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Condensate Quality as the Operating Index under pH Readjustment of the Compost

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Ⅰ. Introduction

The pH of the compost may be decreased in the initial stage of aerobic composting process, which is probably due to evolutions of volatile organic acids and CO_2.[1] In the previous study,[2] the pH readjustment by additive (lime, ammonia water, or condensate mixed with lime) improved the composting rate showing higher reaction temperature, CO_2 evolution and total weight reduction rate. In addition, the condensate quality has been investigated about the possibility as the operating index of the composting process.[3),4]

In line with these studies, it was examined that the condensate quality could be confirmed as the operating index in the pH readjustment test during the fed-batch composting process for food waste.

Ⅱ. Materials and Methods

1. Composting reactor

As reported previously.[3] semicircle reactor was made of stainless steel, and had the volume of $1.0m^3$. On/off timer controlled forced air supply and mixing frequency according to pre-set cycles. The reactor was placed on a load cell to monitor the change of total weight during the process.

2. Materials

Food waste obtained from the S University cafeteria was used as a raw material. The bulking agent seeded for three weeks was mixed with food wastes. The detailed properties of food wastes and bulking agent were previously reported.[2]

3. pH readjustment in fed-batch composting

The fed-batch test was consisted of 11cycles divided by the newly adding time of food wastes. During the composting process, pH below 6.5 was controlled as optimal range (about pH 8.0) by putting $Ca(OH)_2$ (lime, in Cycle 2, 3), NH_4OH (ammonia water, in Cycle 4, 7), and the exhaust gas condensate (in Cycle 11) instead of chemical reagent. Details of the operating conditions are shown in Table. 1.

4. Analytical methods

Compost samples were drawn periodically and analyzed for the various physicochemical properties by the solid sample and water extract. The exhaust gas was analyzed for CO_2, O_2, CH_4 and NH_3 concentration.

The condensate was collected from by-passed exhaust gas into the condensation apparatus. The volume, pH, temperature, ionic compounds, and carbon chemical forms of the condensate were measured. In the field test, the reaction temperature, total wet weight, and ambient temperature were monitored every sampling time. The analytical methods were described previously.[2]

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Table. 1 Operating conditions of each cycle during fed-batch test

Cycle No.	Initial pH	Initial Moisture Content (%)	Operating Time (hours)	Reagents for pH Readjustment	Dosage of Reagents (g/kg TWW)	Input Materials (kg)		
						Water	Food Waste	Bulking Agent
1	8.11	49.39	65	-	-	15*	70	280
2	7.80	46.18	47	Lime	3.63	12.5**	70	-
3	8.00	51.50	56	Lime	1.84	40***/8**	70	-
4	8.36	50.25	61.5	Ammonia Water	4.51	15**	70	-
5	8.34	49.57	34	-	-	-	70	-
6	8.30	51.38	41	-	-	-	70	-
7	8.40	50.49	47	Ammonia Water	2.95	7**	70	-
8	8.46	51.75	79.5	-	-	-	70	-
9	8.18	47.26	41.5	-	-	-	70	-
10	8.43	48.82	46	-	-	20*	70	-
11	7.90	46.30	68	Lime	1.29	10***	70	-

Aeration(40ℓ/min) on/off time : 30min/15min, Agitation(7rpm) on/off time : 10min/20min
* : Water was added in the middle of cycle to inhibit the excessive loss of moisture content
** : Water was added with pH readjustment reagent
*** : Water was added with food waste input to adjust initial moisture content
**** : Condensate was added instead of water

Ⅲ. Results and Discussion

1. pHs of compost and condensate

As reported previously,[2] the composting rate in the cycles (cycle 2-11) with pH adjustment was increased at about 30% comparing with the cycle 1 (the test without pH adjustment). So, it was known that the pH of compost could be used to control the composting rate.

On the other hand, the pH of compost is a useful index of compost process,[5] but it is difficult to be measured continuously at on site. Because the analysis of condensate pH would be more convenient than that of solid sample, pH of the condensate was compared to pH of the compost. Fig. 1 shows the pH variations of compost and condensate in each cycle.

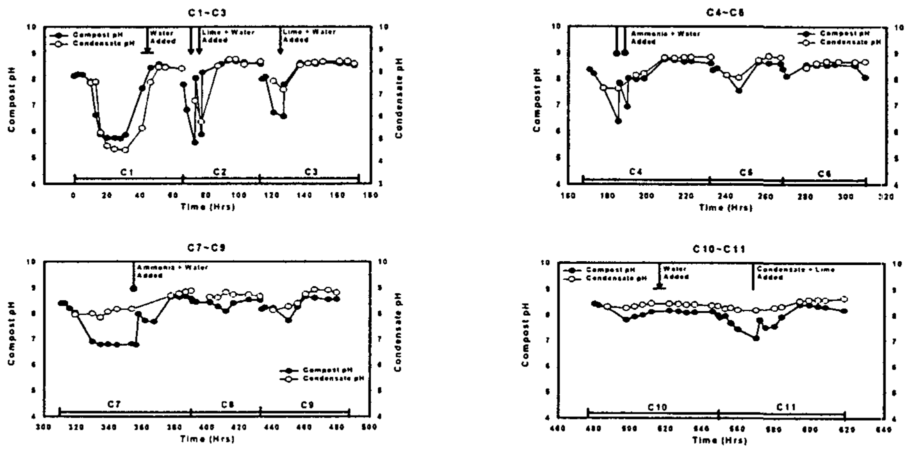

Fig. 1. Time course of pHs of compost and condensate in all cycles, C1~C11

The pH variation patterns of condensate were similar in all cycles and showed in accord with that of compost. Therefore, the pH of condensate could be used to evaluate the composting process instead of the pH of compost.

2. Relationship of ammonia concentration between exhaust gas and condensate

The variations of condensate pH were compared with that of NH_4^+-N concentration in the condensate (Fig. 2(A)). There were linear relationships with correlation coefficient $R^2 = 0.693$ in case of the pH readjustment using lime, and $R^2 = 0.571$ using ammonia water. In addition, the variation patterns of condensate pH and NH_3 in exhaust gas were very similar, even though the linear relationship between them was not significant (Fig. 2(B)). Therefore, the pH of condensate could be successfully used to predict the NH_3 evolution pattern in the composting process regardless of pH readjustment. When the NH_4^+-N concentration in the condensate gradually decreased, the pH of condensate was maintained at the weak alkaline range. It could mean that the active stage of composting would be finished. To quantify the NH_3 evolution using condensate pH or NH_4^+-N concentration, the further researches are now under way.

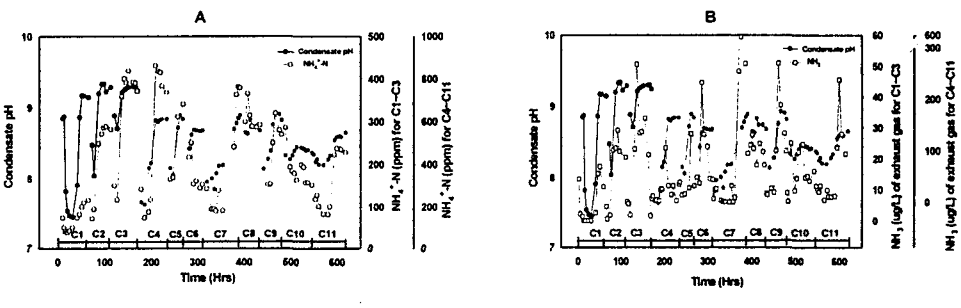

Fig. 2. A : Time course of condensate pH and NH_4^+-N concentration in the condensate.

B : Time course of condensate pH and NH_3 evolution of exhaust gas

3. Carbon forms in the condensate

Fig. 3 shows the variations of organic carbon and inorganic carbon content in the condensate during cycle 1~3 and cycle 7~9. As shown in Fig. 3, each chemical form of carbon was changed over time, and the variation patterns were relatively similar for all cycles. In the early hours of each cycle under low pH condition, the organic carbon content increased and reached a peak. On the other hand, from the middle of each cycle, the organic carbon content decreased and the inorganic carbon content started to increase. At this time, CO_2 evolution showed the second peak, and pH of compost increased. These phenomena were to be expected since the generation of organic acid contributed to organic carbon content in the condensate in the beginning of each cycle, and then the rapid increase of CO_2 evolution did same role for the increase of the inorganic carbon content in the condensate. It was also verified from the cycle 8 and 9, when the high level of the inorganic carbon was shown with the high evolution of CO_2 in the beginning of each cycle. These results suggest that the changes of carbon chemical forms in the condensate could be used as a useful index to predict the composting process.

Time courses of organic carbon to inorganic carbon ratio of the condensate for all cycles are illustrated in Fig. 4. In the end of each cycle, the values of this ratio are always below 0.5. Therefore, it could be used to determine the time to finish one cycle and to start the next cycle.

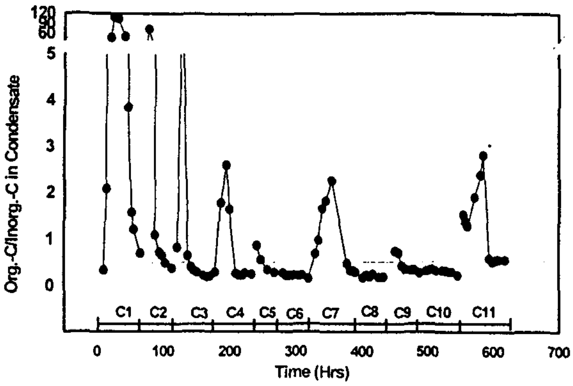

Fig. 3. Time course of Organic carbon / Inorganic carbon ratio of the condensate in each cycle

IV. Conclusion

The condensate properties have been reported as the good operating index of composting process in the previous studies.[3), 4)] It was confirmed again especially under the operation in which the pH of compost was controlled artificially.

The pH of condensate was in accord with the NH_3 evolution as well as the pH of compost. The variation of the carbon chemical forms in the condensate had a uniform pattern. In addition, the organic carbon to inorganic carbon ratio in the condensate showed a constant value in the end of composting regardless of the application of the pH readjustment, and even of the type of adding material for the pH readjustment.

Therefore, it was determined that the condensate properties represent the gaseous metabolite evolved in the composting process, and could be used as a good index to predict and evaluate the composting process.

V. References

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