

Study of Compost Maturity during Humification Process using UV-Spectroscopy

N. Sanmanee, K. Panishkan, K. Obsuwan, and S. Dharmvanij

Abstract—The increments of aromatic structures are widely used to monitor the degree of humification. Compost derived from mix manures mixed with agricultural wastes was studied. The compost collected at day 0, 7, 14, 21, 28, 35, 49, 77, 91, 105, and 119 was divided into 3 stages, initial stage at day 0, thermophilic stage during day 1-48, and mature stage during day 49-119. The change of highest absorptions at wavelength range between 210-235 nm during day 0-49 implied that small molecules such as nitrates and carboxylic occurred faster than the aromatic molecules that were found at wavelength around 280 nm. The ratio of electron-transfer band at wavelength 253 nm by the benzonoid band at wavelength 230 nm (E_{253}/E_{230}) also gradually increased during the fermenting period indicating the presence of O-containing functional groups. This was in agreement with the shift change from aliphatic to aromatic structures as shown by the relationship with C/N and H/C ratios ($r = -0.631$ and -0.717 , $p < 0.05$) since both were decreasing. Although the amounts of humic acid (HA) were not different much during the humification process, the UV spectral deconvolution showed better qualitative characteristics to help in determining the compost quality. From this study, the compost should be used at day 49 and should not be kept longer than 3 months otherwise the quality of HA would decline regardless of the amounts of HA that might be rising. This implied that other processes, such as mineralization had an influence on the humification process changing HA's structure and its qualities.

Keywords—Compost maturity, UV spectroscopy, humification, humic acid

I. INTRODUCTION

COMPOSTS derived from mix manures and agricultural wastes are useful as they help reducing the agricultural wastes and utilizing them to improve soil quality. Although it is lower cost when compared to chemical fertilizers, there are some inherent problems. One of them is the quality of the compost as the types of raw materials are different every time of mixing [1]-[4]. Therefore, the confidence of farmers to apply the varieties of compost is questionable. Samples were sieved through 2 mm mesh and kept frozen for further analysis

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To gain the high profit in compost application in the field, several indices are used to assess the quality of compost, such as color, odor, temperature, C/N ratio, H/C ratio including the humic acid quantity. However, in last decade these parameters were considered insufficient to evaluate the degree of compost maturity [1]-[2], [4]. To better understand the evolution of humic substance structures, the parameters related to the quality of humic structures such as spectroscopic measurement were employed [1]-[2]. The wavelength range between 200-220 nm indicates the small molecules such as nitrate and carboxylic that most likely appear in the humification process faster than the aromatic or unsaturated molecules at longer wavelength (280 nm, etc) [1]. The absorbances at 253 (E_{253}) and 230 (E_{230}) nm represents the electron-transfer band and benzonoid band. Both are related to each other as the increasing of E_{253} is greatly affected by the degree of substitution in the aromatic ring [2]. Therefore, the higher ratio of E_{253}/E_{230} helps to determine the degree of possible nature substitution. It also indicates the presence of O-containing functional groups on the aromatic ring such as hydroxyl, carbonyl, and ester groups [2]. In this study, the compost derived from mix manures and agricultural wastes was used to evaluate the compost maturity. The samples were collected along the fermenting period—day 0, 7, 14, 21, 28, 35, 49, 77, 91, 105, and 119 and were further analyzed for humic characteristics.

II. MATERIALS AND METHODS

Compost derived from mix manure—bat, chicken, pig and cow mixed with chopped *Leucaena leucocephala* de Wit, bran of rice, dolomite, molase, fish fermented juice, and micronutrients for 2.13, 8.5, 17, 17, 10.63, 25.5, 10.63, 2.3, 2.13, and 4.25% , respectively. The samples were collected during fermenting period at day 0, 7, 14, 21, 28, 35, 49, 77, 91, 105, and 119. General parameters such as pH, temperature, odor, and texture were monitored to help in determining the compost maturity stage. The humic acid (HA) was extracted after the method of International Humic Substance Society (IHSS) [5]. Carbon (C), hydrogen (H), and nitrogen (N) were analyzed using Perkin Elmer 2004 CHN analyzer. The spectroscopic measurements were done by Jasco UV-Spectrophotometer model V-530. Statistical analyses were calculated using SPSS program.

III. RESULTS AND DISCUSSIONS

A. Compost Stage

Compost was divided into 3 stages—initial stage at day 0, thermophilic stage during days 48, and mature stage during days 49-119. As shown in Table 1, at day 0 the temperature was equal to an ambient temperature which was 27°C. Most of the ingredients showed their own textures. During the thermophilic stage, the temperatures were rising around 30-39°C and strong odor of ammonia appeared. After day 49 till the end of mixing period called mature stage, the temperatures of compost were cooled down equal to the ambient temperature again. At this stage, there was no ammonia odor and the compost turned dark brown without any notice of the origin materials.

TABLE I
CONDITION OF COMPOST ELABORATION

Age	Stage	Temperature
0	Initial stage	The temperature was equal to ambient temperature which was 27 °C
1-48	Thermophilic stage	High temperature occurred (around 30-39°C)
49-119	Mature stage	The ambient temperature was achieved again (27.3-28.3°C)

B. Humic acid and UV-Spectroscopy

The amounts of HA in Table 2 varied throughout the period of mixing suggesting that there were more than one mechanism that involved in the humification process. At initial stage where the activity of microorganisms had just started, the amounts of HA mainly from the manures themselves was high, 48.9 mg/g. During the thermophilic stage where there were high activities of microorganisms, HA was reduced as some small HA molecules might be used as a food source in the biological activities. This was supported by the highest C/N ratio of HA found at the beginning and became lesser during the thermophilic stage. Because the amount of HA was changing over period of mixing, so some research indicated that the amount of HA could not be an only good parameter to monitor the compost maturity [6]. In the mature stage, the amounts of HA were rising again as the formation of larger HA appeared from many small molecules. This was in agreement with the C/N ratio that increased from the thermophilic stage and became stable around 7.7 during this period.

To better understand the evolution of humic substances in order to more fully comprehend the natural process occurring in the compost, the UV- spectroscopy was employed. The shapes of spectra (Fig.1) revealed that the highest shoulder around 210 nm at day 0 gradually changed its summit to longer wavelength, 228 at day 7 and 232 at day 35, and constant at 235 nm after day 49. This implied that the small molecules which their absorbencies were in a range between 200-220 nm, such as nitrates and carboxylic appeared at the

TABLE II
HUMIC QUANTITY AND ITS CHARACTERISTICS

Day	HA (mg/g) \pm SD	C/N	H/C	E ₂₅₃ /E ₂₃₀
0	48.9 \pm 2.45	12.6	0.15	0.49
7	29.7 \pm 11.52	11.1	0.14	0.74
14	19.5 \pm 9.95	7.4	0.13	0.76
21	14.1 \pm 2.13	6.6	0.12	0.77
28	25.1 \pm 2.97	6.9	0.12	0.73
35	28.0 \pm 4.76	6.7	0.12	0.77
49	36.3 \pm 2.97	7.7	0.12	0.92
77	45.2 \pm 4.14	7.7	0.11	0.91
91	31.4 \pm 2.38	7.8	0.12	0.95
105	46.0 \pm 1.92	7.7	0.12	0.91
119	60.1 \pm 6.29	7.5	0.13	0.94

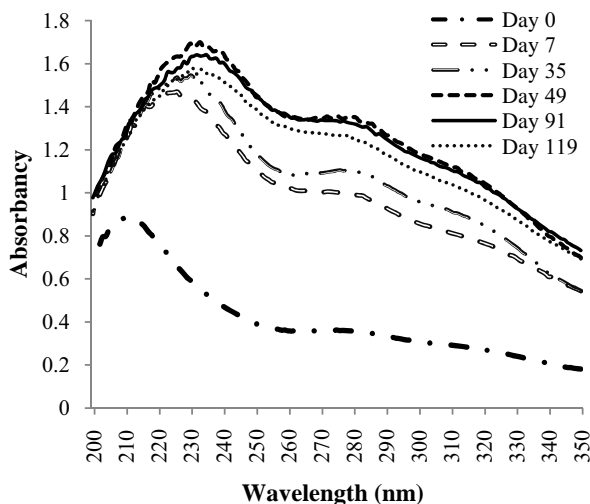


Fig. 1 Evolution of UV spectra of compost during the fermentation period

beginning of the fermenting period faster than the aromatic molecules that were found at wavelength around 280 nm according to the Domeizel et al. [1]. The ratio of electron-transfer band at wavelength 253 nm by the benzonoid band at wavelength 230 nm (E_{253}/E_{230}) also gradually increased indicating the presence of O-containing functional groups since O was a major active electron transfer atom in any functional group on the aromatic ring (hydroxyl, carbonyl and ester groups) [2]. This was in agreement with the shift change from aliphatic to aromatic structures as shown by the relationship of E_{253}/E_{230} with C/N ratio (Fig.2) and H/C ratios (Fig. 3) ($r = -0.631$ and -0.717 , respectively, $p < 0.05$). Both C/N and H/C ratios were correlated to each other as well ($r = 0.848$, $p < 0.01$). Lower C/N ratios usually came from binding of nitrogen-containing compounds into the HA molecules [3] and losing some C via micro organisms activities [7] while lower H/C ratios showed the increasing of aromatic structures as well [8]. The constant C/N and H/C ratios at the final stage suggested that there were the resistant forms of HA appeared [7]. As noticed by the UV- spectral deconvolution, since day 49, the shapes of spectral were rather the same with a little declination after 3 months.

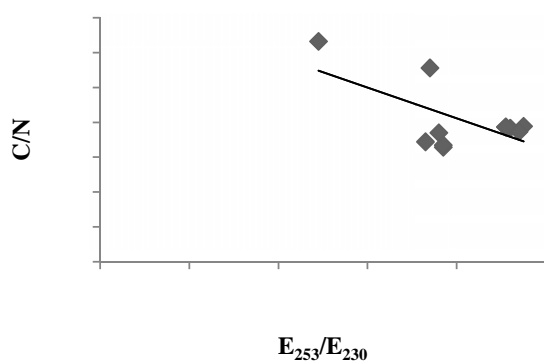


Fig. 2 Correlation between C/N ratio for the HAs and the E_{253}/E_{230} ; $r = -0.631$, $p < 0.05$

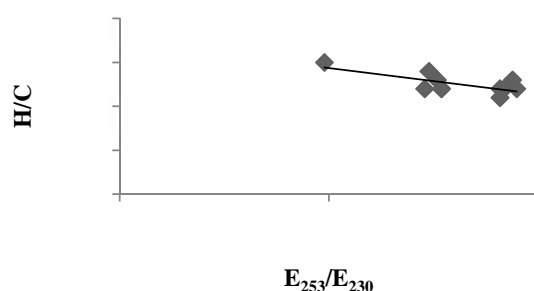


Fig. 3 Correlation between H/C ratio for the HAs and the E_{253}/E_{230} ; $r = -0.717$, $p < 0.05$

IV. CONCLUSION

The amounts of HA alone could not be the only good parameter to monitor the compost maturity. As the quality of HA is subjected to change during the humification process, longer mixing time is not necessarily yielding the better HA's quality. In this study, the compost should be used at day 49 to gain the highest of the HA's quality and should not be kept longer than 3 months otherwise the quality of HA would decline regardless of the amounts of HA that might be rising. From this point of view, the UV spectral deconvolution showed better qualitative characteristics to help in determining the compost quality. This method also is less expensive and more practical when compared to other luxurious techniques, such as NMR and ESP.

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REFERENCES

- [1] M. Domeizel, A. Khalil, and P. Prudent, "UV spectroscopy: a tool for monitoring humification and for proposing an index of the maturity of compost," *Bioreour. Technol.*, vol. 94, pp. 174-184, Feb. 2004.
- [2] M. Fuentes, G. González-Gaitano, and J. M. García-Mina, "The usefulness of UV-visible and fluorescence spectroscopies to study the chemical nature of humic substances from soils and composts," *Org. Geochem.*, vol. 37, pp.1949-1959, Sept. 2006.
- [3] M. Fukushima, K. Yamamoto, K. Ootsuka, T. Komai, T. Aramaki, S. Ueda, and S. Horiya, "Effects of the maturity of wood waste compost on the structural features of humic acids," *Bioresour. Technol.*, vol. 100, pp.791-797, Jul. 2008.
- [4] F. Sellami, S. Hachicha, M. Chtourou, K. Medhioub, and D. Ammar, "Maturity assessment of composted olive mill wastes using UV spectra and humification parameters," *Bioresour. Technol.*, vol. 99, pp.6900-6907, Mar. 2008.
- [5] International Humic Substances Society, *Isolation of IHSS Samples*. Located at <http://ihss.gatech.edu/isolation.html>. Accessed Apr 8, 2010.
- [6] M. Benito, A. Masaguer, A. Moliner, N. Arrigo, and R. M. Palma, "Chemical and microbiological parameters for the characterization of the stability and maturity of pruning waste compost," vol. 37, pp. 184-189, Feb. 2003.
- [7] K. H. Tan, *Humic matter in soil and the environment*. New York: Marcel Dekker, Inc., 2003, pp. 131-133.
- [8] J. Pajaczowska, A. Sulkowska, W. W. Sulkowski, and M. Jedrzejczyk, "Spectroscopic study of the humification process during sewage sludge treatment," vol. 651-653, pp. 141-149, Jan. 2003.