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Research article

Composting and lixiviation, case study in Médenine-Tunisia

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Abstract
Composting is an important method for the recycling of organic waste collected from agricultural trashes or kitchen scraps. Adding compost to sandy soils improves the water holding capacity, and makes clay soils easier to work and plant. Through adding organic matter to the soil, compost can help to improve plant growth and health. This study was about the preparation of compost from organic domestic leftovers and garden trimming wastes. Different physicochemical characteristics of compost were determined during and after realization. In addition, incubated compost with rainwater were studied, in order to simulate the behavior of this product in the environment and to understand the effect of lixiviated water. The kinetic evolution of various physicochemical characteristics was followed for a period of several weeks. In fact, by incubating compost in rainwater, it liberates minerals likes calcium, magnesium and phosphates.

Key words: Composting, Kinetic, lixiviation, Tunisia.

1. Introduction

The serious problem of domestic waste emanating from the island of Djerba, located in the governorate of Medenine in southern Tunisia, is due to the growing number of inhabitants and tourist visitors reaching the number 160000, according to the general survey of the population realized in 2014. Several solutions emerged to address this problem, such as waste compression, recycling or composting. In the first place, this work consisted in studying the composting of organic waste or bio-waste from municipal waste mixed with a structuring agent: crushed green waste. Second, a study was carried on the kinetic evolution of compost, incubated for a hundred days, in rainwater.

2. Material and methods

The composting center of Djerba Houmt Souk (Medenine Governorate Tunisia), is a pilot station for processing organic waste. They come from the organic fraction corresponding to food waste (food residues such as peelings ... except bones) and green waste (garden waste). The reception of garbage is done three times a week. There are four windrows in the composting center that are 12 meters long and 2.5 meters wide. In order to reduce the odors released from the leachate, a biofilter is used. It is a bucket containing crushed green waste. The water needed to moisten the filled bucket is stored in a tank located right next to the windrow.

2.1. The treatment of municipal waste by composting

Composting is an aerobic biological valorization process that transforms organic matter into a fertilizer, which is a stable and hygienic product. Composting takes place according six consecutive steps:

a) Reception of organic waste:

This step involves the reception and the preparation of the organic waste by eliminating impurities (plastic, aluminum, metal cans, glass waste ...). The sorting of these impurities is manual carried out by the personnel.

b) Grinding green waste:

The grinding of green waste is necessary to facilitate their degradation. It is made by a BANDIT MOD7L1390 XP grinder. This green waste is used as a structuring element during the composting process.

c) Placing in windrows:

This stage implements the favorable conditions for composting. The organic waste is mixed thoroughly with the green waste in equal proportions. The windrow is then covered with a layer of vegetable waste having a thickness of 30 cm. Finally, it is covered with a tarpaulin to limit heat loss and evaporation.

d) Reversing:

The reversing accelerates the degradation of the organic matter and it allows the mechanical aeration of the compost. During the thermophile phase, the reversal is done regularly because the biological activity requires a lot of oxygen.

e) Screening:

During this operation, the materials are divided into very fine fractions. Hence, the remaining unwanted materials as plastics, glasses are eliminated.

f) Maturation:

During this step, the organic materials are stabilized compared to the raw materials composted. This compost is prepared from 50% municipal waste and 50% crushed green waste, 18t of each fraction. Daily control of the temperature and the humidity is done automatically every 20 minutes, using implanted probes in different parts of the pile. Hand humidity tests and a self-heating test are performed.

2.2 Physico-chemical analysis

The physicochemical analyzes were carried out according to Dugain's method. Mineral analyzes were carried out by an acid attack of the ashes. The samples were then analyzed by atomic absorption. The apparatus used is a HITACHI model Z-6100.

2.3 Study of the incubation of compost in rainwater

This study on compost lexiviat, concisted on the incubation of three grams of compost in 1.5 liters of rainwater during 14 weeks. The pH, conductivity and concentration of various ions were monitored during this incubation.

the end of the biological process, the pH values obtained are close to neutrality. These neutral pH values The evolution of the electrical conductivity shows that the values start from a value of 4 mS/cm to reach a value of 8 mS/cm. The increase of the conductivity during the composting process results from the concentration of the mineral fraction following a decrease of the organic fraction under the effect of the microbial activity. At the end of the composting process, the conductivity reaches a value of 7.72 mS/cm.

3. Results and discussion

3.1. Follow-up of composting

The composting of organic-waste mixed with green waste lasted 80 days by watering and turning over as needed. The compost obtained was characterized by the smell of potting soil; the temperature was similar to the ambient temperature. The general appearance of this compost was granular and dark since the original compounds were no longer distinguished by naked eyes.

3.2. Study of composting parameters

One of the characteristics of composting is the release of heat. This heat is an indicator of how composting works. The evolution of the temperature was recorded during the composting process. In the figures 1,2,3 below, the temperature rises quickly after 30 days of composting to reach maximum values around 70 °C, it is the thermophilic phase.

The short duration of the thermophilic phase, is the index of a balanced porosity, the homogenization of the mixture and a good aeration for the good development of microorganisms. After few weeks, this temperature decreases: it means that the degradation is well advanced. We can consider that the maturation phase starts from the 70^{th} day of composting since the temperature stabilizes and the mixing has no more considerable effect on the elevation of this parameter. The temperature of the pile is confused with the ambient temperature thus testifying to the absence of a microbial degradation activity.

The figure 4 of pH evolution during the composting process shows initially an acidic pH of 4.25. This value increases during the thermophilic phase to reach an optimal alkaline value of 8.47. This alkaline phase lasts about a period of 30 days. During this phase, the mineralization of the nitrogen compounds and the release of ammonia produce the alkaline medium. At are characteristic of a mature compost and this is the effect of humic substances in compost.

Watering the mixture during the formation of the windrow is essential. The humidity can be higher than 60% and reach 70%. A gradual decrease in this parameter is recorded during the composting process. From a value of about 70%, the humidity decreases to a value of 30%. At the end of the process, the water content of the composts obtained attests to the maturity state of the compost.

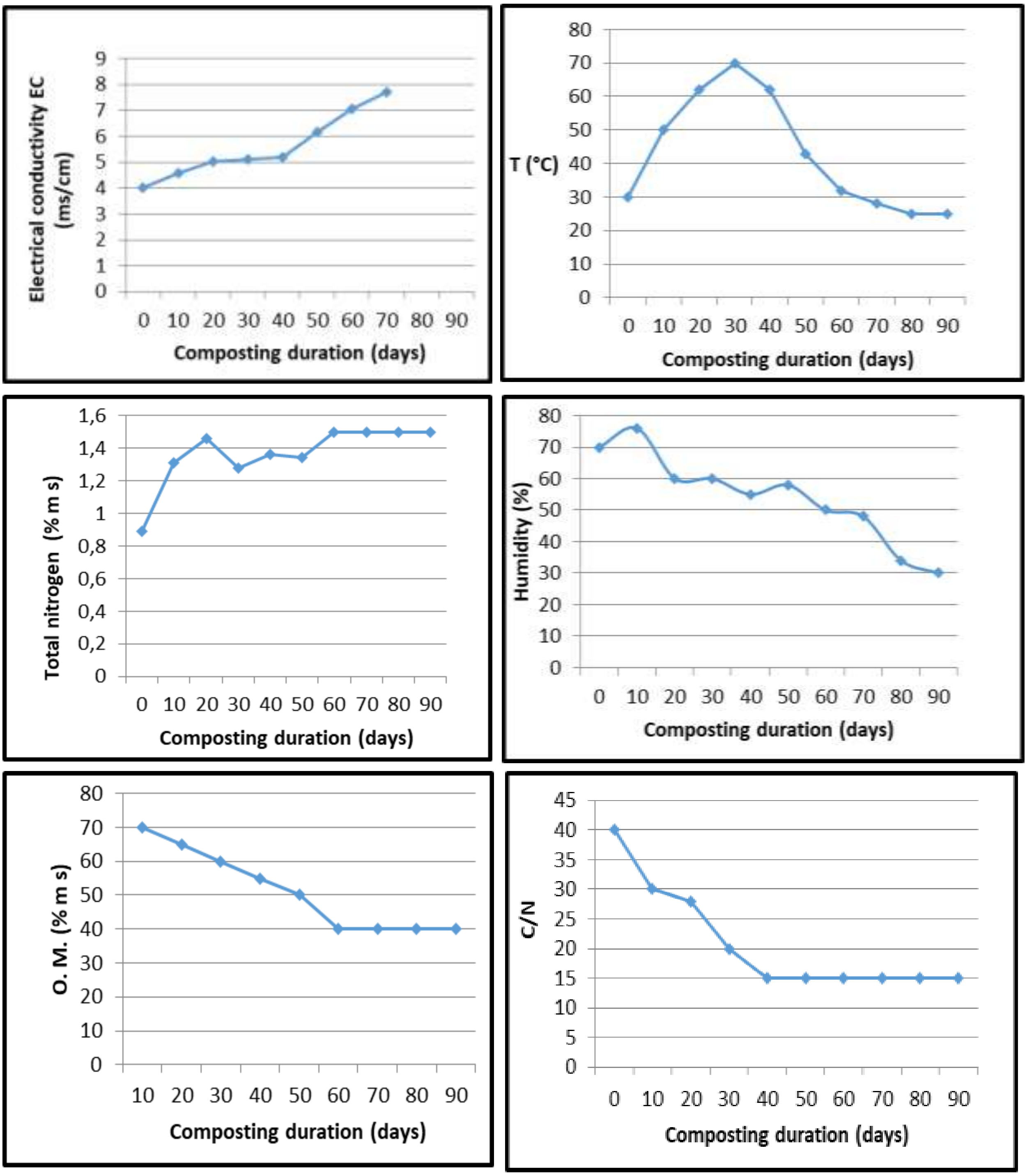

Fig. 1: Study of composting parameters

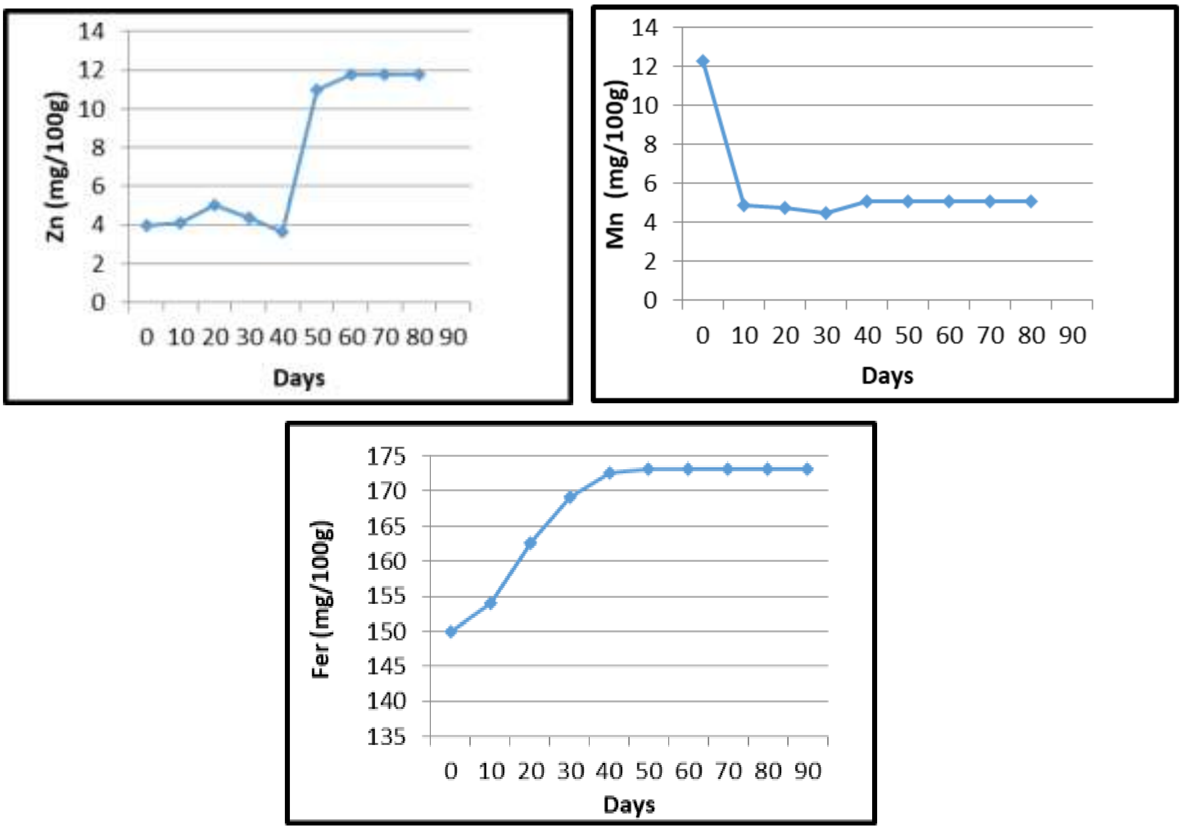

Fig. 2: Evolution of elements within environmental interest during composting

Table 1: Physico-chemical characterization of the compost obtained

Parameters	Compost
pH	7.35
EC (mS/cm)	5.86
Humidity %	15.8
DM %	84.2
OM %	38.5
MM %	61.2
TOC %	19.5
TNK %	1.48
C/N	12.9
K (mg/100g)	459.2
Ca (mg/100g)	1834
Mg (mg/100g)	287
Na (mg/100g)	1553
Fe (mg/100g)	173
Zn (mg/100g)	11.8
Mn (mg/100g)	5.04

E.C.: Electrical conductivity; D.M.: Dry matter; O.M.: Organic Matter; MM: Mineral Matter; T.O.C.: Total Organic Carbone; TNK: Total Nitrogen Kjeldahl.

At the beginning of composting, the C/N ratio has a value of about 40. This important value is the result of the presence of carbon-rich bio-waste. During the composting process, the C/N ratio decreases gradually. After 50 composting days, the value of C/N reaches a value of 15, which is according to Mustin in the optimal zone (between 15 and 8). The reduction of the C/N ratio is explained by a release of organic carbon at the state of CO_2, released by the microorganisms that attack the easily biodegradable organic fraction. In addition, this reduction in the C/N ratio can also be explained by the increase in the percentage of total nitrogen during the composting process which results from the degradation of the proteins from the starting materials under the effect of heat and the action of microorganisms. At the end of the process, the organic fraction composed by a variety of complex molecules and that does not degrade completely, is remaining.
The organic matter OM decreases during the first 60 days to reach a value of 40% of the dry matter. A close correlation can be seen from the kinetics of moisture evolution, C/N ratio, and organic matter in the compost mixture.

3.3. Elements within environmental interest

Minerals can be classified into several different groups according to their interests. Thus, we distinguish minerals that are indicators of the environmental quality of composts such as iron, manganese, zinc and copper. An excess of these minerals can represent a form of pollution and degradation of the chemical quality of the compost.
The evolution of the manganese concentration during the composting process, shows practically constant values of the Mn concentration, of the order of 5 mg/100 g, which is a concentration similar to that of the commercial manure used by the farmer [1,2].
From an environmental point of view, it is disadvised to have manganese-rich composts, because same as iron, this element could prevent the absorption by the plant of certain minerals (antagonistic effect with other minerals) such as calcium [3].

The concentration of zinc during the composting process is generally low, complying with standard NF U 44-05 [4], starting from a value equal to 4 mg/100g. The curve has a peak that reaches 11 mg/100 g at the 50th day, then undergoes a slight increase to reach a maximum of 11.7 mg/100g.

3.4. Elements of agronomic interest

Minerals of agronomic interest such as potassium, calcium, sodium and magnesium are indicators of the fertilizing value of compost.
The concentration of potassium during the composting process starts from a value of 400 mg/100g. This important value is explained by the richness of organic matter and green waste in potassium. The content of this element undergoes an increase to reach a maximum of 700 mg/100g, this is due to the heterogeneity of the starting materials. At the end of the process, the values obtained decrease to reach values close the initials.
Calcium concentration increases during the composting process. This increase can be explained by the use of tape water for humidification which is a hard water rich in calcium, in addition to the potential release of calcium in the medium by transformation of the starting materials. During the maturing phase the calcium content becomes stable at the end of the process.

The general evolution of the magnesium concentration shows that there is a decrease over time. This concentration starts from a value of 1000 mg/100g. The magnesium concentration decreases rapidly until the 30th day. Then the concentration of magnesium varies slowly until the end of the composting process to reach a value of 287 mg/100g. This can be explained by the leaching of this element by the repetitive process of humidification in addition to the absence of generative sources, given the lack of raw materials in this element.
The sodium concentration increases with fluctuation to reach a peak of 1825 mg/100g. This increase is due to the richness of the tap water used for sodium humidification. The fluctuation is due to the heterogeneity of the raw materials. The sodium concentrations stabilize during the ripening phase at a value of 1553 mg/100g.

3.5. Characterization of the compost:

After an 80-day composting cycle, a mature compost is obtained. The results of these analyzes are detailed in the table 1.

The compost studied has a pH almost neutral and slightly alkaline. This indicates the maturity of the product as well as the presence of humic substances that are characterized by their buffering effect.
The electrical conductivity value does not exceed the organic amendment standard and the organic matter contents are higher than 20 and comply with the EU Ecolabel as reported by Lasaridi et al. 2006 [5].

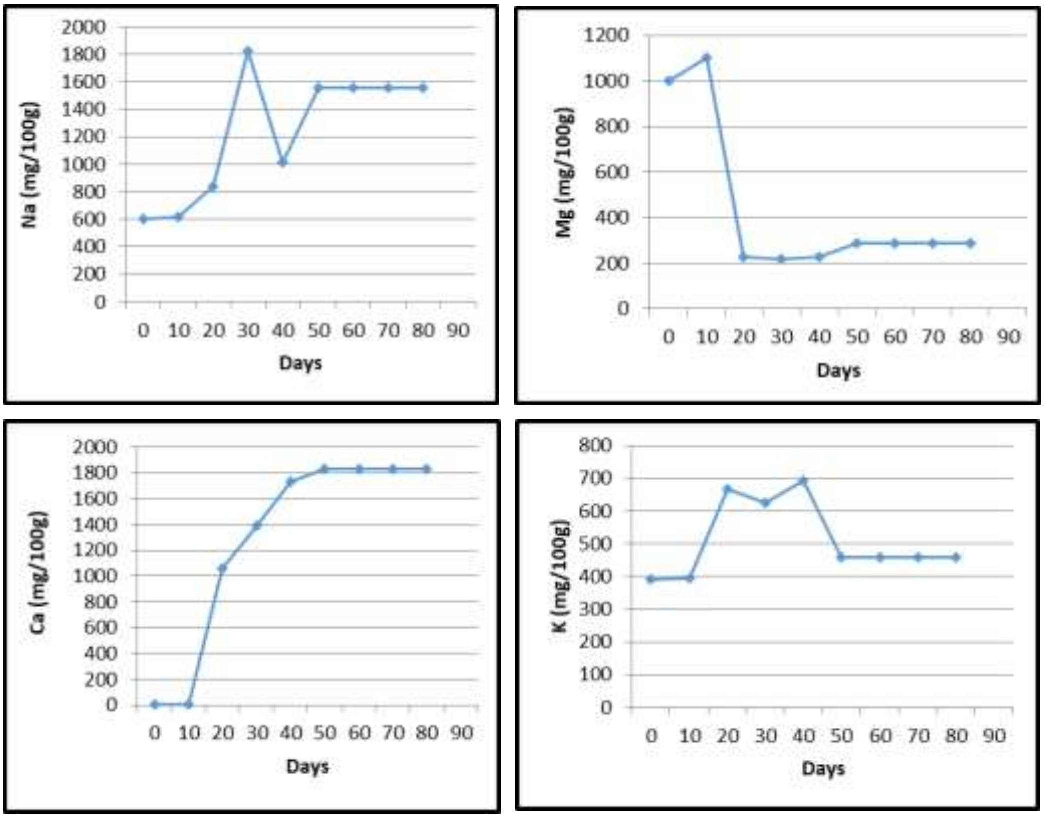

Fig. 3: Elements of agronomic interest

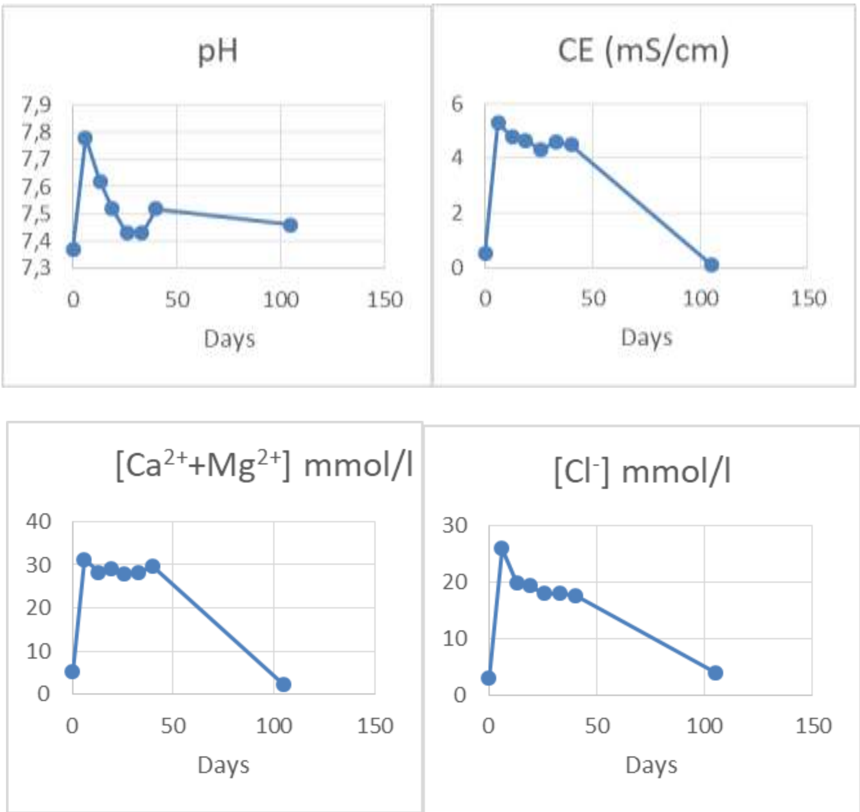

Fig. 4: Kinetic evolution of some physicochemical properties

On the other hand, the amount of Total Nitrogen is important in the studied compost and proves the fertilizing value of the finished product. The C/N ratio has a value close to 12 that reflects mature compost as shown by Bernal et al. [6]. Overall, the compost obtained has a considerable richness in mineral elements. Thus, these indicators show the fertilizing value of the compost as well as its environmental quality.

3.6 Study of the lixiviat

In order to understand the potential impacts of contacting compost with the elements of nature like water, certain chemical characteristics were collected during the incubation period of compost in rainwater. At the beginning of the compost degradation process, the pH, conductivity and concentrations of Cl^- and (Ca^{2+} Mg^{2+}) increase, indicating dissolution and mineralization of the compost. Then, they diminish signalling the end of this process by the recombination of the dissolved entities and their fixation on the organic matter in particular the humic acids as described by Mariangela [7]. In fact, Tipping [8] reported the remarkable affinity of humic acids for metal ions since they tend to form stable complexes with them. This evolution towards a state of equilibrium after 100 days of incubation is justified by values close to those measured at the beginning of the experiment. Which is in agreement with the works of Cantin [9].

4. Conclusion

The first part of this is study was of a project on the recovery of household waste by composting in the composting center of Djerba Houmt Souk (Medenine Governorate Tunisia). The second part of this study was the investigation of the potential impact of compost on water. This project continues with an in-depth study of the kinetics of the physicochemical properties of the composting process as well as the extraction of added-value materials from compost such as humic acids

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