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Study on the Maturity of Vegetable Waste Composting by Three-Dimensional Fluorescence Spectroscopy

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ABSTRACT

The paper uses the discarded vegetables discarded in the Sanlu Highway ice bank as the raw material, and the water content will be the lowest after drying by air drying (the default water content is 0 in this paper). After the waste vegetables were recovered, the water content was adjusted to 50-60% for composting, and the cycle was adjusted to 2 months. After sampling 14 times, the temperature and pH were recorded. In the process of composting, the conditions of aerobic and hypoxic conditions were controlled, and two control variables, inoculating bacteria and no inoculating bacteria, were set, and relevant data were recorded during the composting liquid extraction process. In the whole composting process, the three-dimensional fluorescence parallel factor analysis was carried out, and the toc in the compost was used as the core data to analyse the material structure, so as to analyse the change of the maturity in the composting process, and provide theoretical guidance for its physical and chemical experiments.

KEYWORDS

Fluorescence method; Vegetables; Maturity; Compost

1. INTRODUCTION

High-temperature aerobic composting is one of the most important ways for the world to recycle solid wastes such as kitchen waste, municipal sludge and livestock manure. Compost maturity is an important yardstick for evaluating composting process and composting product quality. Unfertilized compost contains small molecular organic substances, ammonia, volatile organic acids and phenols which are toxic to plants. When applied to soil, it affects the growth and development of crops, and cannot achieve the purpose of increasing production and income. In addition, compost maturity is also an important basis for the design, operation and composting process control of composting plants, directly related to the construction cost and operating efficiency of the composting plant [1].

There are many evaluation indicators for compost maturity, and there are commonly used physics, chemistry, biology and comprehensive evaluation indicators. In order to understand the composting process and compost maturity from the perspective of material structure, the researchers also used the spectral analysis method. To date, infrared spectroscopy (IR) and 13 C-nuclear magnetic resonance (13C-NMR) methods have been used more frequently. The IR method can distinguish the characteristic functional groups of the compound. The 13C-NMR method can provide information on the molecular skeleton of the organic molecule, and can more sensitively reflect the nuances of the chemical environment of the carbon core, and help to determine complex organic matter.

2. MATERIALS AND METHOD

2.1. Test Materials and Design

The discarded vegetables for testing were taken from the Sanlu Highway ice storage. The waste vegetables after drying (the default moisture content is 0) are used as the composting nitrogen source, and the 5 cm long wheat straw is used as the carbon source to adjust the carbon to nitrogen ratio by 30:1. The moisture content of the material was adjusted to 55% by clean tap water, and the piles were stacked in a strip shape, and the length, width and height of the pile were 1.5, 1.0, and 1.0 m, respectively. The compost was covered with a linen bag and kept for 3 times. The compost is turned over once every 3 days in the first week and then every 1 week.

Table 1. Main components of compost raw materials

project	Total nitrogen	Total phosphorus	Total potassium	Organic matter
Abandoned vegetables	24.4	18.9	10.2	282
Wheat straw	6.3	0.51	31.7	422

2.2. Sampling and Measurement

A thermometer was inserted into each of three different directions at 9:00 am at 9:00 am, and the temperature was averaged. Samples were taken on the 0, 3, 6, 13, 20, 27, 34, 48, and 60 days of compost. After thoroughly mixing the piles, a total of 14 samples were taken for measurement.

Weigh 10000 g of fresh sample, mix with distilled water at a volume ratio of 1:5, shake for 30 min, 4000 r / min, filter after 20 min, the filtrate is used to determine the pH value (measured by pH meter), ammonium nitrogen (indophenol blue) Colorimetric method), nitrate nitrogen (ultraviolet spectrophotometry). After the fresh sample is air-dried, it is pulverized through a l mm sieve for determination of organic matter and total nitrogen content, and is determined by potassium dichromate volumetric method-external heating method and sulfuric acid-salicylic acid-catalyst digestion method [2].

3. RESULTS ANALYSIS

3.1. Temperature Change During Composting

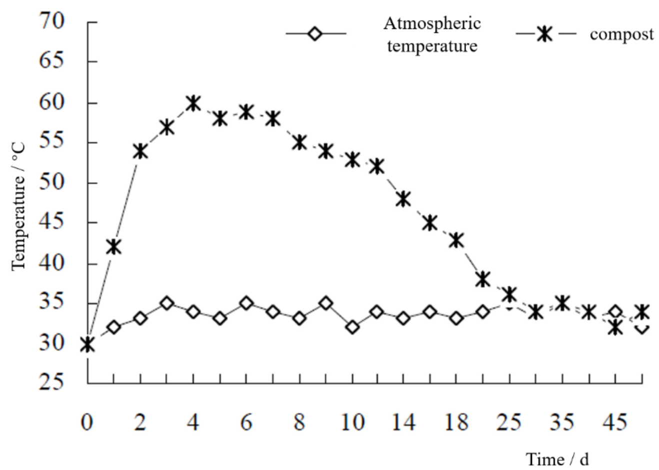

Figure 1. Temperature changes during composting.

It can be seen from Figure 1 that there are three main stages of compost temperature change, namely the heating stage, the high temperature stage and the post-cooking cooling stage. In the aerobic composting process, temperature is a key factor affecting microbial activity and composting processes. High temperature can kill pathogens, and the organic matter degrades fastest in the proper temperature range. At the same time, it needs to remove the water under appropriate conditions and the heap temperature is reduced [3]. Therefore, the temperature of the heap determines the composting speed. The speed. After 1 day of fermentation of wheat straw and waste vegetables, the temperature of the heap reached above 42 ℃, which was higher than the ambient temperature by nearly 10 ℃. After that, the temperature rose rapidly. The temperature reached 60 ℃ on the fourth day and the temperature above 50 ℃ in the composting process. The phase was maintained for 11 days and then the temperature dropped.

3.2. Changes in pH During Composting

It can be seen from Fig. 2 that in the initial stage of composting, the pH value rises rapidly. After the composting temperature is basically stable after 30 days of composting, the pH value of the compost is basically maintained at a dynamic equilibrium state of about 8.3. It meets the standard of 8.0~9.0 of the pH of composted compost. The increase of pH in the early stage of composting is caused by the decomposition of organic acid and the production of a large amount of NH_3. In the later stage of the heaping, the decrease of NH_3 volatilization rate and the nitrification of nitrifying bacteria in the later stage of composting cause a large amount of H^+ to cause pH drop [4]. In some previous reports, the pH value at the beginning of composting decreased, and the stage of maturity increased again. This phenomenon did not occur in this study.

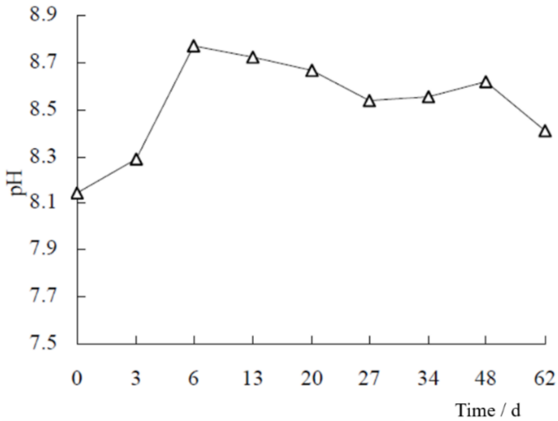

Figure 2. Changes in pH during composting.

3.3. Changes in Carbon to Nitrogen Ratio During Composting

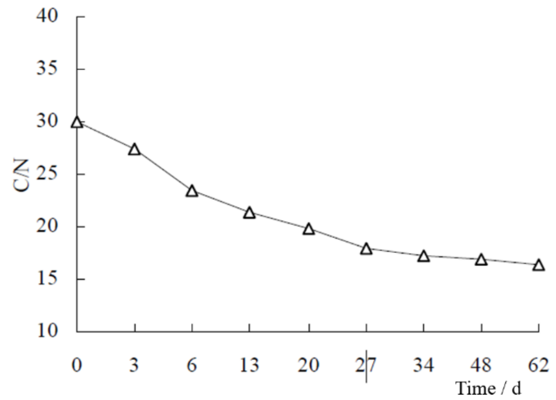

Figure 3. Changes in C/N during composting.

C/N is a commonly used indicator for testing the compost ability of compost products. When the C/N ratio of composting products is reduced to (15~20): 1, the compost is considered to be ripe. It can be seen from Figure 3 that the end of composting, C/N is 16.4. In [5], it is recommended to use T = (end point C/N) / (initial C/N) to evaluate the degree of maturity, and that the compost is maturing when the T value is less than 0.6. The literature [5] also shows that the compost basically reaches maturity when the T value is less than 0.6. At the end of the compost, the T value was between 0.54.

3.4. Changes of Ammonium Nitrogen and Nitrate Nitrogen During Composting

At the beginning of composting, the concentration of $NH_4^+\text{-}N$ in the compost quickly increased, and after reaching a high peak in 6 to 13 days, it tends to decrease, as shown in Figure 4. This is because microbial activity exacerbates the decomposition of organic nitrogen, resulting in a large amount of NH_4^+. After the high temperature period, compost $NH_4^+\text{-}N$ gradually decreased due to the assimilation of microorganisms, loss of NH_3 volatilization and nitrification. At the end of composting, the $NH_4^+\text{-}N$ content was reduced by 74.2% compared to the highest. As shown in Figure 5, after the high-temperature composting stage, the content of $NO_3^- - N$ in the compost began to increase significantly, which may be due to the high temperature conditions in the previous period inhibiting the growth activities of nitrifying bacteria and affecting the smooth progress of nitrification. At the end of composting, the $NO_3^- - N$ content was 787 mg/kg.

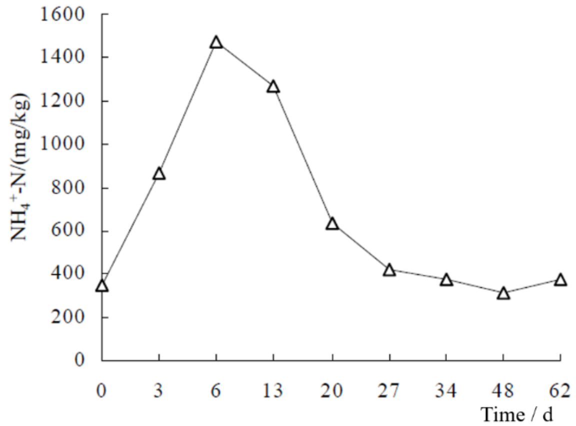

Figure 4. Changes in $NH_4^+\text{-}N$ during composting.

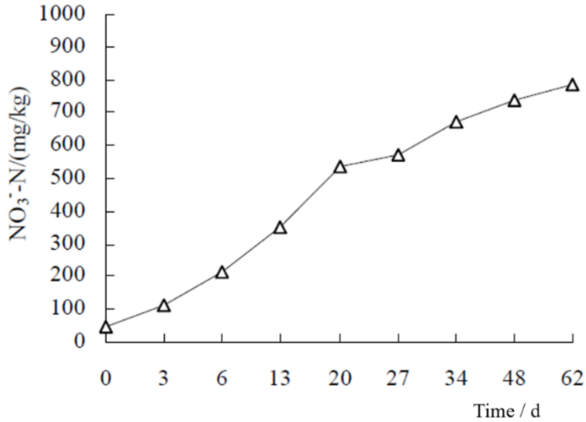

Figure 5. Changes in $NO_3^- - N$ during composting.

3.5. Chemical Indicator Change Process

The curve of the chemical indicators (TOC, TN and conductivity) of composting in the composting process of vegetable waste (Fig. 6) shows that in the early stage of composting (0-6 days), TOC, TN and conductivity are first stabilized at a lower level. The levels were about 4.08-4.88 mg/L, 0.68-1.51 mg/L and 1.86-2.93 mS/cm, respectively. During the high temperature period of compost (7-14 days), the TOC, TN and conductivity increased rapidly to 10.47. Mg/L, 7.52 mg/L and 5.76 mS/cm.

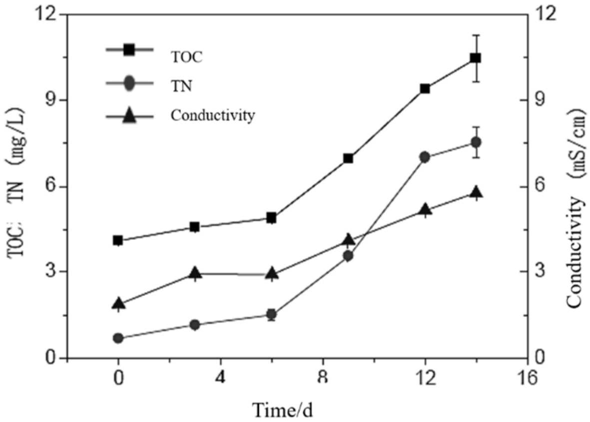

Figure 6. Corrosion-related chemical indicators (TOC, TN and conductivity) during composting.

Composting aerobic fermentation process is actually the process of microbial utilization of nutrients, obtaining its own growth, reproduction and metabolism, and at the same time degrading refractory organic matter into soluble organic matter and organic matter humification [6]. The process of degradation and utilization is a process of dynamic equilibrium. When the degradation of organic matter is greater than the soluble organic matter utilized by microorganisms, the soluble matter in the heap tends to increase, and on the contrary, it tends to decrease. The gradual increase in EC may be the result of a gradual decrease in water content in the heap and the production of phosphates, ammonium salts, etc. by microorganisms.

4. THREE-DIMENSIONAL FLUORESCENCE SPECTRUM CHARACTERISTICS OF VEGETABLE WASTE COMPOSTING PROCESS

The three-dimensional fluorescence spectrum is a spectrum obtained by changing both the excitation wavelength and the emission wavelength. It can obtain fluorescence intensity information when the excitation wavelength and the emission wavelength are simultaneously changed, and can perform spectral recognition on overlapping objects in a multi-component complex system. The various substances in the DOM are characterized one by one. Figure 7 shows the three-dimensional fluorescence spectrum during the composting process. As can be seen from the figure, in the early stage of composting (0 and 3 days), four protein-like peaks (A, B, C, D) and two humid acid peaks (E, F) were detected in the DOM; At daytime, three protein-like peaks (A, C, D) and two humid acid peaks (E, F) were detected in the DOM; in the high temperature period of compost (9 days, 12 days, 14 days), its DOM Two protein-like peaks (C, D) and two humid acid peaks (E, F) were detected. It is known from the literature that peak A (Ex/Em=220~230nm/300~320 nm) is a tyrosine-like substance, peak B (Ex/Em=270~290 nm/300~320 nm) and D (Ex/ Em=270~ 290 nm/350~ 370 nm) is a soluble microbial by-product. Peak C (Ex/Em=220~ 230 nm/350~ 370 nm) is a tryptophan-like substance, peak E (Ex/Em =240~250nm/400~ 420 nm) is a fulvic acid-like substance, and the peak F (Ex/Em=320~330nm/400~420 nm) is a humid acid-like substance [7].

Hemic acid, fulvic acid and other substances will be formed in the aerobic compost of vegetable waste. The content of humid acid in the initial stage of composting is low. With the advancement of the heaping process, the effects of various simple compounds in the compost on microorganisms Under the gradual synthesis of complex humid acids. The composting process is a process in which a tyrosine-like substance and a tryptophan-like substance are continuously reduced, and a fulvic acid-like substance and a humid acid-like substance are continuously increased. After composting, the organic matter stability is increased, and the compost maturity is improved. This phenomenon can be clearly observed from Figure 7. After composting, Humin acid, fulvic acid and other substances become the main part of soluble organic matter.

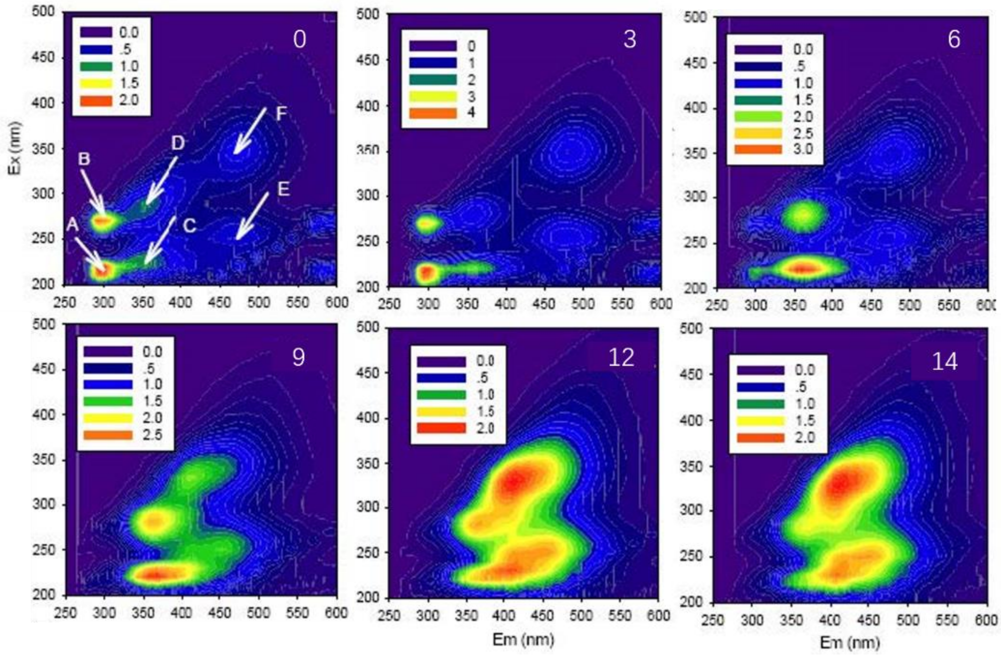

Figure 7. Variation characteristics of three-dimensional fluorescence spectra with time during composting

5. CONCLUSION

After 60 days of stacking in the experiment, the compost temperature was maintained at slightly above ambient temperature. During the cooling phase, as the decomposable substrate continues to decrease, the activity of the microorganisms slows down, and even if the temperature of the turnover does not rise, it enters the stage of maturity. During the fermentation process, the temperature drops after each turnover due to regular turn-overs, but the temperature is 1 to 2 days after the stack is higher than before the stack. The increase of pH in the early stage of composting is caused by the decomposition of organic acid and the production of a large amount of NH_3. In the later stage of the heaping, the decrease of NH_3 volatilization rate and the nitrification of nitrifying bacteria in the later stage of composting cause a large amount of H+ to cause a decrease in pH. C/N showed a downward trend during the composting period. This was because the microbial consumption of large amounts of carbohydrates decreased with the accumulation of the total carbon, and the total nitrogen increased. The C/N of the pile gradually decreased and the compost gradually reached. Decomposed. In the experiment, the concentration of B showed a tendency to decrease in the early stage of the early stage, which was due to the fact that microbial activity aggravated the decomposition of organic nitrogen, resulting in a large amount of NH_4^+. After the high temperature period, compost NH_4^+-N gradually decreased due to the assimilation of microorganisms, loss of NH_3 volatilization and nitrification. At the beginning of composting (0-6 days), TOC, TN and conductivity were first stabilized at a lower level; at the high temperature of 165 (7-14 days), TOC, TN and conductivity increased rapidly to 10.47 mg/ L, 7.52 mg/L and 5.76 mS/cm.

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