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Use fuzzy mathematical method to study the evaluation of compost maturity index

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ABSTRACT

Aiming at the composting process there is no uniform maturity judgment basis now, proposed to use fuzzy mathematics method to establish a maturity of compost process evaluation for comprehensive evaluation system, the system can reflect the actual compost maturity situation.

KEYWORDS

Aerobic composting;
Maturity;
Comprehensive evaluation index.

EVALUATION OF COMPOST MATURITY INDEX CURRENT SITUATION

Sludge composting processis divided into aerobicfermentation andanaerobic fermentation of two kinds of process. Anaerobic fermentation methane, hydrogen sulfide, carbon dioxide produced byother metabolites can cause odor. Due to the slow decomposition of organic matter, the fermentation cycle for 4 ~ 6 months, the area is too big. The other mosquito breeding, sewage flows, have two pollution is serious, not suitable for large-scale industrial sludge disposal. Modern process is aerobic composting, it has a high rate ofdecomposition of organic matter, the composting cycle short, smellless. But the residence time of traditional aerobic composting longgenerally 10 - 15 days, area is too large, artificial turning labor bulky problem. Factory machinery compost is the mainstream of composting technology development, development of efficient compostingmachinery also is an urgent requirement.

Aerobic composting technology of mechanization is in controlledcondition, biodegradation of perishable organic matter in sewage sludge by aerobic microorganisms, make whole process has good stability of the humic particles. At present, the sludge aerobic fermentation composting technology is the research and developmentat home and abroad are used in feeding, stirring, ventilation, efficientfermentation device of material at the same time, its core is theaerobic fermentation tank. According to the shape of the fermentation tank can be divided into several categories: vertical multistagefermentation tank; silo type fermentation tank; horizontal rotation fermentation tank; the horizontal open fermentation tank.

In recent years, domestic and foreign scholars of different composting materials, composting sludge compost maturity in physical, chemical and biological indicators studied. Researchers agree that, in different mate-

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rials, different composting of the composting process, reflecting the compost maturity physical, chemical and biological indicators showing a complex changes, only using a single index can only reflect from a compost maturity degree, and can not fully reflect the actual situation of the composting process of composting. Therefore, using multiple indicators from different angles (such as harmless, reduction aspects) reflects the compost maturity, in recent years has become a research focus. By mathematical methods of these indicators of compost maturity comprehensive consideration, will make the evaluation more comprehensive, scientific sex and maneuverability. Grey clustering method, gray correlation analysis method, fuzzy mathematics method and mathematical method in evaluation of compost maturity application have been reported, some scholars using fuzzy comprehensive evaluation method for garbage, pig manure compost maturity respectively were evaluated in this study, but they choose evaluation system is not the same, there is no unified evaluation index degree of maturity of compost using[1]. This article through the analysis of a single index on composting conditions, by using basic theory of fuzzy mathematics, comprehensive and single index influence the results, obtained comprehensive evaluation index for analysis of overall situation of compost maturity.

FUZZY MATHEMATICS COMPREHENSIVE EVALUATION INDEXES

Selection of commonly used compost maturity evaluation index: Accumulated temperature0Oxygen consumption rate Change rate of C/N0NH_3-N/NO_3-N0Seed germination index (GI), Use fuzzy mathematical method to different material compost maturity degree of objective, reasonable evaluation, so as to obtain the sludge, garbage compost maturity universal evaluation methods.

Selected five on compost maturity influence index as the factor set, That is $U=\{u_1,u_2,u_3,u_4,u_5\}$, u_1 for C/N than the rate of change, u_2 for NH_3-N/NO_3-N than the rate of change, u_3 for Oxygen consumption rate (gO_2/(kgVS·h)), u_4 for Accumulated temperature (°C·h), u_5 for Seed germination index (GI)[2]. According to the evaluation set, $V=\{V_1,V_2,V_3,V_4\}$, Here, V_1 full maturity, V_2 maturity, V_3 basic maturity, V_4 not maturity. The compost maturity evaluation criteria classification is shown in TABLE 1.

On the composting operation of the large amount of measured data after the technical treatment, the data in TABLE 2.

According to the above TABLE establishing single factor evaluation matrix R, such as factor u_4, a total of 36 statistics it belongs to *V1* for the number 8, accounting for 22% of the total, so, other similar seek.

$$R=\begin{pmatrix}0.06 & 0.63 & 0.28 & 0.03\\ 0.31 & 0.50 & 0.14 & 0.06\\ 0.08 & 0.50 & 0.36 & 0.06\\ 0.22 & 0.28 & 0.44 & 0.06\\ 0.36 & 0.33 & 0.17 & 0.14\end{pmatrix}$$

This is according to the previous data to establish the evaluation matrix, on compost maturity evaluation, but also calculate weight distribution , the various factors on the membership, membership function with the

TABLE 1 : Evaluation of compost maturity standard grading list

Index type	Ⅰ (full maturity)	Ⅱ (maturity)	Ⅲ(basic maturity)	Ⅳ(not maturity)
$\eta_{C/N}$ (%)	≥60	<60, ≥30	<30, ≥12	<12, ≥0
NH_3-N/NO_3-N	≤0.5	>0.5, ≤0.91	>0.91, ≤3	>3
Oxygen (gO_2/(kgVS·h))	≤0.5	>0.5, ≤1.0	>1.0, ≤1.5	>1.5
Accumulated temperature (℃·h)	≥13000	≥11000, <13000	≥9000, <11000	<9000
GI (%)	≥80	<80, ≥60	<60, ≥50	<50

following formula.

(1) on membership function

$$\mu_1(u_1)=\begin{cases}1 & , \quad u_1 \geq 60\\ 1-\frac{2}{9}(u_1-60)^2 & , \quad 30 \leq u_1 < 60\\ \frac{2}{9}(u_1-12)^2 & , \quad 12 \leq u_1 < 30\\ 0 & , \quad u_1 < 12\end{cases}$$

(2) on membership function

$$\mu_2(u_2)=\begin{cases}1 & , \quad u_2 \leq 0.5\\ 1-2\left(\frac{u_2-0.5}{13}\right)^2 & , \quad 0.5 < u_2 \leq 0.91\\ 2\left(\frac{u_2-0.91}{13}\right)^2 & , \quad 0.91 < u_2 \leq 3\\ 0 & , \quad u_2 > 3\end{cases}$$

(3) on membership function

$$\mu_3(u_3)=\begin{cases}1 & , \quad u_3 \leq 0.5\\ 1-2\left(\frac{u_3-0.5}{13}\right)^2 & , \quad 0.5 < u_3 \leq 1.0\\ 2\left(\frac{u_3-1.0}{13}\right)^2 & , \quad 1.0 < u_3 \leq 1.5\\ 0 & , \quad u_3 > 1.5\end{cases}$$

(4) on membership function

$$\mu_4(u_4)=\begin{cases}1 & , \quad u_4 \geq 13000\\ 1-2\left(\frac{u_4-13000}{3000}\right)^2 & , \quad 11000 \leq u_4 < 13000\\ 2\left(\frac{u_4-11000}{3000}\right)^2 & , \quad 9000 \leq u_4 < 11000\\ 0 & , \quad u_4 < 9000\end{cases}$$

(5) on membership function

$$\mu_5(u_5)=\begin{cases}1 & , \quad u_5 \geq 80\\ 1-2\left(\frac{u_5-80}{0.3}\right)^2 & , \quad 60 \leq u_5 < 80\\ 2\left(\frac{u_5-60}{0.3}\right)^2 & , \quad 50 \leq u_5 < 60\\ 0 & , \quad u_5 < 50\end{cases}$$

TABLE 2 : The composting process parameters measured data list

u_1	u_2	u_3	u_4	u_5	u_1	u_2	u_3	u_4	u_5
42.6	0.4	0.9	13200	90	33.9	0.8	0.8	10240	77
41.1	0.5	0.5	10002	97	37.7	0.5	0.7	11030	51
12.0	0.6	1.0	11003	83	44.8	0.9	1.2	9970	42
12.4	0.3	0.8	12005	80	43.0	0.2	0.9	10005	84
12.0	0.9	1.4	13700	74	53.4	0.8	1.3	9809	75
13.0	0.4	1.2	12300	73	47.3	0.7	1.2	12034	80
25.9	0.4	1.3	15300	79	38.4	0.9	1.4	10230	28
13.9	0.8	0.7	11000	84	47.1	1.1	0.9	12620	64
24.1	0.6	1.2	12000	75	60.7	1.6	1.4	17023	54
52.3	0.8	0.5	10400	89	47.6	0.6	0.8	12080	47
53.4	0.9	1.8	9850	79	39.0	1.1	0.8	13062	56
55.3	0.4	1.3	9960	68	53.5	1.7	0.5	17650	80
60.4	0.6	1.6	9860	67	13.9	0.8	1.2	8327	42
30.8	0.5	1.4	9780	82	48.6	1.8	1.5	9560	89
22.7	0.8	2.5	9880	71	38.9	1.2	0.8	10800	55
46.6	0.6	1.4	10050	87	45.1	0.8	0.7	11520	46
34.5	0.7	0.8	13500	88	27.8	1.2	0.9	8962	52
33.9	0.5	0.8	14300	51	27.4	1.2	0.6	9876	79

Then the weight distribution is determined as $A=(\mu_1(u_1),\mu_2(u_2),\mu_3(u_3),\mu_4(u_4),\mu_5(u_5))$.

According to: $B=A\bullet R$, Current maturity degree can be obtained by the comprehensive evaluation index.

For example the first composting process, various factors of average data: u_1=53.9. u_2=0.4, u_3=0.4, u_3=1200 u_4=84, They were brought into the top five membership function formula. Can be obtained A=(0,1,1,0.78,1). To calculate $B=A\bullet R=(0.92,1.55,1.01,0.31)$, Normalized after B=(0.43, 0.34, 0.11, 0.09). According to the maximum membership principle, the conclusion is " maturity ".

If the second times to get the comprehensive evaluation for B=(0.33, 0.26, 0.13, 0.09), Although it is named " maturity ", but compared with the first, " maturity " degree lower than the last, and thus can be considered the first compost than second good.

CONCLUSION

To sum up, through the fuzzy mathematical method

to establish the mathematical model of comprehensive maturity evaluation of single index can get a comprehensive index for evaluation of an aerobic compost maturity situation. Be able to better reaction compost actual maturity effects, follow-up study of compost and influence factors of composting process provides a great convenience.

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