

Experimental study on biological dehydration pretreatment of kitchen waste

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Abstract. Aerobic fermentation treatment technology is one of the effective means of kitchen waste resource treatment at present. Due to the high moisture content of kitchen waste, dehydration pretreatment is needed before aerobic composting. At present, China usually adopts mechanical methods such as forced extrusion for dehydration treatment, which not only has high energy consumption, but also has high content of solid suspended solids (SS) and chemical oxygen demand (COD) in sewage. Sewage is difficult to meet discharge standards. In this paper, biological dehydration technology is proposed to pretreat kitchen waste. Experiments show that biological dehydration pretreatment can dehydrate kitchen waste, effectively reduce the SS and COD values in sewage, which is of great significance to the resource treatment of kitchen waste.

1 Introduction

On July 1, 2019, Shanghai took the lead in implementing the "Shanghai Municipal Household Waste Management Regulations" to classify and treat household waste in four ways. Among them, kitchen waste (wet waste) is mainly organic waste such as fruits, vegetables and leftovers discarded in daily household life, with a high annual output.

Kitchen waste is rich in organic substances and has the characteristics of perishability, high water content and high organic content. After proper treatment, it can be transformed into new resources [1]. Aerobic fermentation treatment technology is one of the effective means of kitchen waste resource treatment at present.

A large number of studies have shown that moisture content is an important factor affecting aerobic fermentation treatment technology, usually controlled at 55%~60%. Therefore, kitchen waste should be pre-treated by dehydration before aerobic composting.

At present, mechanical methods such as gravity, centrifugal force and forced extrusion are usually used for dehydration treatment in China, which not only has high energy consumption, but also high content of solid suspended solids (SS) and chemical oxygen demand (COD) in sewage, making it difficult to meet the sewage discharge standards [2, 3].

In this paper, through the biological dehydration technology of kitchen waste pretreatment, namely to join in the kitchen waste aerobic bacteria, anaerobic bacteria and enzymes and other microbes, degradation of kitchen waste components such as cellulose, starch, protein, make the kitchen waste part of the free water and bound water release, so as to achieve the effect of biological dehydration. At the same time, Microbes generate a lot of

heat in the process of metabolism, which also helps dehydrate kitchen waste [4, 5].

2 Experimental materials and methods

2.1 Experimental materials and devices

The raw materials of kitchen waste in this experiment are from Wusi Farm, Fengxian District, Shanghai, and the microbes used are from Sukehan Bioengineering Co., LTD. Biological dehydration experimental device of kitchen waste adopts biochemical reactor of Shanghai Tongjian Yuanda Environmental Protection Mechanical Engineering Co., LTD., as shown in Figure 2, the experimental device consists of biological dehydration chamber, crushing mechanism, stirring mechanism, heating mechanism, drainage tank and so on.

The crushing mechanism for kitchen waste shear crushing, stirring mechanism to kitchen waste and microbial fully mixed, heating device for heating reactor; The effective volume of the biological dehydration chamber was 0.5m³, and 200kg of kitchen waste was injected as experimental raw material.

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Figure 1. Experimental raw material.



Figure 3. Electric heating constant temperature drying oven.



Figure 2. Experimental apparatus.

2.2 Experimental methods

In this experiment, microorganism (A) and biological dehydration treatment time (B) were selected as the influencing factors, and the moisture content of kitchen waste (i), PH value of kitchen waste (ii), solid suspended solids SS (iii) and COD (iv) of sewage were used as the investigation indexes.

In the first group, bacillus subtilis was added to decompose cellulose. In the second group, aerobic bacteria, anaerobic bacteria and a variety of enzymes were added to decompose protein, fat and cellulose.

The moisture content and PH value of kitchen waste at 10 hours and 12 hours after material input were tested. SS and COD were measured in sewage samples at 1h, 3h, 6h, 8h, 10h and 12h after material input. The moisture content of kitchen waste is dried and measured by hX-101-00BA4 electric thermostatic drying oven of Itong Century Technology Company; the PH value of kitchen waste is measured by Xima PH 848 test pen; the SS and COD values of experimental sewage samples are measured by Shanghai Kai Lin Environmental Protection Technology Co., LTD.

3 Results and analysis

3.1 Water content and PH value

The moisture content of the two groups showed an obvious downward trend, as shown in Table 1. Microorganisms effectively degraded the components of kitchen waste, making it release water.

The dehydration effect of the first group was better than that of the second group because the experimental raw materials contained a large number of vegetables with high cellulose content and low protein, starch and other components. The microorganisms added in the first group were mainly *Bacillus subtilis*, which destroyed cellulose, and could destroy plant cell walls and release water from cells.

The second group contained many proteases and complex strains that destroyed components such as proteins and starches, which were less effective in dehydration than the first group.

When nitrogen sources in kitchen waste are utilized by microorganisms, pH increases. The raw material selected in this experiment contains a large number of vegetables (pakchoi) with a low C/N ratio (C/N) of about 10[6] and rich nitrogen source. Therefore, the PH value of the experimental raw material after 12 hours of microbial action is weakly alkaline.

Table 1. Moisture content and PH value results.

Numble	Moisture content-initial	Moisture content-8h	Moisture content-12h	PH-12h
1	92%	79.14%	72.89%	7.6
2	92%	80.79%	75.94%	7.4

3.2 Experimental sewage SS and COD values

According to the sewage discharge standard, the concentration of more than 60 pollutants is stipulated in the maximum allowable discharge classification standard. However, for the sewage discharged after the dehydration of kitchen waste, its SS and COD values are high and can be discharged up to the standard only after being treated

by the sewage treatment plant, which seriously increases the treatment load of the sewage treatment plant.

It can be seen from the data in Table 2 that the data in the control group are SS value and COD value of raw kitchen waste pulverized by the grinder.

Comparing the experimental data set with the mechanical crushing data (SS=18 950 mg/L, COD=43 026 × 103mg/L), it can be seen that the dehydration treatment of kitchen waste by biological dehydration technology compared with mechanical crushing and other treatment methods can effectively and greatly reduce the SS value and COD value in sewage and reduce the burden of sewage plant.

Table 2. SS value and COD value of sewage.

Numble	Element	1h	2h	6h	8h	10h	12h
1	SS mg/L	284	266	288	300	2010	276
	COD mg/L	4.12	4.17	3.46	3.64	5.64	5.77
2	SS mg/L	284	254	2130	2130	2190	305
	COD mg/L	4.74	3.70	9.97	7.10	7.59	5.30

From Figure4, we can see that the suspended solids of four samples are significantly higher than those of the other eight groups. This is because sewage is sampled from the pool at the bottom of the equipment. When the sampling time catches up with the mixing of the mixing equipment or just ends, the sewage at this time is likely to be mixed with a small amount of kitchen waste reactants, and the content of suspended solids in the waste water is high. Controlling sewage discharge time can effectively control the content of suspended solids in sewage.

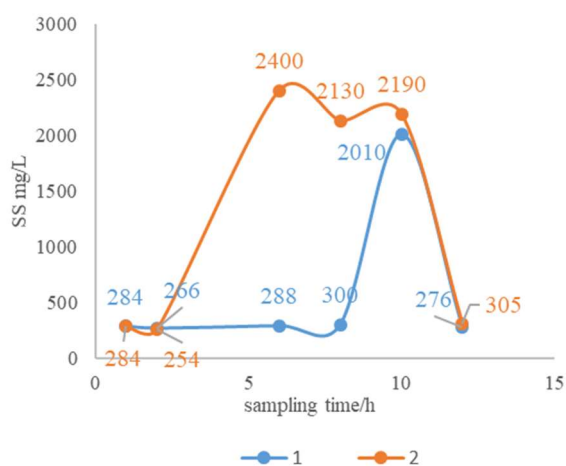


Figure 4. Diagram of SS value changing with time.

As can be seen from Figure 5, COD values of the four groups of water samples are significantly higher than those of other water samples, which is significantly related to the above sewage sampling time.

The solid suspended matter values of the four groups of water samples were also higher, mainly due to the small amount of kitchen waste reactants mixed.

After the exclusion of interference, the value of the remaining sewage suspended solids fluctuates 3 x103 mg/L and 6 x103 mg/L, with no difference of order of magnitude, which is far lower than the COD value of the kitchen waste broken sewage, but still fails to meet the national discharge standard, which may be related to the reaction time.

The duration of action on microorganisms can be days or months, so it is necessary to extend and explore the duration of biological dehydration further.

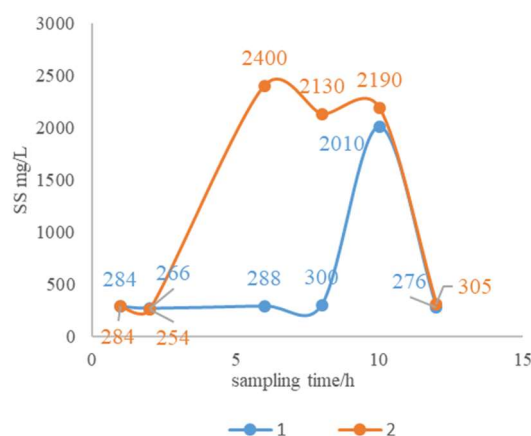


Figure 5. Diagram of COD value changing with time.

4 Conclusion

This paper provides a way to pretreat kitchen waste by using biological dehydration technology, and experiments verify that the biological dehydration pretreatment technology can effectively remove the moisture of kitchen waste and the kitchen waste after reaction is in weak alkaline, which is conducive to the subsequent aerobic fermentation.

In addition, the SS and COD values of the waste water produced by the biological dehydrated kitchen waste are much lower than those of the kitchen waste water produced by the mechanical crushing, which is conducive to the discharge of sewage and effectively reduce the load of the sewage treatment plant.

In order to further explore the application of biological dehydration technology in the pretreatment of kitchen waste, the reaction time can be extended, the sampling time interval can be extended, and the change of moisture content of kitchen waste, SS and COD values in sewage with the reaction time can be further explored, so as to find the optimal reaction time of biological dehydration pretreatment of kitchen waste.

References

1. C Wang, GQ Shen, JJ Pu, Anaerobic fermentation coupled carbonization of food waste and its application prospect in landscape greening, Landscape Architecture, 2020(6)14-18.

2. W Zheng, Current situation and countermeasures of kitchen waste treatment, *Energy Conservation and Environmental Protection*, 2020 (4)32-33.
3. SR Yu, XM Xie, Discussion on energy treatment and pretreatment of kitchen waste, *Energy and Environment*, 2021(1)89-90.
4. SY Zhang, JX Liu, JG Geng, Research progress of sludge pretreatment method based on compost, *Applied Chemical Industry*, 201, 50(7)2008-2013.
5. XJ Liang, SZ Geng, QL Xue, Treatment of food waste by dehydration in situ, *Journal of Agricultural Products Processing*, 2010(2B)98-102.
6. RQ Li, R Xu, AF Yu, Biodegradation of waste vegetable leaves by microbial fermentation, *Bulletin of Soil and Water Conservation*, 2019(3) 163-169.