure-5
Variation averages of the C content according to localities any confused stations

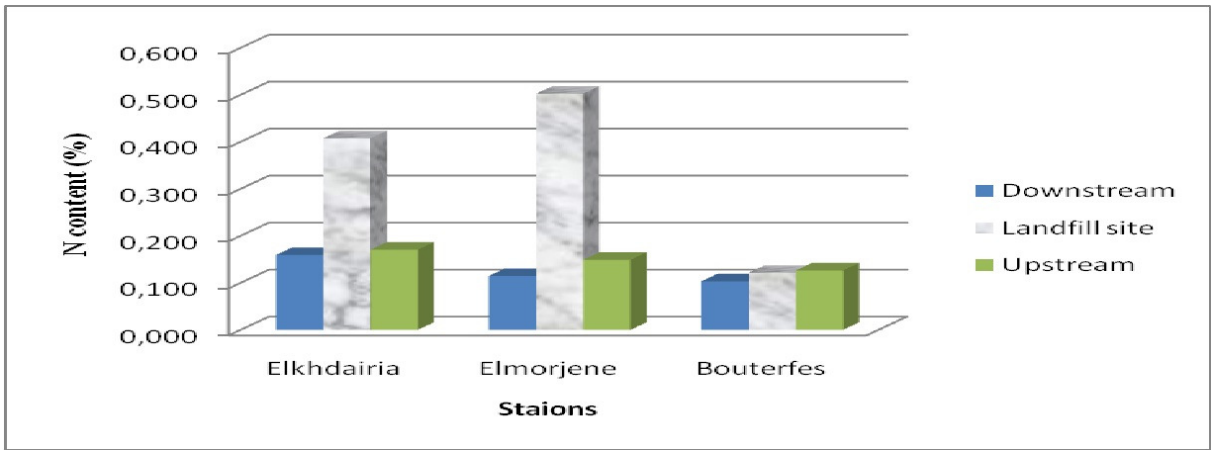

Figure-6
Variation of the N content according to stations

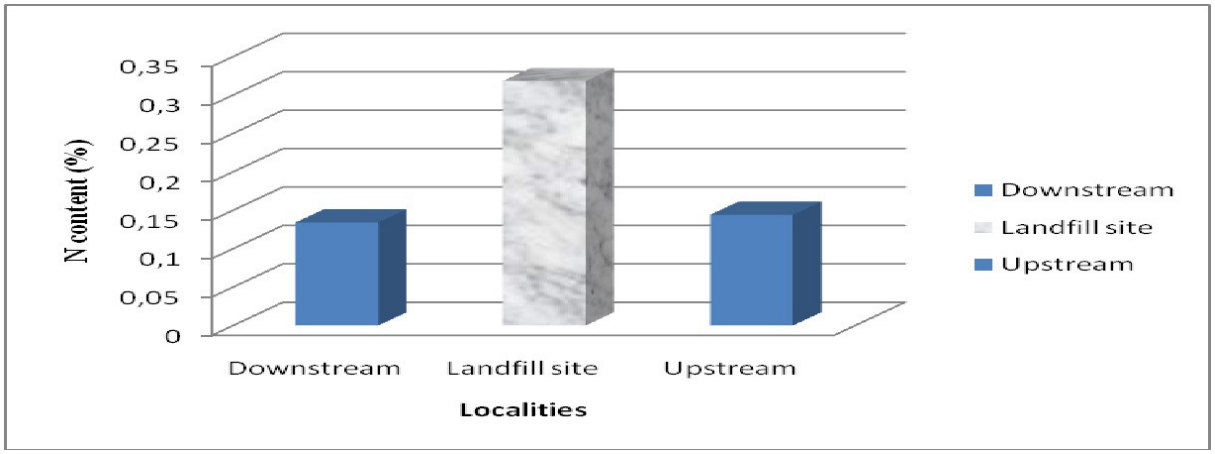

Figure-7
Variation averages of the K content according to localities any confused stations

The Carbone /Nitrogen ratio: The C/N ratio informs about the degree of soil organic matter evolution in the presence of micro-organisms. Thus, a C/N ratio < 10, reflects an active microbial life [11] and a good biological activity leading to a stable humus, but a ratio definitely higher than 10 indicates a fresh organic matter and a bad biological activity of the soil; which mean asphyxiated soil[21].

Starting from the various studied soils, we registered a C/N ratio of 23 in the 5 years municipal solid waste, of 19 in the municipal solid waste of 20 years and 4 in the 10 years municipal solid waste. Our results are not conforming to those found by François and al., who found in the landfill site of 3, 8 and 20 years was 46, 21 et 16. These authors explained the rise in ratio C/N for the 3 years municipal solid waste by the important content carbon and they considered that the last two ratios are very close to those met in a compost of household waste[22].

The comparison between our results and those obtained by François and al.,[18] watch that C/N ratio found in the municipal solid wastes of Tabarka is a lot lighter, resulting from a less industrial activity also the waste accommodated in these municipal solid wastes, it had made of an organic matter quickly compostable. By basing us on the conclusions of François and al.[18], we can conclude that the municipal solid waste of El Khdairia and of the City El Morjène belongs to the category of compostable municipal solid wastes, in opposition to the municipal solid waste of Bouterfès which had been characterized by a low nitrogen content (0, 1%). The physico-chemical characteristics of this site are closer to the characteristics of a soil than of those of a municipal solid waste. The increase in the C/N ratio in the 5 years municipal solid waste in summer testifies to the increase in population in Tabarka (to which the summer tourists had added). For the abandoned municipal solid wastes, we can explain the reduction recorded during the winter by the fact that in sandy soil, the organic matter losses by streaming or cheluviation are very important (figure-8 and figure-9).

Olsen Phosphorus: The phosphorus content was always higher in the municipal solid wastes than in the close zones. The most

important concentration had recorded (20, 73 mg kg-1) in the municipal solid waste of El Morjène. This concentration is significantly less in the two other municipal solid wastes, reaching only 4.12 Mg kg-1 in the soil of El Khdairia and 1.96 Mg. Kg-1 in that of Bouterfès. By taking account as if not contaminated localities of the area of Tabarka, we note that this concentration had multiplied by eight while passing from a nearby pilot soil (0, 85 to 0, 95 Mg. Kg-1) in municipal solid waste (8.86 Mg. Kg-1) (figure-10 and figure-11).

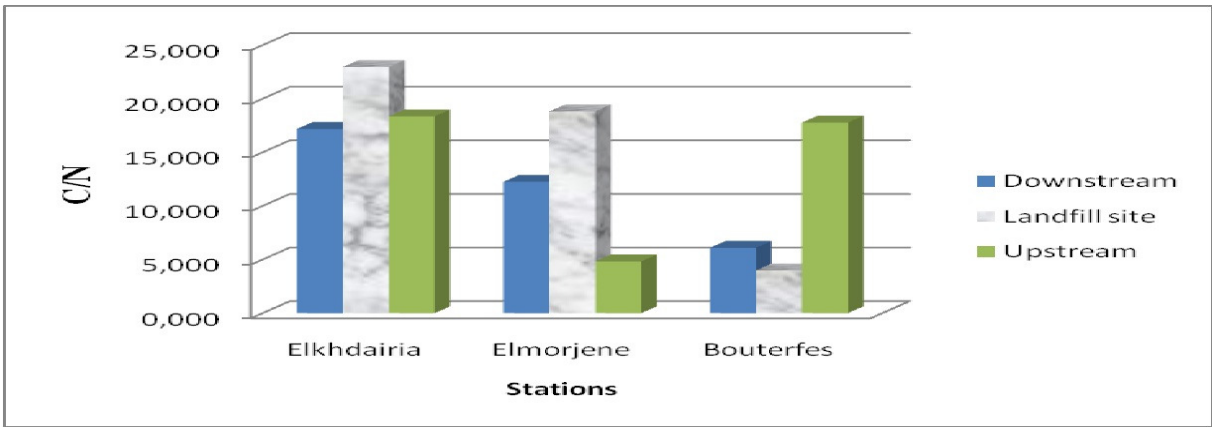

Figure-8
Variation of the C/N ratio according to stations

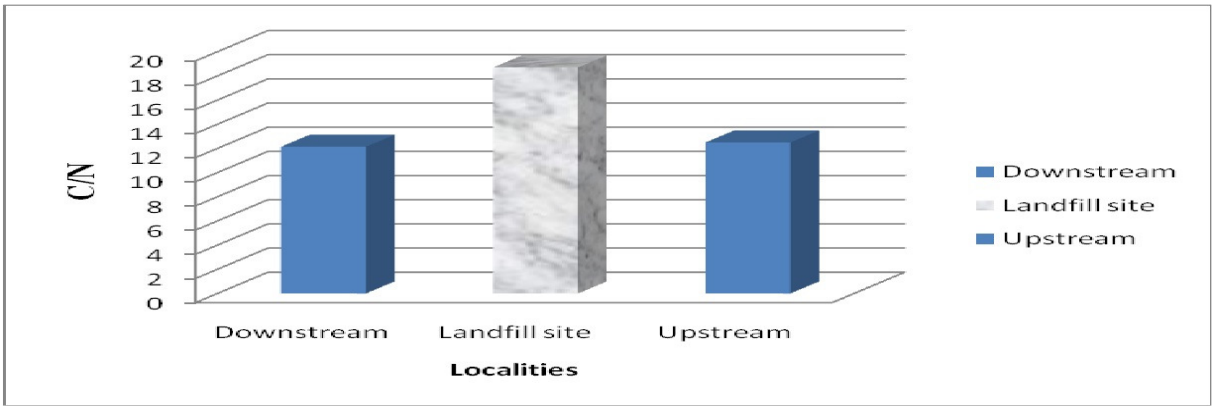

Figure-9
Variation averages of the C/N ratio according to localities any confused stations

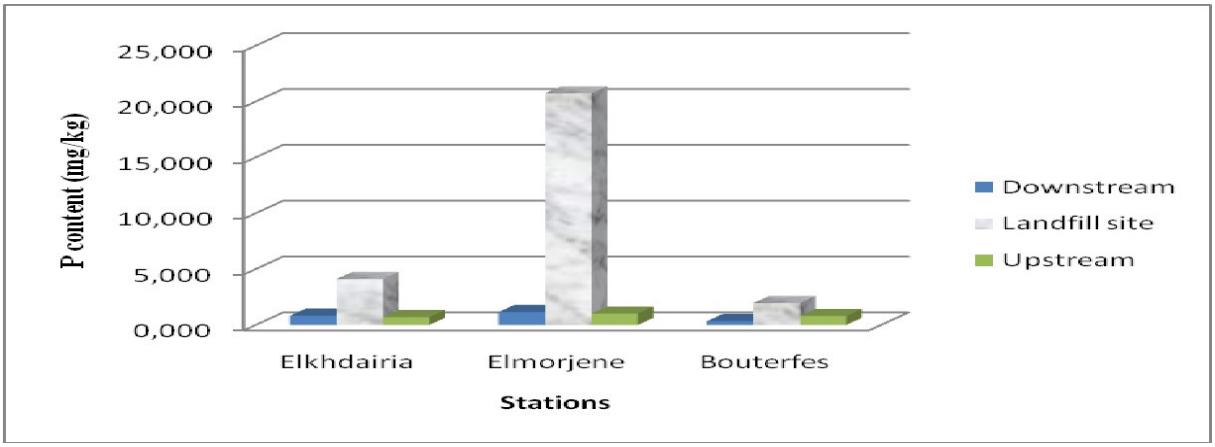

Figure-10
Variation of the P content according to stations

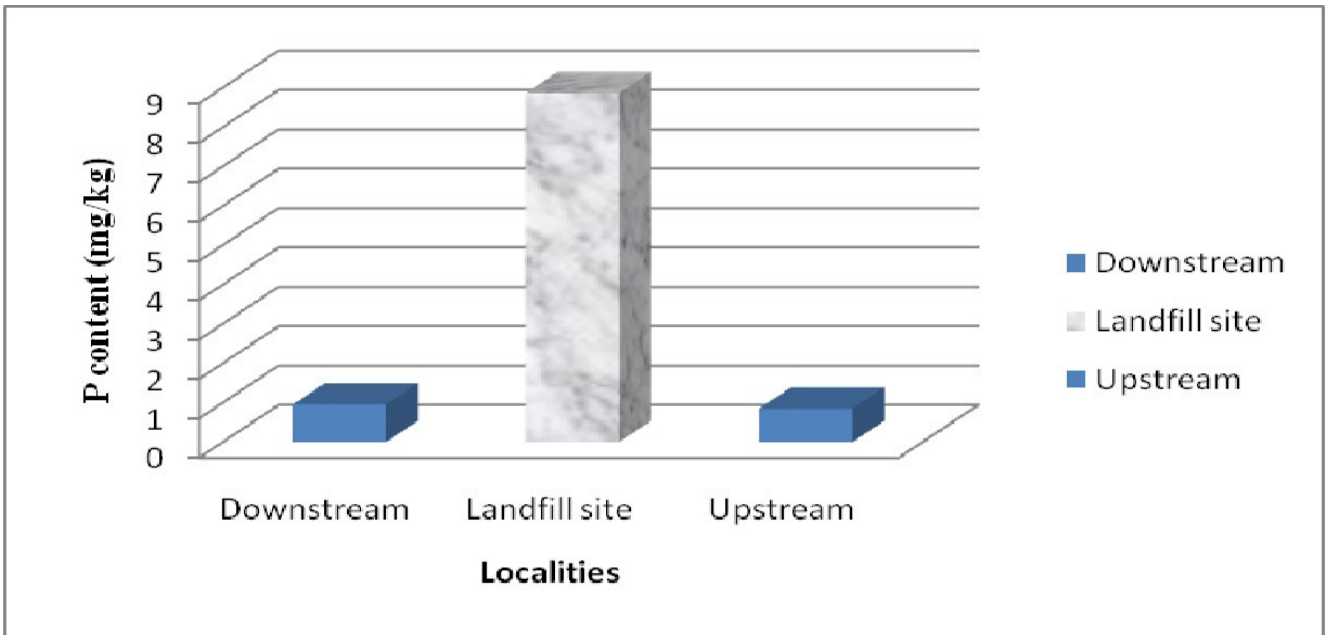

Figure-11
Variation averages of the P content according to localities any confused stations

To verify environmental interaction, a measuring of Phosphorus content, as a soil quality indicator in a minimum data set, is necessary[23].

According to soil quality index values and associated soil property threshold values and interpretation[16], the concentration recorded in the municipal solid waste of El Morjène was adequate for plant growth.

The seasonal variations in the phosphorus concentration are not significant for the municipal solid wastes of El Morjène and Bouterfès but, in the municipal solid waste of El Khdairia, the P content had multiplied by two during the summer. This increase is due to the increase in the tourist activity in the summer, characterized by an abundant fruit, vegetable supply, meat, fish, etc.

Potassium: The study of the total potassium contents (K) in the various soil of the area of Tabarka showed that they decrease largely while passing from the station of El Khdairia where we recorded the highest value : 2700 Mg kg-1 to the station of City El Morjène (442 mg kg-1) to become negligible in the station of Bouterfès (150 mg kg-1). This returns primarily to the fact that the K contents are largely determined by the soil type. Indeed, K is lixiviated less as much when it is present in a clay soil [11], however it was known that in the various studied soils the clay content also decreases while going from the municipal solid waste of El Khdairia to that of City El Morjène and will be negligible in Bouterfès (sand pit).

By taking into account the investigation conducted by the Ademe[22], the station of El Khdairia has a similar concentration of K to those found in household waste compost (figure-12 and figure-13).

Calcium: The total calcium contents registered in the various stations are much more significant than the potassium contents. Indeed, in the soil of the municipal solid waste of El Khdairia, we noted that total calcium is about 8% but about 3% in the two other municipal solid wastes. The high rates of that explain well why there is no vegetation in the interior of the municipal solid waste, since, for calcium excess, it disturbs the roots operation and decrease the organic matter mineralization[11,20] (figure-14 and figure-15).

For Ca and K, according to soil quality index values and associated soil property threshold values and interpretation[16], the contaminated soil of Tabarka present an excellent reserve of these two factors.

Sodium: For sodium (Na %), by taking account only contaminated localities, had the highest concentration recorded in the 5 years municipal solid waste (300 mg kg-1) but the minimal one had noted in the 20 years municipal solid waste (110 Mg kg-1). In the municipal solid waste of Bouterfès (10 years) the Na content is of 140 Mg kg-1 on the level of the center and does not exceed the 50 Mg kg-1 in the close zones. This variation is due to the fact that the center of this municipal solid waste is closer to the sea than the two other localities, which influenced the level of salinity in this soil. The types of the soil, as well as, municipal rubbish dumps age clarify this conflict (figure-16 and figure-17).

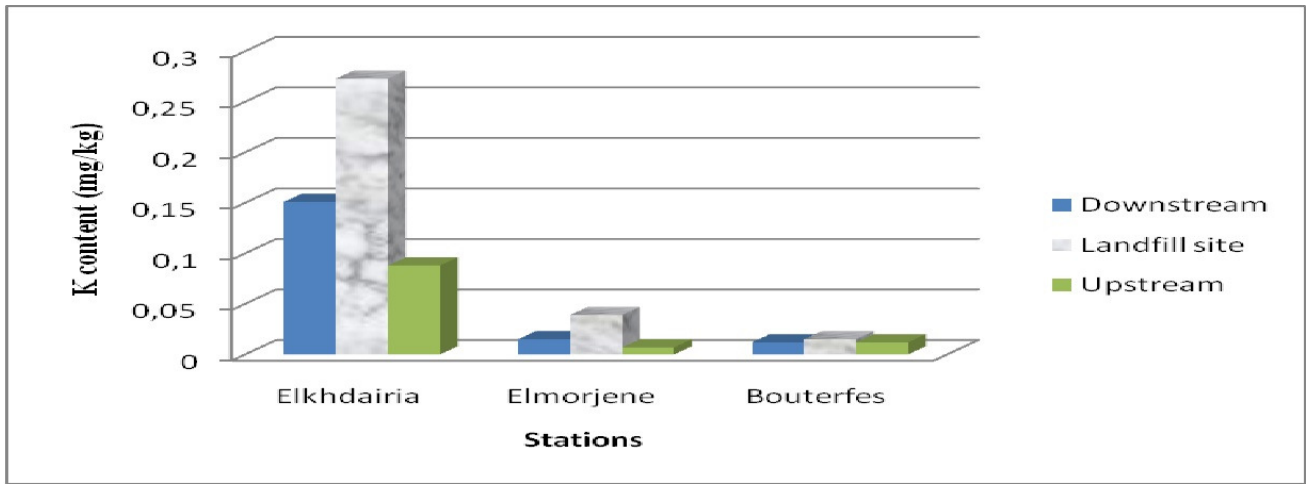

Figure-12
Variation of the K content according to stations

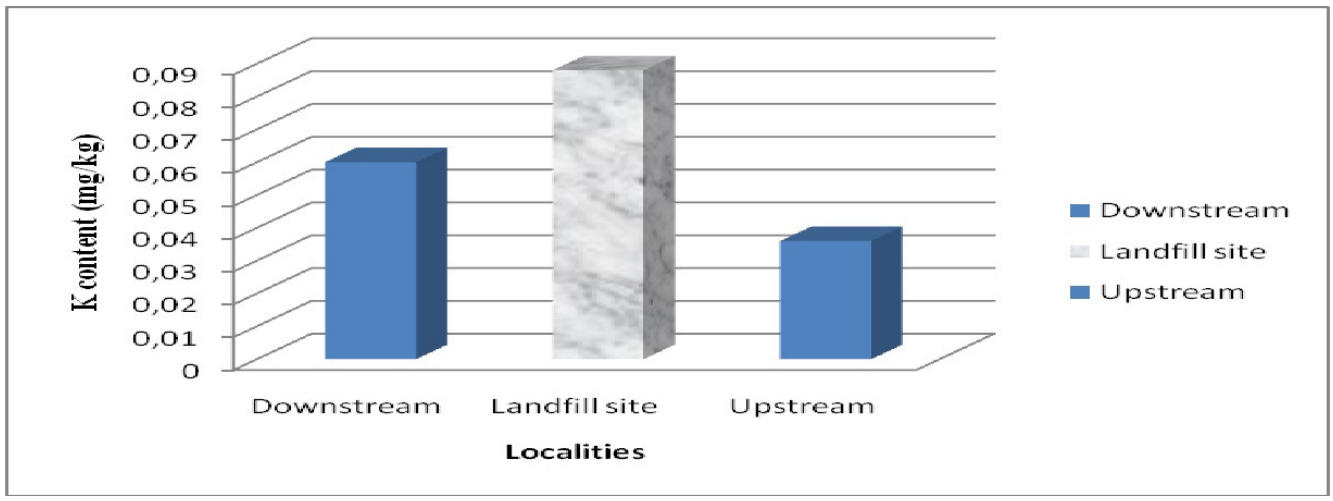

Figure-13
Variation averages of the K content according to localities any confused stations

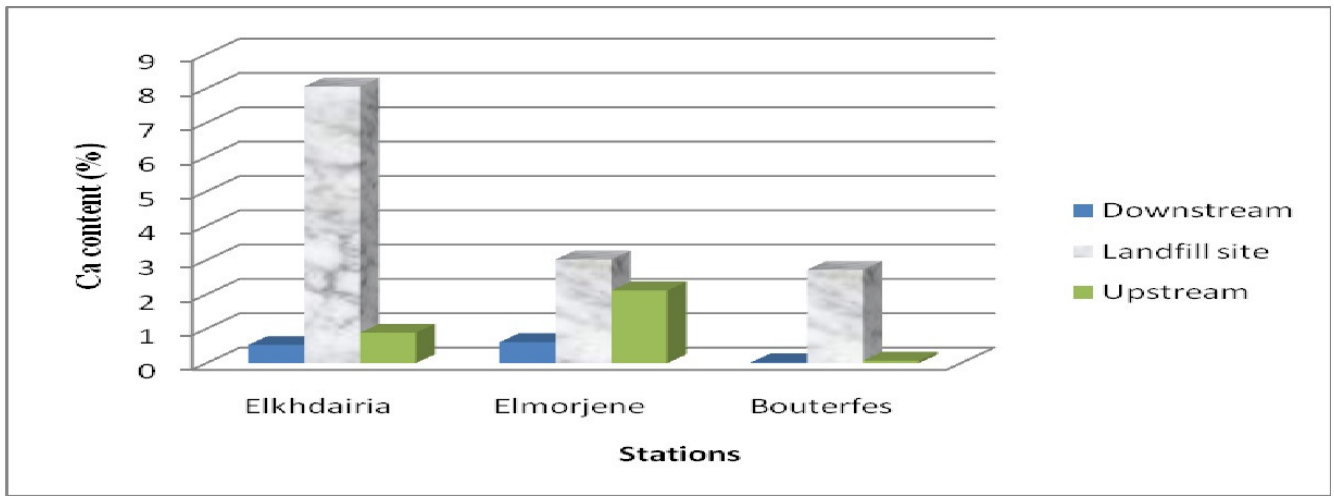

Figure-14
Variation of the Ca content according to stations

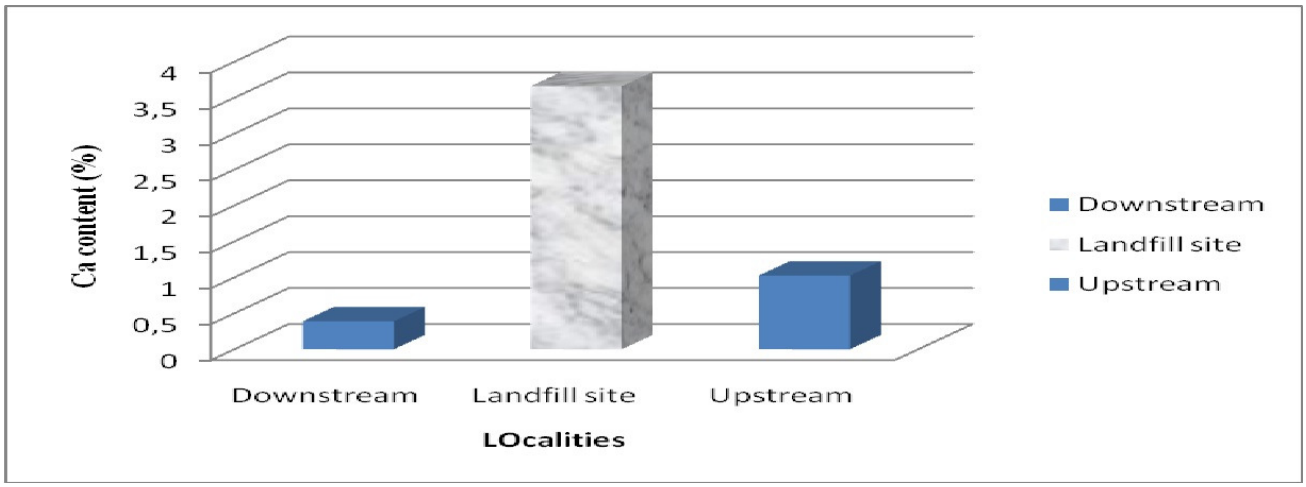

Figure-15
Variation averages of the Ca content according to localities any confused stations

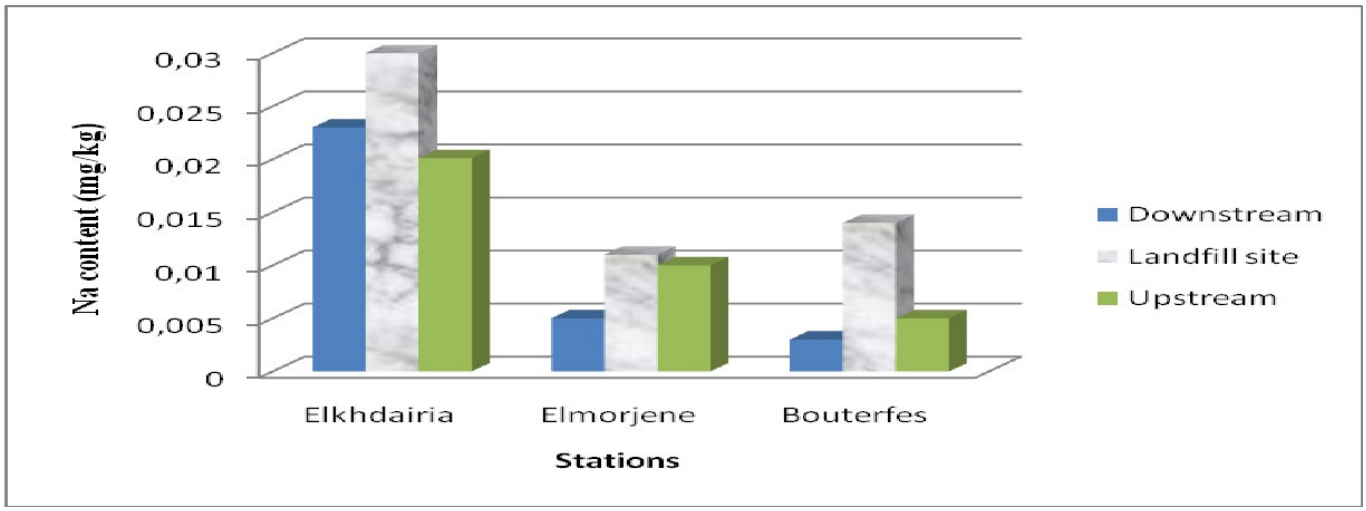

Figure-16
Variation of the Na content according to stations

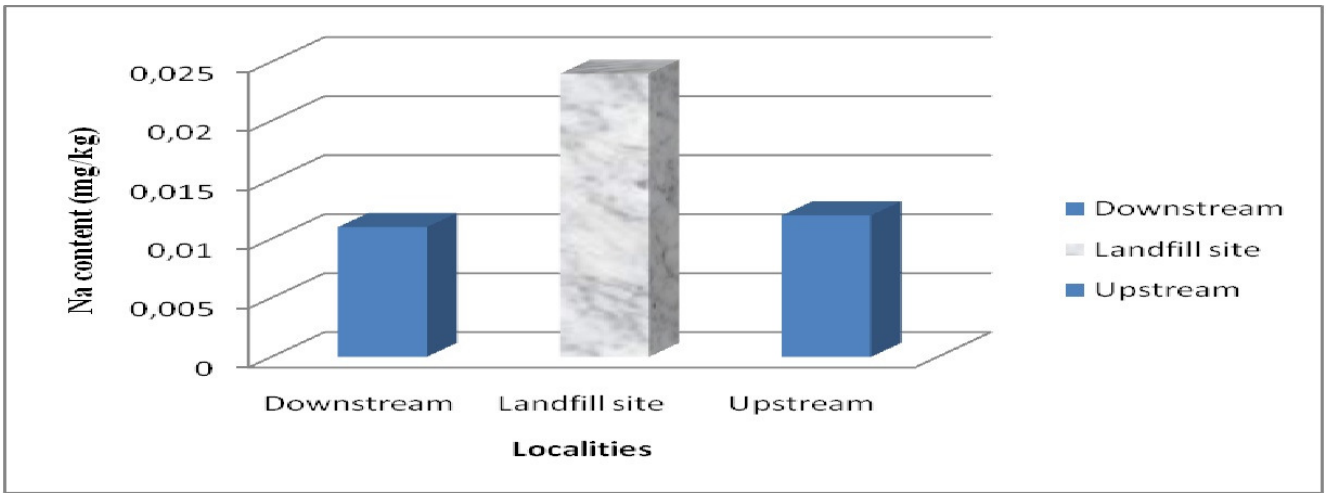

Figure-17
Variation averages of the Na content according to localities any confused stations

Variation according to the site and the Season: The contents of nitrogen (N), carbon (C) and Olsen phosphorus (P) in the soil varied significantly between stations and localities ($p < 0,001$) but seasonal variation do not exert any significant effect on these three elements.

The Ca total content, varied significantly ($p < 0,001$) by stations, locality and season, as well as the interaction station-locality.

For sodium (Na) content, the station exerted a significant effect ($p < 0,001$). Also, a clear difference of the soil total sodium content appeared according seasons ($p < 0, 01$).

The total soil potassium contents (K) varied significantly according stations ($p < 0,001$) and localities ($p < 0, 05$).
But the season did not exert any significant effect on total sodium and potassium content.

For most studied elements (C, N, Ca, K, Na), we found out that the results recorded in the station of Bouterfès and more particularly in the center of the municipal solid waste, are strongly influenced by the nature of the soil.

Thus, for the majority of the studied biogenic salts, one does not manage to discover significant differences between the pilot soils and the nastiness of the municipal solid waste on the level in this station (Bouterfès) which was now abandoned sand pit.

The results of the analysis of the variation of the content of the soil of major nutrient elements are given in table 1.

Conclusion

Biological, chemical, and physical properties of Soil are dynamic and can change respectively in response to how the soil was handled. IT represents the nourishment of the human development and the majority of the terrestrial ecosystems. It was certainly the subject of a multitude of researches although those being interested in the soils polluted by heavy metals are relatively recent, since the soil had characterized for a long time by the phenomenon of self-purification.

This study sought to explain the consequences of a garbage dump on the soil and if it is possible to produce organic waste present for a compost production.

For that, we studied the major nutritive element's content (total calcium, total potassium, total sodium, carbon, phosphor and nitrogen) in various samples of soil.

In the soils receiving a contribution of municipal solid waste, the nutritive macronutrients content is very important and significantly different from the contents recorded in the taken soils of the not contaminated close zones.

The manuring of organic matters presents a big potential of valuation but he can present diverse risks if he is badly handled.

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Table-1
Variation in soil macro elements content following stations, localities and according seasons

	C	N	P	C/N	Ca	Na	K
Factor	**Signification**						
Season	0,07 ns	3,72 ns	0,59 ns	8,27 **	24,18***	8,80**	3,75 ns
Station	14,88***	26,81***	38,10***	17,42***	7,75***	9,45***	17,05***
Locality	23,99***	51,94***	56,60***	1,08 ns	49,07***	1,90 ns	4,28*
Station*Locality	12,35***	19,02***	37,49***	8,30 ***	7,32 ***	0,92 ns	0,50 ns

Significative Deference à : * :5%; ** : 1%; *** : 0,1%

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