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Valorization of *Jatropha curcas* waste by composting

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Abstract

Jatropha curcas is a species that belongs to the Euphorbiaceae family that originated from Central America. The species is generally used for the production of oil which is further processed into biodiesel by transesterification. For intensive production several parameters are important and among them is pruning that generates significant amounts waste biomass. In this context the objective of our study is to make use of this green waste by composting. In the pilot study carried out here a total of 48 kg (40 kg of branches and 8 kg of fruit shells) of homogenized waste was placed in a bioreactor. During composting, the reactor was fed by a compressed air flow to ensure thorough oxygenation. An automatic system continuously kept the biomass in movement. During the composting process, samples were taken at different stages to monitor various physicochemical parameters. After 1 month of composting, the analysis revealed the flowing parameters: C /N<21, $NH4^+/NO3^-$<1 and a pH between 5 and 7. The levels of phosphorus rose after the 5th day of composting to reach 0.03 mg/g. These results confirm that the final compost meets the standards required for its use in agriculture.

Keywords: *Jatropha curcas* L., green waste, composting, reactor.

Introduction

In the last decades, the world looked towards using alternative energies such as biodiesel from some oleaginous species. *Jatropha curcas* is one of the most used species for biodiesel production [1] and *Jatropha* oil has the characteristic of inhibiting the corrosion of steel which can be used in industry [2]. It belongs to the Euphorbiaceae family and is native to Central America [3], distributed in Africa and Asia by Portuguese via the Cap Verde islands and Guinea Bissau [4].

Jatropha can develop under adverse conditions. It can grow in a broad range of soils with a pH ranging between 6 and 8 [6] and even on drained gravelly. Aerated sands and silts of at least 45 cm of depth are the best grounds for *Jatropha* [5]. The important contents of the biogenic salts enable him to develop on and enriched the grounds degraded.

Good production of fruits *Jatropha* depends on several agricultural practices, such as pruning. The pruning not only increases the number of branches and thus the number of fruits, but also allows to keep a tree form that facilitates the harvesting.This operation generates green waste rich in mineral elements such as (NPK).The objective of our study is the valorization of the green waste of *Jatropha* by composting so that one can re-use it as a fertilizer**.**

Materials and methods

2.1. Materiel

Our greenwaste originated from the demonstration field of the JatroMed project located in Had Draa, Essaouira. After pruning, the branches of the plants of the Mali genotype are collected and were cut out into small pieces and mixed with the hulls of the fruits.

40 kg of branches and 8 kg of the fruit hulls were mixed and homogenized and placed in a bioreactor, with a capacity of 100 liters. During composting, the reactor was supplied by a flow of compressed air to ensure oxygenation. An automatic system ensures the continuous shaking of the system. During composting, samples are taken at different stages (T0, T5, T15, T25 and T30 days), to follow their various physicochemical parameters.

2.2. Methods

2.2.1. Physical parameters

Temperature measurement

The temperature was measured daily for a period of 30 days in situ by an electronic thermometer. Based on these measurements we calculated the average temperature.

PH measurement

10 g of the sample was crushed and then put into a vial and mixed with10 ml of distilled water and then stirred for 30 min. The pH was measured using a pH meter (20 Basic Creson).

Conductivity measurement

10 g of the ground sample was mixed with 10 ml of water and then subjected to stirring for 30 min. The conductivity was measured with conductivity meter (Creson Basic 20).

2.2.2. Chemical parameters

Determination of organic matter

The organic matter content was determined after calcinations of the total sample. This rate was calculated by difference between the initial sample weight and the weight of the ash, knowing that during the calcination, the weight loss was due to the 100% combustion of the organic matter [7].

Available phosphorus

There are several methods for available phosphorus dosing among them the Olsen method. 1g of fresh compost was added to 20 ml of Olsen reagent, the mixture was stirred for 1 hour, followed by filtration. 1 ml of the filtrate was added to 4 ml of distilled water and to 5 ml of AB reagent in a test tube. The tube containing the reaction mixture was put in a water bath at 80°C for 10 min. After cooling, the reading of the optical density was performed using a spectrophotometer at 820 nm. The phosphorus value was determined using a standard curve [8].

Mineral nitrogen: $NO3^-$/$NH4^+$

The contents of ammonium and nitrate were determined on 0.5 g of fresh sample. The sample was distilled according to the Kjeldahl method in the presence of 10 ml of NaOH 40%. Subsequently, it was titrated with 0.02 N sulphuric acid in the presence of Tachero dye [9].

Quantification of total Kjeldahl nitrogen

Digestion of the organic material (0.5 g) with sulphuric acid (10 ml) in the presence of 0.5 g of the Kjeldahl catalyst can convert different forms of nitrogen in ammonium sulphate. Distillation of ammonia under the action of a strong base can recover it by Boric acid (H_3BO_3). NKT content is determined by the Velp-UDK 132 distillation unit.

3. Results and discussion

3.1. Physical characteristics of composted substrates

Before starting the composting process, preliminary analyzes are required to support the operation of the process, the results are presented in Table 1.

Table 1: The initial physicochemical characteristics of composted green waste

Analyzes	
pH	**8.1**
Conductivity (mS/cm)	**0.57**
Organic Matter (%)	**88**
Total carbon (%)	**52.50**
Total azotes (%)	**0.8**
Available phosphorus (%)	**0.02**
C/N	**65.6**

During the composting process the temperature increases to 68°C and then decreased gradually to ambient temperature. The shape of the temperature graph differentiates between different phases of the process; the initial phase, which took 3 days from 23°C to 44 °C (Fig. 1) the thermophilic phase which is characterized by a gradual increase in temperature to 67.4°C for 15 days; and the decline phase (end of the stabilization phase) characterized by the sudden reduction of the temperature until reaching values close to ambient temperature (24°C). The evolution of the temperature during the composting process was related to the activities of bacteria and fungi [10].

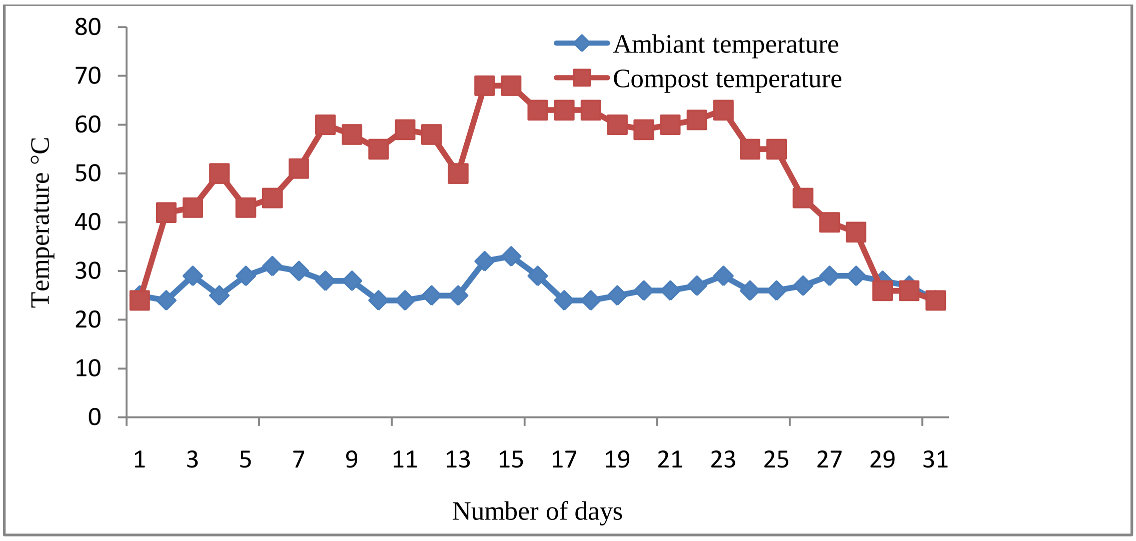

Figure 1: Evolution of temperature during composting

The pH gradually decreased during composting to reach 5.5 then it goes back to a value of 7.1; this decrease was due to microbial activity, mainly the production of CO_2 and organic acids during the first phase of composting [10] [11].The pH of the compost was a parameter modulated by several factors including the nature of the composted substrate and microbial activity.

The conductivity during composting increased from 0.57 mS/cm to 8.8 mS/cm. This increase was related to the degradation of organic matter by microbial community that enables the digestion of organic matter and it follows the release of minerals in to the environment which induces the increase in the conductivity of the compost (fig. 2). The same result was reported by [12] for *Jatropha* hulls.

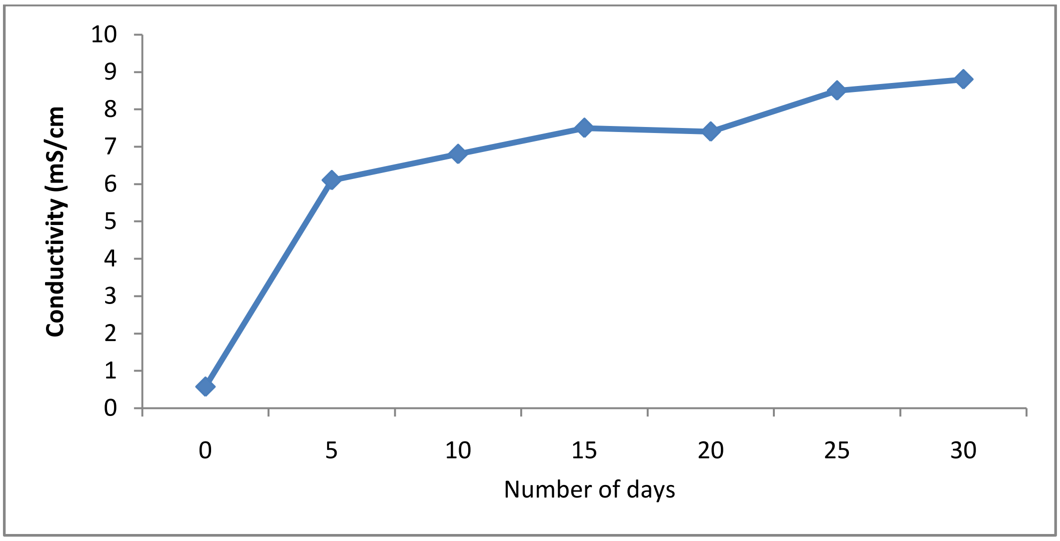

Figure 2: Evolution of conductivity during composting

3.1. Chemical characteristics of composted substrates

The contents of available phosphorus are stable throughout the composting process, with a slight increase after the 5th day of the composting from 0.02% to a value of 0.03%, resulting in are lease of phosphorus following mineralization organic matter (fig. 3).

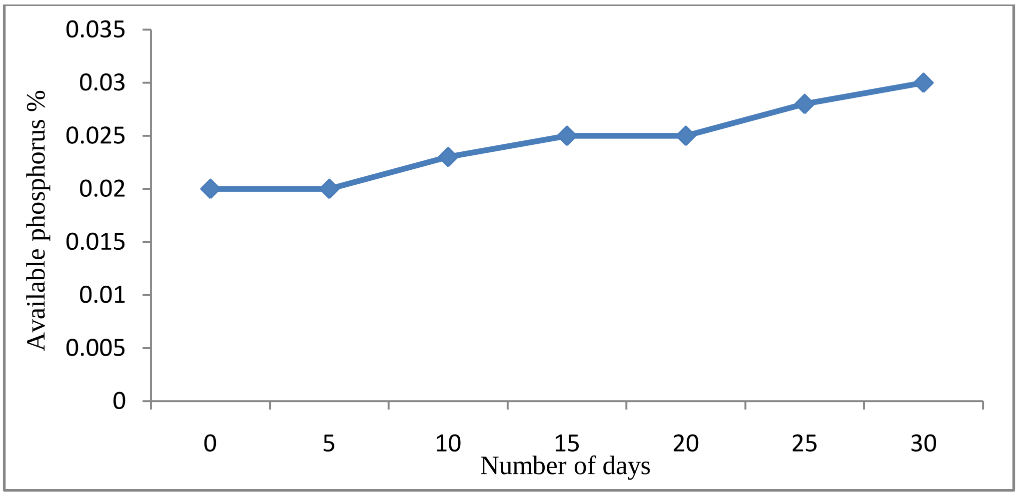

Figure 3. Evolution of available phosphorus during composting

The organic carbon is transformed by the microbial activity in to volatile carbonaceous compounds like the organic acids and from gases like CO_2. A net loss of the percentage of carbon during the process of composting is observed and it passes from a percentage of 52.7% to a value of 48%. Sharma [10] reported a value of 23.40% for the hulls of the fruits of Jatropha (fig. 4).

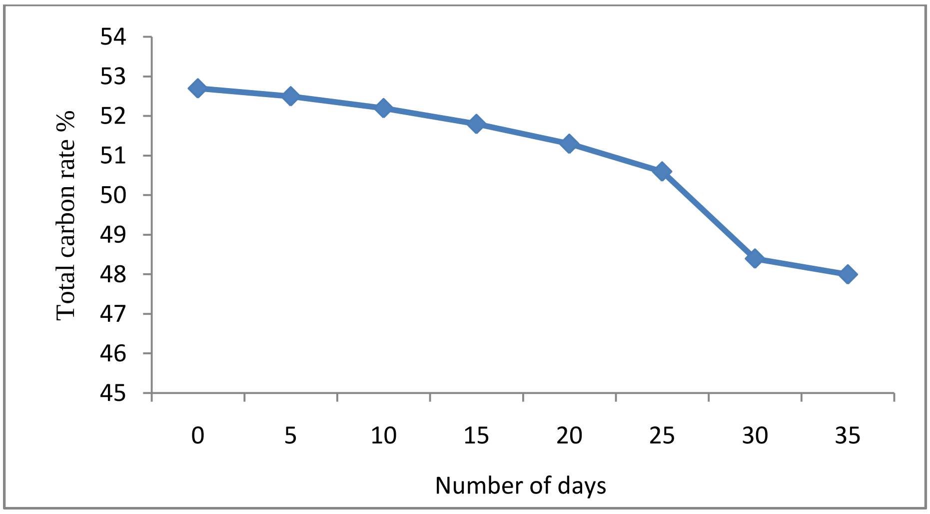

Figure 4. Evolution of the total organic carbon content during composting

Nitrate is a mineral form of nitrogen generated by nitrification of the nitrogenous organic compounds that is purely a microbial process. During composting, the content of nitrates increases from 3.1 to reach 15.9 after 30 days. While the value of NH_4^+ was between 0.9 and 6 (fig. 5).

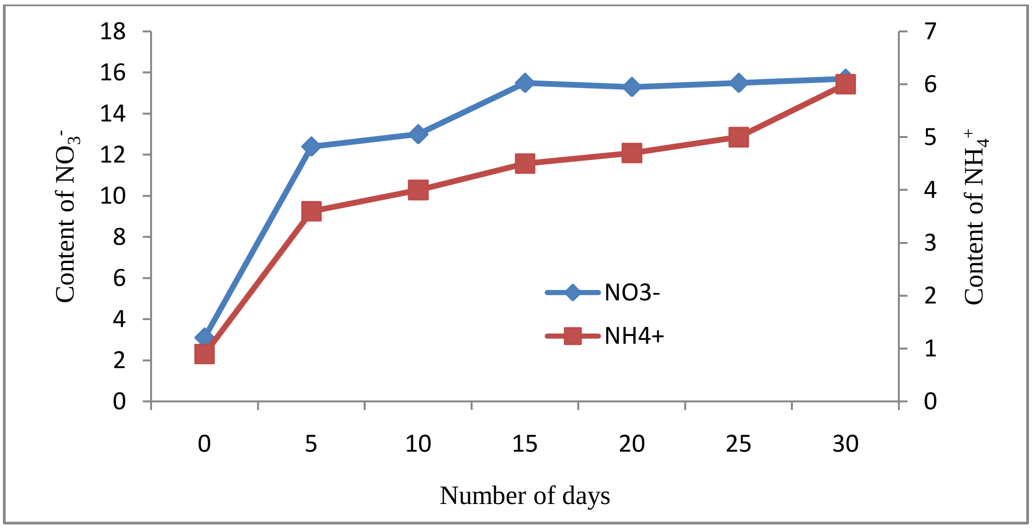

Figure 5. Evolution contents of $NH_4^+$and NO_3^-during composting

The ratio NH_4^+/NO_3^- is an important parameter in determining the quality of the compost. $NH_4^+$is produced during their action of ammoniation by ammonifying bacteria. This transformation is accomplished during the nitrification stage using nitrifying bacteria. When there is a decrease in pH, the $NH_4^+$is converted into ammonium. Ammonium is slowly oxidized to nitrite and, subsequently, and quickly to nitrate leading to quantity of nitrate to be higher than that of NH_4^+. For our compost the ratio NH_4^+/NO_3^- in the final stage was 0.37 which is less than 1, which indicates that the compost is mature. According to California Compost Quality council [13], composts having NH_4^+/NO_3^- ratio lower than 0.5 can be considered as very mature, while those with this ratio between 0.5 and 3.0 as mature, and those with a ratio greater than 3 as immature composts.
The C/N ratio is a parameter determining the maturity of the compost. The initial mixture has a ratio of 65.6, which is still relatively high. After 30 days of composting, the C/N has reached the value of 20.5 indicating a

good composting and stability of the final compost. Manab et al. [14] reported a value of 28.7 for *Jatropha* meal.

Conclusion

After 1 month of composting of *Jatropha* green waste, the physicochemical analysis showed a C /N<21, a NH_4^- /NO_3^-<1 ratio, a pH between 5 and 7. These results confirm that the final compost meets the required standards for the use of compost in agriculture. Other parameters are recommended in particular the phytotoxicity test. In plain field tests are also desirable to evaluate the fertilising and the impact of compost on the soil-plant system**.**

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