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Study on the Changes of Maturity Indexes in the Composting Process of Chaohu Lake Sediment

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Abstract: Using the method of composting in the greenhouse, the research was carried out in a 1:1 ratio between the sediment of Chaohu Lake and the deciduous garden stalks by adding a small amount of pig manure to adjust the carbon-nitrogen ratio for composting. The results showed that the temperature and pH both increased first and then decreased during the composting process. During the composting process, the high temperature of 55℃ for more than 4 days meets the temperature sterilization requirements of composting hygiene. During the entire composting process, the moisture content, organic matter, and total nitrogen all showed a downward trend, and the loss of organic matter was about 50.84%. The seed germination index showed an upward trend, eventually reaching 93.1%. After 5 weeks of composting and fermentation, all the composting indicators have reached or approached the GB8172—1987《Urban Waste Agricultural Standards》.

Keywords: Sediment compost, Maturity index, Control parameter.

1. Preface

With the green revolution and the rise of ecological agricultural technology, composting has attracted more and more attention as an important means of reducing and recycling solid waste, and it is showing an increasing trend in the composting application of solid waste such as garbage in China. Chaohu Lake is the earliest large lake affected by eutrophication among the "Three Lakes" in my country. Recent research shows that although most of the water pollution sources of Chaohu Lake come from the discharge of urban and rural domestic pollution, industrial and agricultural sewage, etc. [1], when the external pollution has been effectively contained, the endogenous pollution(A large amount of nutrients such as nitrogen and phosphorus are accumulated in the lake sediment formed by long-term deposition) should become a new focus. Sediment deposits a large number of organic pollutants and inorganic salts containing a large amount of N and P, which will be permanently released to the water body, resulting in secondary pollution of the water body. Therefore, to fundamentally solve the pollution problem of rivers and lakes, it is not only necessary to cut off external pollution from the source, but also to control or even eliminate endogenous pollution [2], mainly to control the sediment. Dewatering sludge for composting is one of the important means to achieve sludge reduction, harmlessness and resource utilization. At the same time, with the increasing scale of sewage in China year by year, the sludge production in various places has increased sharply [3]. How to deal with this kind of solid waste and turn waste into treasure can be used as a reference for the treatment of the same type of sludge. The composting process is a humification process, which will be accompanied by the changes of water content, pH value, temperature, organic matter and seed germination index (GI) in the sludge composting process. The study of these indexes has important guiding significance for the resource utilization and agricultural evaluation of sludge in the later stage [4].

This study takes sludge as the main raw material at the level of preliminary test, adds urban garden waste such as bark and leaves as conditioner, and adds pig manure as conditioner to optimize the carbon nitrogen ratio and moisture content of sludge, so as to make the composting reaction go smoothly [5].The research on the material changes in the mixed composting process of garden waste and sludge under normal temperature composting conditionsis will be helpful to optimize the process parameters and improve the composting efficiency [6].

2. Materials and Methods

2.1. Test materials

The material used in this test is sediment, which is taken from Yuxikou of Chaohu Lake; Garden waste is mainly composed of garden leaves and straw. Garden leaves and straw are purchased from nearby garden companies and cut into fragments of about 0.5cm. Pig manure is taken from nearby pig farms and has been stacked for half a month. The physical and chemical properties of raw materials are shown in Table 1

Table 1. Physical and chemical properties of main raw materials

Project	Water content (%)	Organic matter (%)	Total nitrogen (%)
Sludge	72.32	30.46	0.26
Garden waste	12.45	89.97	0.74
Pig manure	71.21	16.39	0.56

2.2. Experimental Design

The design process is to mix a certain amount of sludge and crushed garden waste in a ratio of 1:1, and add a small amount of pig manure to adjust the carbon-nitrogen ratio, stir evenly, and pile them into strips. The materials are piled in a ventilated plastic shed. , Combined with manual turning, turn the heap once every 5-7 days on average, the compost sample collection time is every 7 days in the horizontal and vertical direction of the heap, multi-point sampling, mixing and mixing, grinding and saving for later use, and timely measure all indicators.

2.3. Measurement items and methods

2.3.1 Measurement items the temperature, moisture content, pH value, organic matter, total nitrogen (TN) and seed germination index (GI) of the project

2.3.2 Determination method

Moisture content: use the aluminum box drying method, and use the 105 ℃ constant temperature drying method to measure the moisture content.

Temperature: insert mercury thermometers around the heap, and insert thermometers on the upper, middle and lower layers of the heap respectively. During the composting period, measure the temperature of the heap at 8:00, 13:00, and 18:00 every day, and take the average value.

pH value: The fresh sample is used to measure the pH value, and the filtrate is used to measure the pH value by leaching with a solid-liquid ratio of 1:5, using a pH S-3C pH meter.

Organic matter: the organic matter of compost is determined by burning at 550 ℃ for 1h in muffle furnace.

Total nitrogen: adopt concentrated sulfuric acid-H2O2 digestion and Kjeldahl nitrogen determination method. The above determination methods refer to the soil agrochemical analysis method [7].

Calculation of germination index: zucconi calculation method is adopted, and the calculation formula is GI (%) = (treated germination rate×Treated root length) ÷ (control germination rate × Control root length) ×100

3. Results and Analysis

3.1. Change of composting temperature with time during sediment composting

At the initial stage of composting, the compost is rich in various organic substances, which are rapidly decomposed and release a lot of heat under the action of aerobic microorganisms. Therefore, the compost temperature rises rapidly at the initial stage of composting, and the compost temperature rises rapidly to more than 50 ℃ on the fourth day, reaching the maximum temperature of 61 ℃ on the sixth day. After that, the temperature begins to decrease. On the ninth day of composting, the compost temperature drops rapidly to less than 50 ℃, which is due to the manual turnover on the ninth day, As a result, the stack temperature drops rapidly. Manual turnover can prevent the death of microorganisms caused by too high stack temperature. At the same time, it can also provide oxygen for aerobic microorganisms to make the reactor continue to ferment. The temperature of the reactor rises to more than 50 ℃ the next day after turnover, and begins to drop below 50 ℃ after 4 days. This may be due to the massive degradation of organics by microorganisms in the early stage and the reduction of organics suitable for degradation in the later stage, The decrease of microbial activity leads to the decrease of the reactor temperature. The reactor temperature changes little in the cooling stage. At the end of maturity, the composting temperature drops to close to the ambient temperature.

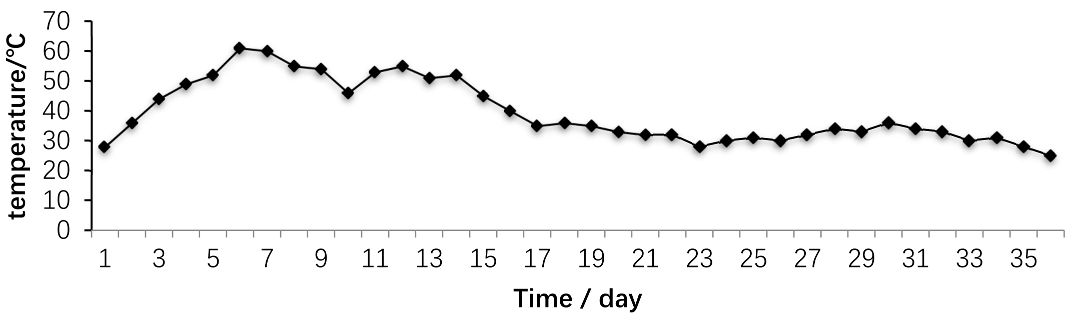

Figure 1. Changes of composting temperature with time during composting

3.2. Change of compost moisture content with time during sediment composting

Water in compost can dissolve organic matter and participate in microbial degradation and metabolism. The temperature of compost can be adjusted by water evaporation. During composting, the moisture content of the pile is also an important factor affecting the composting process [8]. Too high moisture content will delay the decomposition time of organic matter. Too low moisture content will stop the activity of microorganisms and make organic matter difficult to decompose. In this test, the initial moisture content of the reactor is 61.27%. The moisture content of compost is generally 40% - 60%. The change of moisture content of the pile during the composting process is shown in the figure. It can be seen from Figure 2 that the moisture content of the pile shows a downward trend in the whole composting process. After five weeks of fermentation, the moisture content of the reactor decreased from 61.27% to 39.1%, and the moisture content decreased significantly. The water content of the pile decreased rapidly in the early stage and slowly in the later stage, mainly due to the high water content of the compost in the early stage. At the same time, in the early stage of composting, the pile quickly entered the high-temperature fermentation stage, with high pile temperature and high water content, resulting in rapid water volatilization in the early stage of composting. In the later stage of composting, the moisture content of the pile is low and the fermentation temperature of the pile is low, so the decline rate of the moisture content of the pile is small in the later stage of composting.

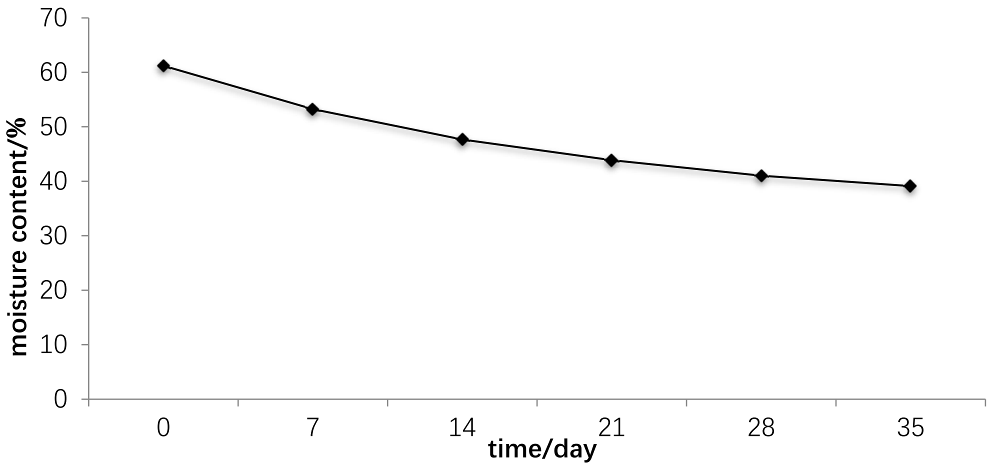

Figure 2. Change of moisture content with time during composting

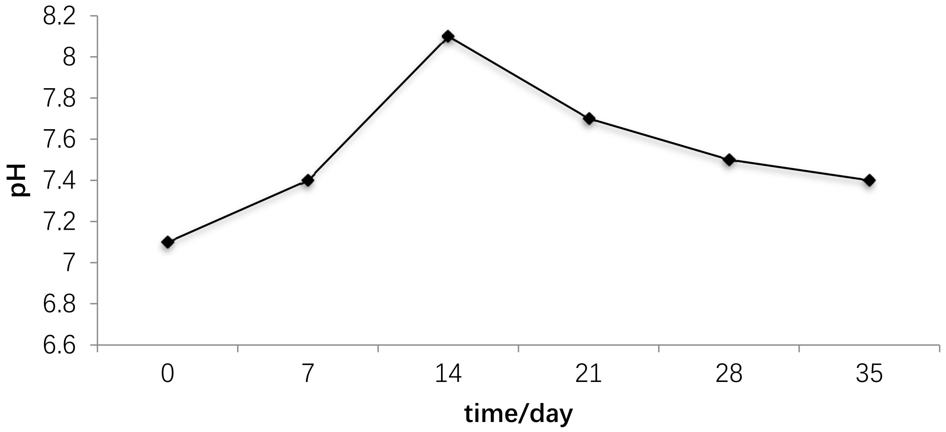

Figure 3. Change of pH with time during composting

3.3. Change of pH with time during sediment composting

It can be seen from Figure 3 that the change trend of pH value in the whole composting process is first increased and then decreased, which is different from the change trend of pH value in the composting process after some scholars' research. This may be that the amount of organic acid produced at the beginning of composting is less, while the rapid temperature rise of early composting makes the nitrogen-containing organic matter produce a large amount of ammonium nitrogen, which increases the pH value of the pile in the early composting process, and the pH value of the pile reaches the maximum value of about 8.1 in the second week of composting. With the progress of composting, microorganisms reproduce rapidly, and the organic acids produced by their activities reduce the pH value of the pile. In the final stage of composting, the pH value of the pile reaches about 7.5. It meets the requirement that the decomposed compost is weakly alkaline. It is generally believed that at the end of composting, if the pH value of composting materials is high, it will greatly promote the volatilization of ammonia, which will greatly affect the nutrients of composting. However, the pH value at the end of composting in this experiment can better avoid the above situation and meet the requirements of maturity.

3.4. Change of organic matter and total nitrogen with time in the process of sediment composting

The content of organic matter in compost plays a certain role in the regulation of composting. When composting general solid waste raw materials, the content of organic matter is controlled at 40% - 60%, which is suitable for composting [9]. The organic matter content of this compost is about 59%, which meets the requirements of relevant composting for organic matter. Composting process is essentially a humification process of organic matter. It can be seen from Figures 4 and 5 that with the increase of composting time, the contents of organic matter and total nitrogen in compost show a gradual decreasing trend. The research results are consistent with those of Qin Li et al. [11]. At the initial stage of this composting, the organic matter content is about 59%, and at the end of composting, the organic matter content is about 29%. More than half of the organic matter is lost in the whole composting process, but at the end of composting, the organic matter content in the compost is close to the basic requirement of 30% of the organic matter in commercial organic compost. The content of total nitrogen in compost decreased from 5.9mg/kg in the initial stage to 5.7mg/kg in the final stage. Compared with the loss of organic matter content in compost, the loss is smaller.

In the whole composting process, the decrease of organic matter and total nitrogen content of compost is in the middle and early stage of composting, with large loss. At the end of composting, the decline rate of both is small. At this time, composting enters a stable period. In the process of composting, the change trend of total nitrogen content is consistent with that of organic matter content, which indicates that there is a certain relationship between total nitrogen content and organic matter loss. The loss of nitrogen in the composting process will affect the quality of composting products. At the end of composting, the total nitrogen content is about 4.7mg/kg. At the end of composting, the total nitrogen content is the main index to judge whether the composting products meet the use standards. According to the requirement that the total nitrogen content of compost in GB8172-1987 agricultural standard for urban waste is greater than or equal to 5mg / kg, the total nitrogen content of compost in this test is close to the requirement of total nitrogen content of compost of 5mg / kg.

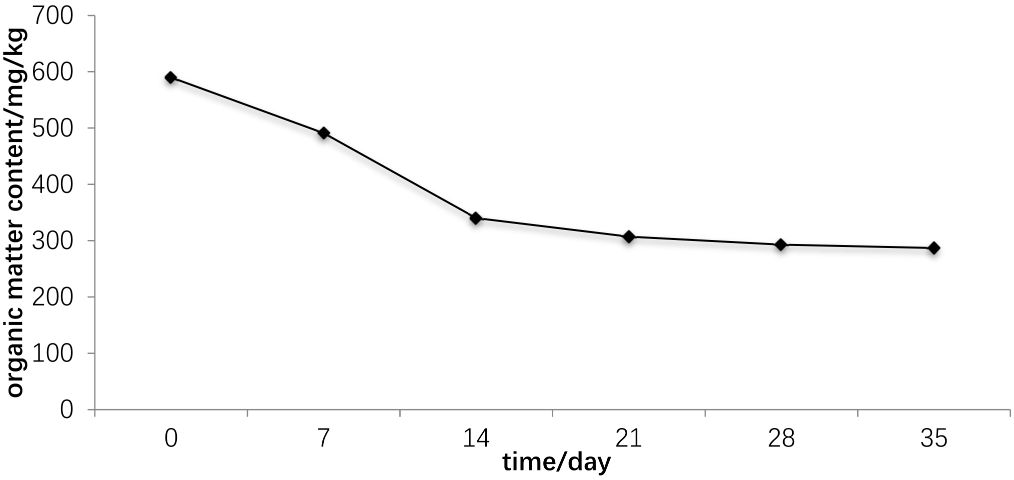

Figure 4. Changes of organic matter with time during composting

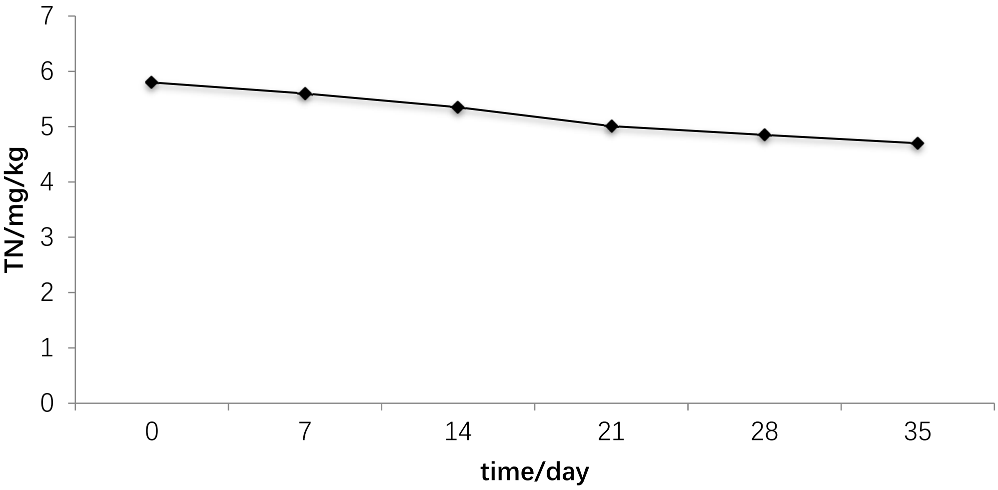

Figure 5. Changes of TN with time during composting

3.5. Change of seed germination index (GI)

The toxicity test of compost water extract on plant seed germination index is a common and effective method to test the maturity of compost [12]. It can be seen from Fig. 6, with the passage of time, the water extract of compost samples gradually increases the germination index of watermelon seeds. During the second and third weeks of composting, the germination index of compost samples increases the most, and the germination index rises rapidly from 50% to more than 80%. This is mainly because this period is the main stage of high-temperature decomposition of compost, in which low molecular organic acids are transformed into high molecular humic acids, At the same time, the degradation of organic matter releases ammonia and the fixation of heavy metals in the compost reduce the conductivity of the compost, resulting in the gradual increase of the germination index of the compost sample. Then the compost entered a stable stage, and the germination index increased from 80% to about 90%, with a slow increase. It is generally believed that if the germination index of the compost sample is greater than 50%, it indicates that the compost product is basically non-toxic. After one week of composting, the germination index of the sample is greater than 50%. When the germination index of compost samples reaches 80% - 85%, this kind of compost can be considered as non-toxic to plants [10, 11]. Taking this as the standard, it can be seen from the above figure that the composting has reached the requirement of no toxicity to plants since the third week.

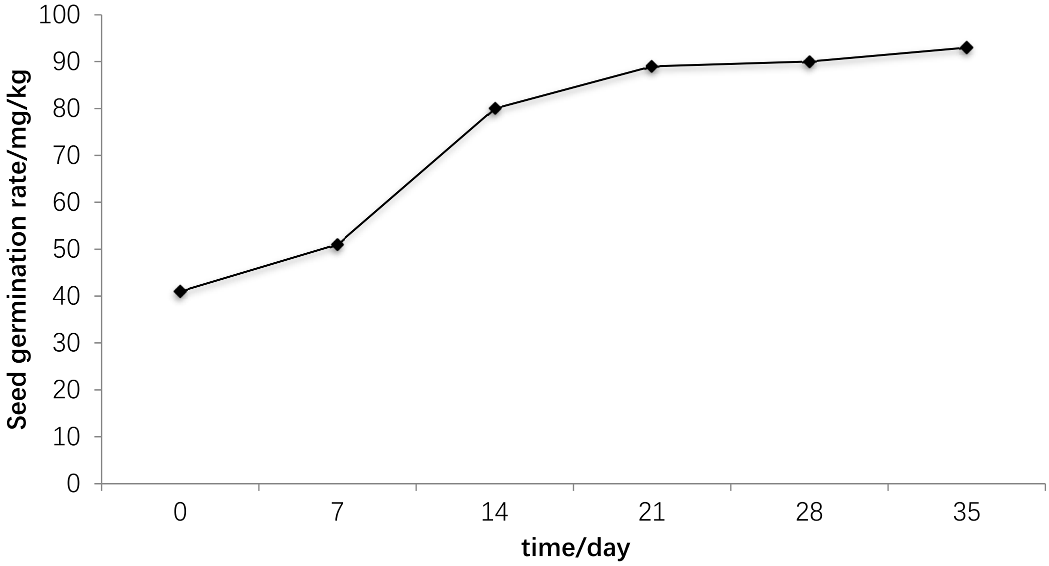

Figure 4. Changes of Seed germination rate with time during composting

4. Discussion and Conclusion

For the composting system, temperature is an important factor affecting microbial activities and composting process. In the process of composting, temperature rise is an important index to reflect the intensity of microbial activity. If the temperature of the sludge pile is kept above 50 ℃ for more than 5 ~ 7 days (or 3 days under 55℃), the pathogenic bacteria in the pile can be killed to meet the hygienic requirements of composting and relevant indicators of maturity [12]. It can be seen from Fig. 1 that the temperature of sludge pile exceeds 50 ℃ for a total of 9 days, and the high temperature of sludge compost above 55 ℃ is maintained for 4 days, which fully meets the requirements of killing pathogenic bacteria in the pile [13]. However, it is significantly less than that of Chang Huiqing et al. [14] for 8 days when the temperature of sludge composting is above 55 ℃ under the condition of 25 ℃ water bath, and the maximum temperature of 65.9 ℃ is also higher than that of the test reactor. This may be related to the impact of external ambient temperature on composting. The sludge composting of Chang Huiqing was carried out under the condition of 25 ℃ in water bath, and the composting test was carried out at the end of March. The outdoor temperature is low, resulting in a short duration of high temperature. Many researchers believe that pH value is an important parameter of microbial activity environment in composting, which can be used as an important evaluation index of compost maturity. Generally, the suitable pH value for microbial growth is neutral or weakly alkaline. Too high or too low pH value will affect the composting treatment and reduce the efficiency of composting [15]. The research shows that the pH of microorganisms with the strongest decomposition ability at high temperature is generally 7.5-8.5. PH value is a parameter that can evaluate the microbial environment. In the whole process of composting, pH value will change with time and temperature [16]. In this experiment, the pH of the whole compost is maintained between 7.0-8.1, which meets the best pH requirements for compost degradation, which is related to raw materials and seasons. During the composting process, the change trend is first increase and then decrease, which is similar to the change trend of pile temperature. However, it is different from the trend that pH first decreases slightly and then increases in the composting process studied by some scholars, which may be related to the increase of pH due to the decomposition of nitrogen-containing organic matter and the volatilization of a large amount of ammonia nitrogen with the increase of reactor temperature. The loss of organic matter by composting and fermentation in the first two weeks was 42.5%. The total nitrogen content also decreased greatly in this stage. It can be seen that the first two weeks are the most intense stage of composting fermentation. However, this stage is also the time period with the most organic matter loss. How to control this stage and minimize the loss of organic matter and total nitrogen is a problem worthy of attention.

The effect of sediment composting can be seen from the comprehensive evaluation of temperature, moisture content, pH value, organic matter content, total nitrogen content and seed germination rate. The fastest rise of pile temperature occurred in the first two weeks, and the highest pile temperature of 61 ℃ occurred on the sixth day. From the perspective of composting hygiene, keeping the high temperature of 55 ℃ for more than three days has achieved the purpose of sterilization, which also occurred in this stage. The change rate of other indicators is large, which mainly occurs in the first two weeks of composting. The pH of compost reached the maximum value of 7.9 from the initial value of 7.13, which occurred in the second week. In the first two weeks, the moisture content of compost decreased from 61.27% to 48.67%. Compared with the latter three weeks, the decline was the fastest. In the second week of composting, the seed germination index increased from 51.1% to 80.23%. Organic matter and total nitrogen decreased by 42.5% and 7.75% respectively in the first two weeks of composting. After five weeks of composting, the indexes of composting reached or approached the agricultural standard for urban waste (gb8172-1987). Therefore, it is feasible to use mixed composting of sediment and garden waste, which also has practical significance for promoting the resource application of sediment.

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