A Holistic Approach to Use the CIELAB Color Space for the Stability Evaluation of Green tea waste – Rice bran Compost

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Abstract

A simple, rapid and eco-friendly method has long been needed for evaluating the compost stability because application of unstable compost in agricultural field causes phytotoxicity. Thus, the CIELAB variables L*, a*, b*, a* x b*, a* / b*, 2000a* / (L* x b*), 1000a* / (L* + b*), chroma (C^*_{ab}), hue (h_{ab}) and color difference (ΔE_{00}) in dried (70 °C) and ground composting materials (particle size ≤ 850 µm), originated from green tea waste and rice bran were studied during composting for stability evaluation using Minolta Colour Reader (CR-13). Most of the measured CIELAB variables were reached roughly in a plateau form from day 84 on. The increase tendency of L* from day 126 of composting may be due to the appearance of white color actinomycetes in that stages. The relationship between CIELAB variables and the popular compost stability evaluation indices (total organic carbon, C/N ratio, NO_3-N concentration, humification index and phytotoxicity) was calculated using Pearson's correlation co-efficient. Most of the CIELAB variables showed strong relationships with the compost stability indices except a* x b*. In this study, L* provided the best relationship with phytotoxicity (r = -0.853), b* with C/N ratio (r = 0.977), 2000a* / (L* x b*) with organic carbon (r = -0.967) and NO_3-N concentration (r = 0.764) and hue with humification index (r = 0.945). The CIELAB color space offers a quick, easy, nondestructive, eco-friendly and inexpensive means of determining the compost stability by characterizing the compost properties in different ways. Further investigations need to be done in testing this procedure on different compost products under differing conditions.

Media summary

Efficient use of CIELAB color space in compost science may lead to develop an easy, quick, inexpensive, nondestructive and eco-friendly way of compost stability evaluation.

Keywords

CIELAB colour space, green tea waste – rice bran compost, stability evaluation

Introduction

Evaluation of the organic waste stability is a crucial requirement before using as composting or landfilling, because application of unstabilized organic materials on soil affects both the crops and the environment due to the presence of phytotoxic compounds (Mondini et al. 2003). During composting mostly biodegradable organic compounds are broken down and parts of the reamining organic materials is converted into humic-like substances (Wu and Ma 2002). Several indices and methods have been proposed for assessing organic matter transformation during composting such as C/N ratio, concentration of organic carbon, humification indices, amount of humic substances and their fractions and spectroscopic measurements those are now being commonly used for compost stability evaluation (Zbytniewski and Buszewski 2005). However, most of these methods are chemical based analyses that consuming time and also costly. Although seed germination index in compost or compost extracts and compost pile temperature are the eco-friendly and commonly used methods for compost stability evaluation, they do not provide clear information about the composition of organic matter at different stages of composting. Hence, a simple, eco-friendly and inexpensive method that will provide information on organic matter transformation has long been needed for evaluating the compost stability.

CIELAB color space, a simple, rapid and eco-friendly way is currently recommended by the Commission Internationale de 1`Éclairage are now being used widely for characterizing the soil organic matter composition due to its uniform space (CIE 1995; Sánchez-Marañón et al. 2004). Results of many experiments revealed that content of organic C, $CaCO_3$ and humic acids in soil are directly related with CIELAB variables (Spielvogel et al. 2004). So, there is a great possibility of the use of CIELAB color space for characterizing the organic matter composition of the materials at different stages of composting and may lead to solve the problem of compost stability assessment as a desirable way. But, to our knowledge, reports on the compost stability evaluation using CIELAB color space are very limited and this is the first holistic report on compost stability evaluation using CIELAB color space.

The objective of this work was to analyze the CIELAB variables of the materials at different stages of composting and find out the relationship between CIELAB variables and commonly used compost stability evaluation indices of green tea waste – rice bran compost (GRC) originated from the mixture of 30% green tea waste and 70% rice bran (v/v, dry basis).

Methods

Figure 1. Calibration of Minolta Colour Reader (CR-13).

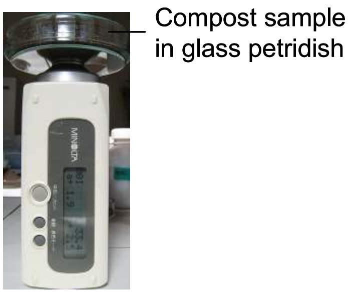

Figure 2. Measurement of compost color using Minolta Color Reader (CR-13).

The changes of compost color during composting with time were measured directly from the bottom of the glass petri dish filled with ground oven dried sample by Minolta Color Reader, CR-13 (0º viewing angle and CIELAB color space, L*a*b*) (Figures 1 and 2). The color reader was calibrated with a clean empty petri dish on white tile before measuring the compost color (Figure 1). The L* is known as lightness, extends from 0 (black) to 100 (white); a* and b* are represent redness – greenness and yellowness – blueness, respectively. High a* means more reddish and less greenish color, and high b* means more yellowish and less bluish color. Chroma (C^*_{ab}) and hue (h_{ab}) were calculated using $C^*_{ab}=\sqrt{(a^{*2}+b^{*2})}$ and $h_{ab}=\tan^{-1}(b^*/a^*)$. Color difference of the two points (ΔE_{00}) with time was calculated between the initial material and the materials of the respective day of composting by the equation of Luo et al. (2001).

The commonly used parameter for compost stability evaluation such as organic carbon concentration was determined using wet digestion method; total nitrogen using a Kjeldahl method; nitrate nitrogen (NO_3-N) using a cadmium reduction method; humification index was calculated by the absorbance ratios of 0.5M NaOH solution for the composting samples studied: *Q*4/*Q*6 (*A*472/*A*664 nm); phytotoxicity of the composting materials during composting was evaluated by seed germination test with komatsuna (*Brassica campestris*) in either water extract of composting materials (0.1 g ml^{-1}) or distilled water for control.

The relationships between CIELAB variables and compost stability evaluation indices were calculated using Pearson's correlation co-efficient.

Results

The values of chromatic coordinates CIELAB [L*, a*, b*], chromatic quotients for color development pattern evaluation [a* x b*, a* / b*, 2000a* / (L* x b*), 1000a* / (L* + b*)], chroma [$\mathbf{C^*_{ab}}=\sqrt{(a^{*2}+b^{*2})}$], hue [$\mathbf{h_{ab}=\tan^{-1}(b^*/a^*)}$] and color difference ($\Delta E_{00}$) of composting materials during composting are illustrated in Figure 3. The value of L* and b* were decreased and a* was increased gradually with the composting time and reached roughly in a plateau form from day 84 on. The increase tendency of L* value from day 126 of composting may be due to the evolution of white actinomycetes in that stages. The value of chromatic quotients a* x b*, a* / b*, 2000a* / (L* x b*) and 1000a* / (L* + b*) of composting materials were also calculated for evaluating the color development pattern during composting. The a* x b* value increased sharply up to 42 days and then decreased accordingly up to 84 days of composting and reached in a stable form there after. The values of a* / b*, 2000a* / (L* x b*) and 1000a* / (L* + b*) were increased gradually

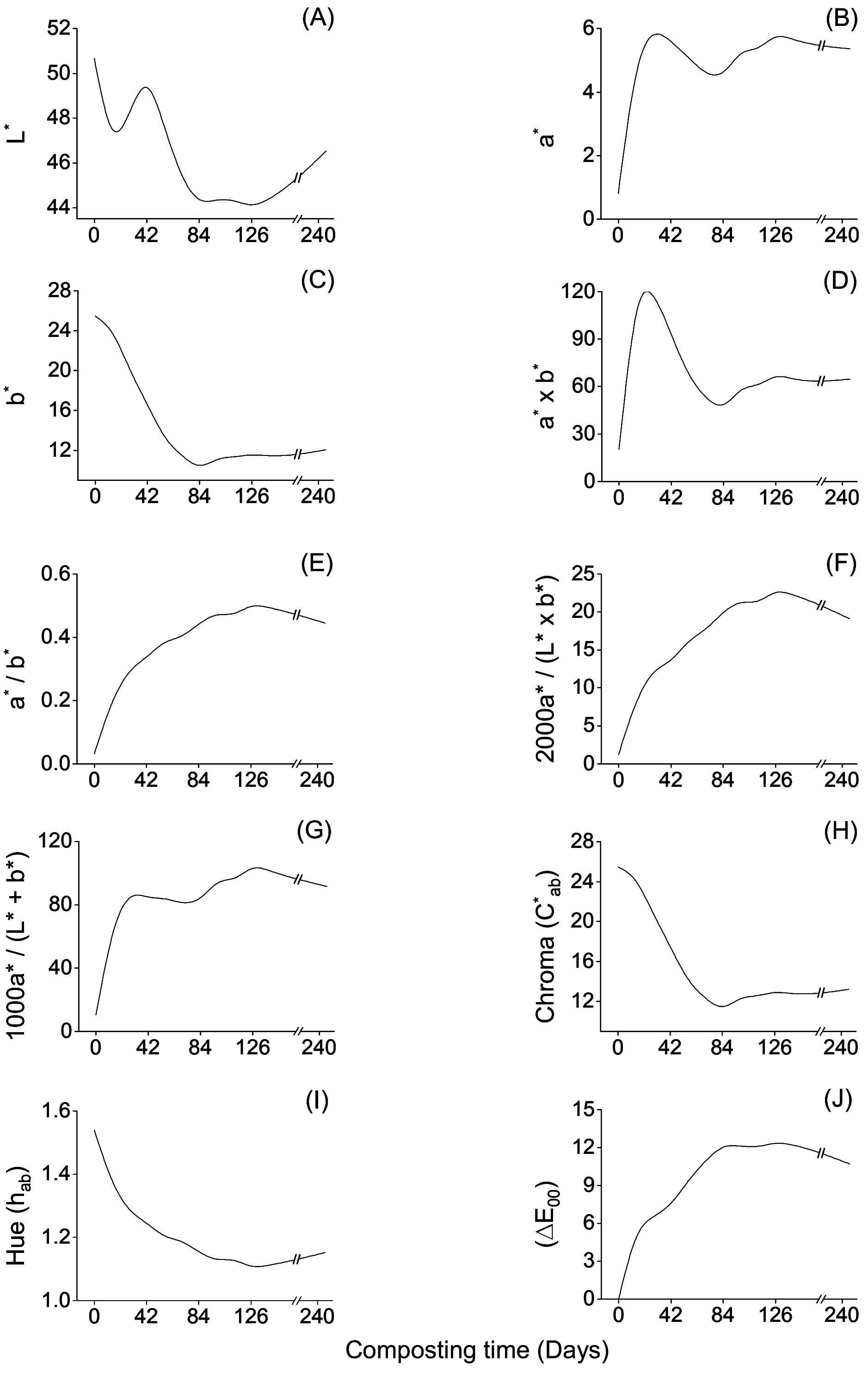

Figure 3. Time courses of CIELAB variables of composting materials during composting. L* (A); a* (B); b* (C); a* x b* (D); a* / b* (E); 2000a* / (L* x b*); (F); 1000a* / (L* + b*) (G); Chroma (H); Hue (I); ΔE_{00} (J). Chroma (C^*_{ab}) and hue (h_{ab}) were calculated using $C^*_{ab}=\sqrt{(a^{*2}+b^{*2})}$ and $h_{ab}=\tan^{-1}(b^*/a^*)$. Two points colour difference (ΔE_{00}) with time was calculated between the initial material and the materials of the respective day of composting by the equation of Luo et al. (2001).

and roughly stabled from day 84 on. The chroma and hue values were also decreased gradually and reached in a plateau form from day 84 on. Finally, the color difference value of initial and respective days of composting materials (ΔE_{00}) with time was also reached in a plateau form from day 84 on. The stabilization of CIELAB variables with time indicated that the transformation of organic matter composition was also stabilized during composting, because there is a direct relationship between soil color and soil organic matter composition, content of organic C, $CaCO_3$ and texture (Spielvogel et al. 2004). Moreover, the characteristics of color changes is an indication of the carbon dioxide content, or the volatile organic acids content in the compost sample (Brinton and Droffner 1994).

The studies of the relationship between compost color (CIELAB variables) and compost stability evaluation indices such as organic carbon concentration, C/N ratio, nitrate concentration, humification index, phytotoxicity were carried out by calculating the Pearson's correlation co-efficient. Most of the CIELAB variables showed strong relationship ($p \leq 0.01$) with the commonly used compost stability evaluation indices except a* x b*and in some cases a*. The stability evaluation indices that indicate the compost stability by characterizing organic mater transformation during composting (organic carbon concentration, C/N ratio and humification index) showed stronger relationship than the other indices (NO_3-N concentration and phytotoxicity). Due to the widely different chemical characteristics of organic wastes, till date, there is no single method that can be successfully used alone for compost stability evaluation (Benito et al. 2003; Mondini et al. 2003). However, the different variables of CIELAB color space showed different levels of relationships with various compost stability evaluation indices. So, there is a great possibility of the use of CIELAB color space for characterizing the compost properties to evaluate the compost stability.

Conclusion

In this study, most of the CIELAB variables of GRC reached a plateau form after 84 days of composting. It indicated that the transformation of organic matter during composting are becoming stable and ready for use as an agricultural substrate from day 84 on. CIELAB variables showed strong correlation with the commonly used stability evaluation parameters especially the parameters assessing organic matter transformation during composting. This study suggests that there is a great possibility of the use of CIELAB color space for the evaluation of organic matter transformation during composting, as an easy, quick, inexpensive, nondestructive and eco-friendly way of compost stability evaluation.

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