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Physico-Chemical Characterization of Co-compost Before and After Extraction for Better Use as a Growing Medium

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Abstract

To evaluate the quality of Co-compost before and after extraction and to study the possibilities of improving its physic-chemical proprieties, two types of Co-compost, Raw *Acacia cynophylla* Co-compost (RACCC) and Raw Sheep Manures Co-compost (RSMCC) were manufactured by composting, in various proportions (2/3-1/3 and 1/3-2/3), *Acacia cynophylla* biomasse and sheep manures. In order to obtain exhausted Co-compost, obtained Co-composts (RACCC and RSMCC) were extracted with water for one month in a ratio of 1/5 to obtain Exhausted *Acacia cynophylla* Co-compost (EACCC) and Exhausted Ovin Manures Co-compost (EOMCC). Raw and exhausted Co-composts were subjected to physic-chemical analysis (Standard Test of Porosity, Organic Matter and Carbone contents, Cation Exchange Capacity). Results obtained showed variations in physic-chemical parameters depending on the type of Co-compost (*Acacia cyanophylla* or Sheep Manure Co-compost) and the influence of extraction procedure (Raw or Exhausted Co-compost). Even if significant differences were observed for diverse Co-composts, recorded values were in the standards of acceptance.

Keywords: *Acacia cyanophylla Co-compost, Sheep Manure Co-compost, Exhausted Co-compost, Physico-chemical behavior, Growth substrate.*

1. Introduction

Peat is the most commonly used material as a plant substrate, although for reasons of cost and sustainability, alternative materials are being investigated [1-2]. Several research studies have shown that organic residues such as forest biomasses, animal manure, paper waste, pruning waste and green wastes, after proper composting, can be used with very good results as growth substrates instead of peat [3-4]. In recent years, the intensive and industrial livestock production system has resulted in high density of animals in relatively small areas and producing large quantities of manure [5-6]. Thus, there was an increasing problem for treating animal manures leading to environmental problems for people, including water contamination [7-8]. Composting is an effective and safe way for reduction of the manure's mass and volume, for destruction of pathogens and stabilization of nutrients and organic matter in it [9]. It is also a biochemical process

converting organic wastes into high nutrient end-products which can be applied as soil conditioners or organic fertilizer [10]. Co-composting is an integrated waste management that involves biological decomposition and stabilization of two different types of wastes which complement each other [11] under conditions that allow development of thermophilic temperatures to eliminate pathogens and plant seeds [12]. Substrates containing composted bio-solids and yard debris had superior performance, but not all their physic-chemical properties are within the suggested optimum range [13]. Material destined for use as a plant substrate must possess a series of physical (low apparent density, high porosity, good distribution of air and water) and chemical properties (appropriate pH, high Cation Exchange Capacity, sufficient provision of nutrients, low salinity, absence of elements and phototoxic compounds), among other properties [14].
Composting sheep manure with screened forest biomass of *Acacia cyanophylla* could offer many environmental and economic benefits for the regions where both sheep manure and *Acacia cyanophylla* are available in great amounts. The aim of this research study was to study some physical and chemical properties of two type of Co- compost: *Acacia cyanophylla* Co-compost and Sheep Manure Co-compost before and after extraction in order to design the most suitable growth substrate.

2. Materials and Methods

2.1. Preparation of Co-compost being tested

Two types of Co-composts were used in the present study and were manufactured from fresh woody materials (branches, and leaves) of *Acacia cyanophylla* and sheep manures without incurring physical treatments (grinding, refining or screening): the first Co-compost is called *Acacia cyanophylla* Co-compost (ACCC) and is manufactured from screened branches of *Acacia cyanophylla* and sheep manures at a ratio of 2/3 and 1/3 respectively. The second Co-compost is labeled sheep manure Co-compost (SMCC) and is manufactured from screened branches of *Acacia cyanophylla* and sheep manures at a ratio of 1/3 and 2/3 respectively. During compost process, windrow piles of 1.5 m high by 10 m long, were constructed. Forced aeration was used for the first eight weeks (bio-oxidative phase), followed by a six-month maturation period during which the piles were turned periodically to maintain adequate O_2 levels. During the maturation phase, the pile was turned every 15 days in order to improve both the O_2 level inside the pile and the homogeneity of the material. Pile moisture was controlled weekly by adding enough water to obtain moisture content of not less than 50%.

2.2. Co-composts extract elaboration

The extraction technique adopted in this research study was the infusion [15]. It consist in putting bags full of Co-compost (Raw *Acacia cyanophylla* Co-compost and Raw Sheep Manure Co-compost) in drums of 80 liters capacity, filled with water for 30 days, with daily agitation of the contents. The Co-compost extraction ratio was about 1:5 (v/v). We fill a bucket of 5 L capacity with Co-compost and poured into a plastic bag which is closed of its upper end. We put the bag in a barrel containing 25 L of water. This operation was repeated three times to this substrate. After every three days, we made four samples from the resulting Co-compost extraction process for monitoring pH, Electrical Conductivity (EC) and Hanging Materials for all three days. The objective of this monitoring is to study the evolution of chemical parameters depending on the extraction time. After that, bags were moved from barrels and exhausted Co-composts were placed for drying in the sun for their subsequent use as a growing medium.

2.3. Growth substrates

To develop an adapted growth substrate, we tested four substrates based on raw and exhausted Co-compost. The organic constituents used for Co-composting (forestry biomass and sheep manure) are widely available in Tunisia; those components are largely available in local production across almost all regional nurseries [16]. It should also be noted that the four Co-composts are divided into two main groups: 2 Raw Co-compost and 2 Exhausted Co-compost obtained from the extraction process (Table 1).

Tableau 1. Identification of growth substrates being tested

Growth Substrates	Composition
RACCC	2/3 *Acacia cyanophylla* + 1/3 Sheep Manure
RSMCC	1/3 *Acacia cyanophylla* + 2/3 Sheep Manure
EACCC	2/3 *Acacia cyanophylla* + 1/3 Sheep Manure
EOMCC	1/3 *Acacia cyanophylla* + 2/3 Sheep Manure

2.4. Physico-chemical analysis of substrates

2.4.1. Physical assessment by the Standard Test of Porosity

In order to assess the physical quality of raw and exhausted Co-compost, before and after extraction, we used the Standard Test Porosity (STP). For this reason, we used a 200 ml capacity cup, a graduated cylinder, a timer and a collection vessel. The standard porosity test consists of filling a cup with the Co-compost being tested. Then water was poured into the beaker containing the substrate until the substrates are completely wet. We note the poured-water volume (Vp) in each cup and the timer is started. Wetted substrates are allowed to stand for about an hour. We pierce the cups bottom to allow non absorbed water by Co-compost to flow for about 10 minutes and non absorbed water was collected in a container and then we note the recovered volume (Vr) of each perforated cup. We note the total water volume (Vt) that a cup can hold without substrate. Then, we calculate total, aeration and retention porosities as follows:

Total Porosity: TP (%) = Vp / Vt x 100

Aeration Porosity: AP (%) = Vr / Vt x 100

Retention Porosity: RP (%) = TP - AP

2.4.2. Assaying of organic matter and of the carbon content

The determination of the Organic Matter (OM) and Carbon (C) was performed according to the method of Walkley and Black [17]. 1 g of previously oven dried compost was set in an Erlenmeyer flask; we added 10 ml of ammonium dichromate and 20 ml of concentrated sulfuric acid. After stirring, the solution rests for 30 minutes. 100 ml of distilled water was added, 10 ml of phosphoric acid and 1 ml of diphenylamine; then the solution was titrated with iron sulfate until it turned to green. OM content was determined according to the following equation. With: OOC expressed in mg; V ': Iron sulfate poured in ml and V: Blank volume poured in ml. The organic matter content (OM) is calculated as follows:

Oxidized Organic Carbon (OOC) = 3 (V' - V) and OM (mg) = Organic C (mg) x 2

From the OM, a deduction of the carbon content will be possible while applying the Tunisian standard as below.

C(%) = (OM% - 1.5) / 1.4

2.4.3. Cation Exchange Capacity

The Cation Exchange Capacity (CEC) is the ability of a substrate to retain and exchange cations. The strength of the positive charge, which varies according to the cation, allows cations to replace another on a substrate negatively charged particles [16].The CEC was determined with 1 M ammonium acetate at pH = 7.

3. Results and discussion

3.1. Assessing Co-compost porosities before and after extraction

The Standard Test of Porosity is the easiest process to physically assess any growth substrate. According to the Directorate General of Forests [19], we must aim in Tunisian forest nurseries, the following physical parameters: TP ≥ 50%; AP ≥ 20% and RP ≥ 30%. Taking the necessary precautions of the test procedure, assessing the porosity of a growing medium is for the nurseryman the easiest way to make the right choice [20]. From Figure 1, we can see that there was a significant difference between the two types of Co-compost (RACCC and RSMCC) according to their TP and a slight difference in RP before and after extraction; however, no significant difference was reported between the two types of Co-compost according to their AP. The extraction process is a deterioration of the substrate structure; it has a more influences on its retention porosity [21-22]. In fact, the extraction phenomenon is causing a direct impact on particle sizes of Co-composts [22]. In addition to slow biological degradation by the microorganisms, the water may act directly by degradation and hydrolysis reactions. Those reactions relatively reduce particle sizes of Co-composts [22-23]. We also note that substrates based on *Acacia cyanophylla* Co-compost (RACCC and EACCC) have the best porosities (TP, AP, RP) before and after extraction process. Overall, all substrates are within the norm of TP ≥ 50%); RP ≥ 30%) and AP ≥ 20%. Before extraction, a significant difference is observed for both RACCC and RSMCC substrates according to their retention (RP) and aeration (AP) porosities. After extraction, a significant decrease was observed in Exhausted *Acacia cyanophylla* Co-compost (EACCC) and exhausted sheep manure Co-compost (ESMCC) for their TP and RP, and a lesser decrease for AP. However, the operation of extraction increases the AP of RACCC, so EACCC records the highest value of AP among the other Co-composts. According to [24], an ideal substrate should exhibit 20-30% Air Space (AS) and Easily Available Water (EAW).

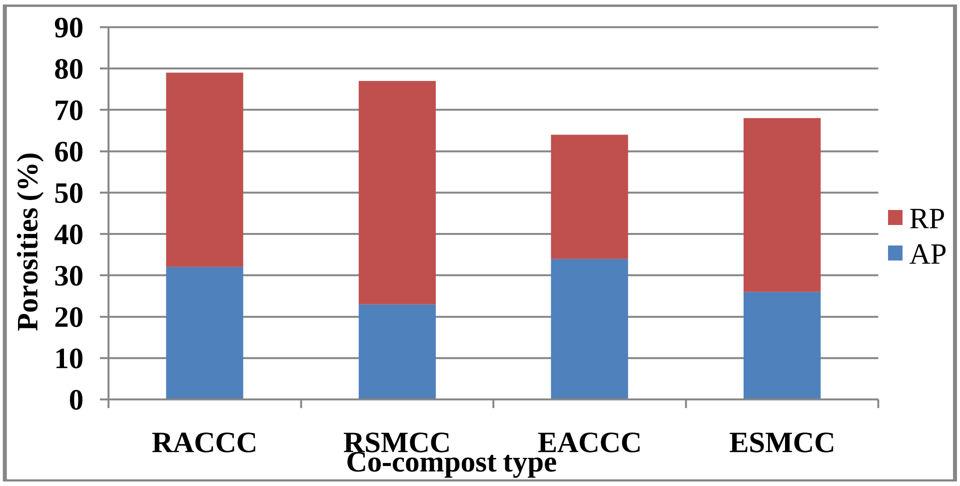

Figure 1. Findings of the porosity of Co-composts before and after extraction

The AS for EACCC was too high (34%) and this means that water should be applied frequently, and in small amounts to avoid leaching. Handreck [25] studied the particle size and physical properties of substrate and concluded that the fraction smaller than 0.5 mm, and in particular between 0.1 and 0.25 mm, has the highest influence on porosity and water retention. An excess of fines (less than 0.1mm) clogs pores, increases non-plant-available water holding capacity and decreases air filled porosity [26]. De Boodt and Verdonck [24] revealed that low percentages of air space in substrates may cause problems for plant growth. The highest air space value and greater air space means that water should be applied more frequently, and in small amounts to avoid leaching [27-28]. Ultimately, porosity results observed for the studied Co-composts were largely better than those obtained for compost and raw Co-compost, and also before and after extraction [29]. The particle fineness was obviously the source of the observed low AP.

3.2. *Cation exchange capacity of Co-compost before and after extraction*

CEC of compost is related to its ability to retain positively charged cations. The humidification process produces functional groups; oxidation of the organic material results in an increase of the CEC. This varies according to pH. A CEC of greater than 60 meq / 100g is characteristic of mature compost [30]. It is considered one of the most important factors affecting fertility of growth substrates. When the CEC is high, the growth substrate can retain nutrient cations avoiding leaching by frequent irrigations. It should be noted from Figure 2 that before extraction, RACCC records a higher value of the CEC than the RSMCC. Thus, the CEC depends on the type of substrate. After extraction, the CEC values decrease for both EACCC and EOMCC; the extraction process has an important role on reducing the CEC of substrate. The difference in CEC between the different substrates may be caused by differences in organic content [31] and the degree of components humification [32].

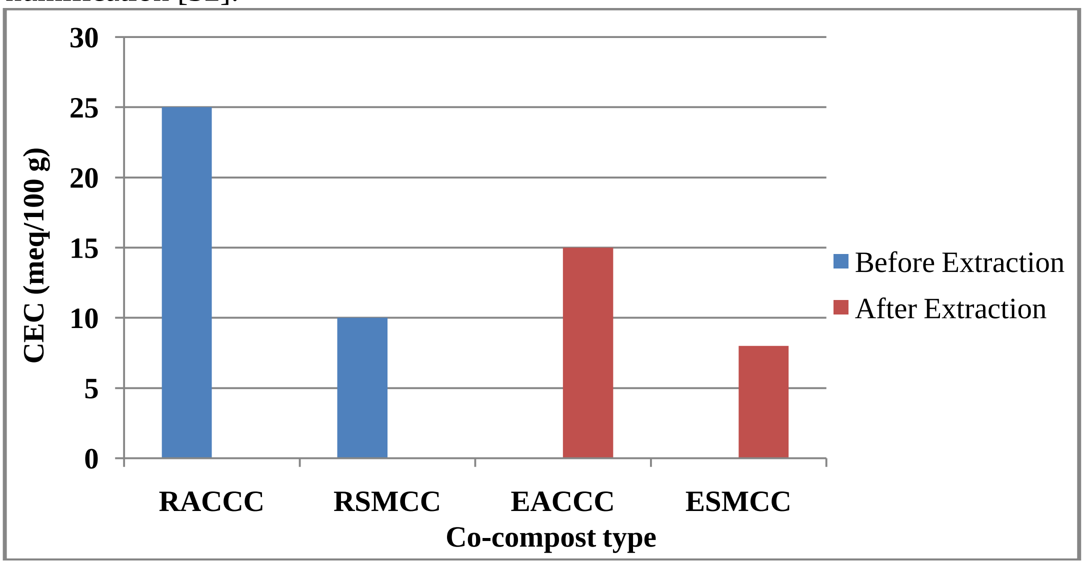

Figure 2. Cation Exchange Capacity of Co-composts before and after extraction

3.3. *Assessing of organic matter and carbon in the Co-compost before and after extraction*

It should be noted from Figure 3 that before extraction, Co-compost RACCC has a higher value of the OM and C than RSMCC Co-compost: OM and C depend on the type of substrate. After extraction, values of OM and carbon decreased significantly for EACCC and ESMCC Co-compost. The depletion of organic matter Co-compost can contribute to a significant decrease in the CEC. This leads us to say that a high value of

CEC is closely related to the wealth of OM and carbon on the substrate. Based on this finding, it should be noted that RACCC Co-compost has recorded the highest values of CEC and OM. However, the decrease in OM and carbon in the RSMCC following the extraction process is minimal and not significant.

OM content is one of the first criteria on which we can judge the compostability of a given product. Microbial activity is found following a decrease in OM content in the product. It is considered by some authors such as [33] as a quality parameter and mature composts. According to [34], the OM content in the case of Co-compost depends on their degree of ripeness. The more the OM content is high, the more the mineralization phenomenon is high. According to the [35], the mature Co-compost should have an OM content < 50%. Specifically, [36] reports that for a quality compost (from the point of view of stability and maturity), the OM content should be between 35 and 45%. According to this criterion, we can say that RSMCC and EOMCC are considered highly stable products as organic matter content in the Co-composts are around 43 and 41% respectively. The operation of extraction seems to significantly improve the stability of the substrates.

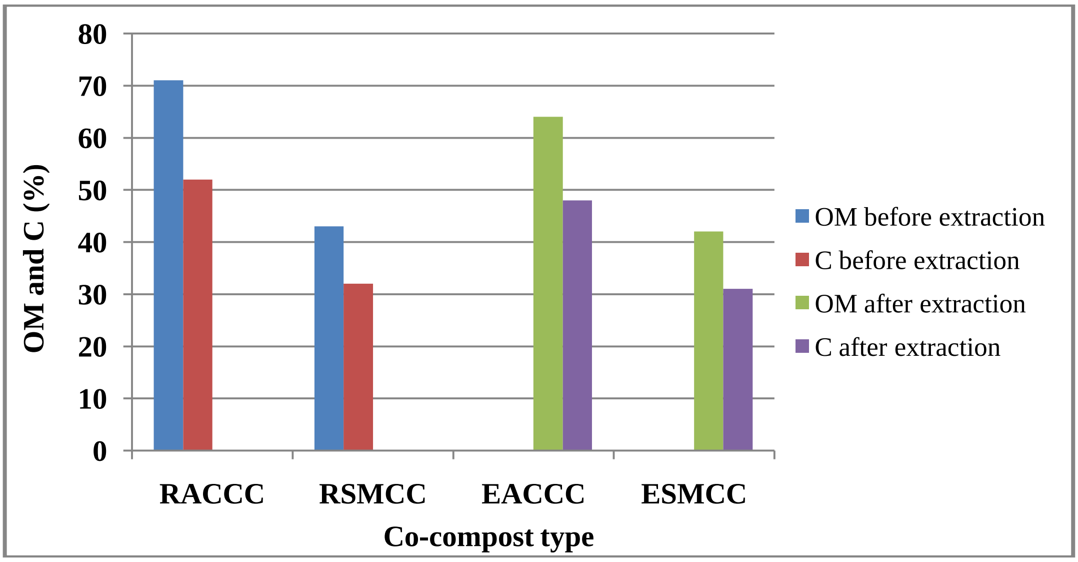

Figure 3. Organic Matter and Carbon of Co-composts before and after extraction

4. Conclusion

After studying the main physical and chemical properties of different tested Co-composts, we can highlight that all samples have revealed both appropriate levels of porosity (Total, Aeration and Retention), that adequate levels of Organic Matter (OM) and Carbon (C), and therefore, the values of the Cation Exchange Capacity (CEC) were found higher. Raw *Acacia cyanophylla* Co-compost (RACCC) showed optimal levels of the CEC, OM and C contents. Studied Co-composts, regardless of the state (Raw or Exhausted) could be used as growing substrates, mainly for forest nurseries. For the stuffing in blister plates, it should be considered for screening before use and / or their partial incorporation with peat. Such alternative generates a lesser payment in Currencies imports while enabling better use of local organic resources.

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