Development of Composting Technology in Animal Waste Treatment*
- Review -

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ABSTRACT : Solid animal wastes in Japan are treated mainly by composting. The composting process under controlled conditions is able to convert the wastes into high-quality organic fertilizer. Various types of composting facilities with/without forced aeration and turning device are available. Characterization of the maturing process during composting was studied, to improve the quality of compost and to make the degree of maturity. Recycling of animal wastes as compost without any environmental pollution will be closely related to the development of sustainable agriculture with organic fertilizer in Japan. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 4 : 604-606*)

Key Words : Animal Waste, Compost, Composting, Maturity, Quality Index

INTRODUCTION

Animal wastes which are taken out from the farm are classified into 3 types; solid, slurry and wastewater (figure 1). Solid wastes are treated by drying or composting. Dried wastes are used not only as fertilizer but also as fuel for combustion to obtain energy. Slurry is applied to liquid composting. Wastewater is treated by activated sludge process to obtain clean water or simplified aeration method to produce liquid fertilizer.

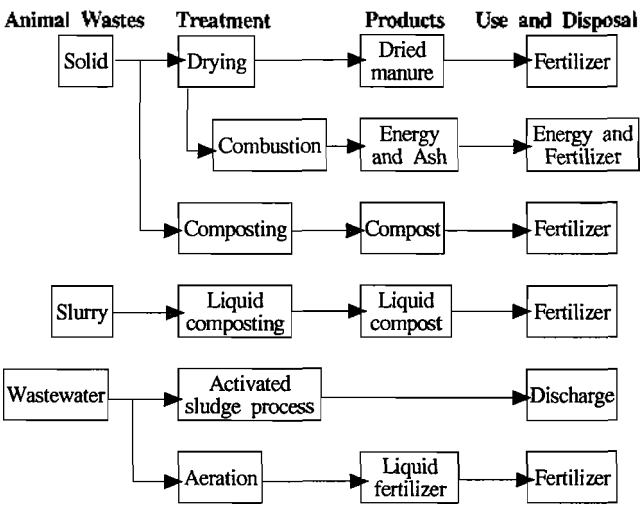

Figure 1. Methods of animal waste management generally used for the farms

Table 1 shows the ratio (%) of treatment methods used by the individual livestock farms. Composting is the main treatment method for solid wastes of dairy cattle, beef cattle and pig. Miscellaneous treatment (69.9% in table 1) of dairy cattle wastes means farmyard manure which is applied directly to the field. Although layer droppings are dried, broiler litter is used without any treatment because it has already dried in the housing. It is difficult to spread slurry (liquid wastes) to most of the cropland in Japan, except a part of Hokkaido where the large-scale dairy farming is popular. The area of animal farm is too small for all the wastes to be applied. The most appropriate techniques of animal waste management involve proper treatment followed by distribution and application of the treated wastes to cropland for agricultural use as organic fertilizer sources, outside livestock farm.Thus compost is the main product from animal wastes in Japan.

PRINCIPLES OF COMPOSTING

Composting is a process by which organic wastes are converted into organic fertilizers by means of biological activity under controlled conditions. The objectives in composting are to stabilize the biodegradable organic matter (BOD) in raw wastes, to reduce offensive odors, to kill weed seeds and pathogenic organisms, and finally, to produce a uniform organic fertilizer suitable for wide distribution and land application. Biological activity involves the microbiological decomposition of organic matter, mainly aerobic decomposition. Microorganisms in compost includes bacteria, fungi, protozoa and invertebrates such as nematodes, worm and insects.

CONDITIONS FOR COMPOSTING

Controlled conditions are important for composting, to distinguish it from other natural biological decomposition processes such as rotting and putrefaction (Haga, 1990). Animal wastes contain a sufficient amount of nutrients (biodegradable organic matter) for micro-organisms and adequate number of microorganisms to enhance the composting process. However, the water

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Table 1. Treatment methods of the farm in Japan (Unit:%)

			Dairy cattle	Beef cattle	Pig	Layer	Broiler
Solid	Composting	High-rate	24.9	9.4	50.0	11.5	5.1
		Windrow	-	89.7	-	-	-
	Drying		5.3	1.3	16.3	63.6	15.0
	Combusion		-	-	-	0.6	13.0
	Miscellaneous		69.9	6.7	33.7	24.3	66.9
	Total		100.0	-	100.0	100.0	100.0
Liquid	Storage		72.3	-	55.1	-	-
	Activated sludge process		1.9	-	12.9	-	-
	Liquid composting		2.1	-	6.9	-	-
	Miscellaneous		23.7	-	25.2	-	-
	Total		100.0	-	100.0	-	-

Table 2. Chemical composition of cattle waste compost (% on dry matter)

		Dry matter	N	P_2O_5	K_2O	CaO	MgO	Na_2O	T-C
Compost with sawdust	Mean	34.5	1.71	1.79	1.96	2.96	0.70	0.52	39.9
	Coefficient of variation	21.5	16.5	36.3	35.0	90.8	40.1	38.6	11.5
Compost with straw	Mean	22.4	2.16	2.15	2.31	2.31	0.96	0.65	36.0
	Coefficient of variation	25.3	20.3	23.0	33.3	35.7	20.9	-	23.3
Compost with rice hull	Mean	27.4	1.35	5.59	1.92	0.95	0.74	-	38.0
	Coefficient of variation	-	-	-	-	-	-	-	-
Compost with grass hay	Mean	24.8	2.30	1.38	2.17	2.06	0.81	0.34	38.2
	Coefficient of variation	19.7	13.2	25.7	46.6	36.7	16.1	-	54.8

content of raw wastes is too high to supply oxygen to the microorganisms. Moisture control of the raw wastes at around 65% by the addition of dry materials such as sawdust, rice hull and dried compost or by pre-drying in greenhouses is necessary to achieve suitable composting. The forced aeration is effective to promote composting process at a rate of 50 to 300L/min per 1 m^3 of the compost. The active degradation of organic matter by the microorganisms under controlled conditions leads to heat generation during composting. The high temperature (higher than 60℃) contributes to the killing of weed seeds and pathogenic organisms, to the evaporation of water and production of sanitary compost for convenience in handling. With occasional turning of the compost pile, the complete composting process requires a few months.

FACILITIES OF COMPOSTING

Various types of composting facilities to achieve favorable conditions mentioned above are available in Japanese farms and compost centers jointly used by several farms. Facilities can be classified into five types; the pile type, the box type, the rotary kiln type, the enclosed vertical type and the open elongated type with turning device (figure 2). For cattle wastes, the pile type and the open elongated type are generally used. For swine and poultry wastes, the open elongated type and the enclosed vertical type are popular.

QUALITY OF COMPOST

Chemical composition of compost

Chemical nutrients in composts vary with the type of animals producing manure and the type of additional materials used. Characteristics of raw animal wastes and their composts are shown in table 2 for cattle wastes, table 3 for swine wastes and table 4 for poultry wastes. These composts are variable, according to the type of animal producing the manure and the type of additional material used.

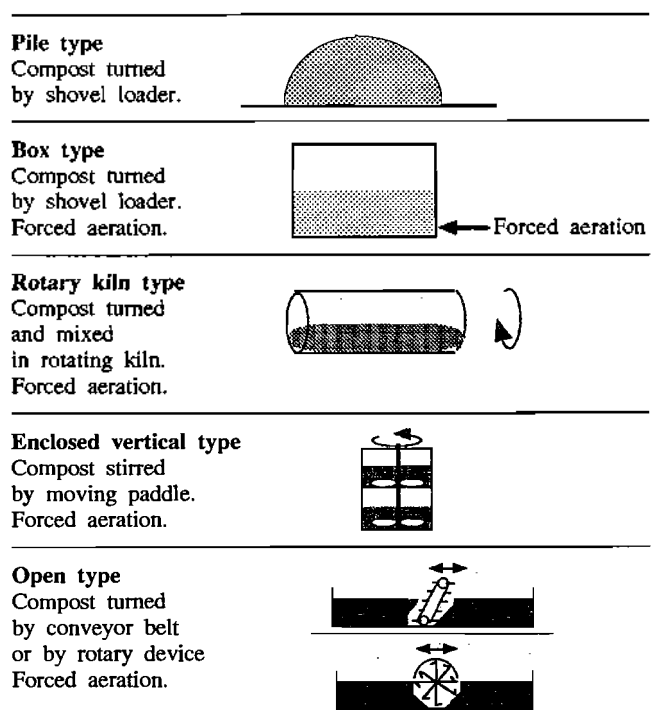

Figure 2. Composting facilities for animal wastes

Table 3. Chemical composition of pig waste compost (% on dry matter)

		Dry matter	N	P_2O_5	K_2O	CaO	MgO	Na_2O	T-C
Compost with sawdust	Mean	42.8	2.22	3.25	1.53	3.00	0.97	0.14	39.9
	Coefficient of variation	21.9	17.7	48.6	39.8	60.0	49.6	-	16.6
Compost with straw	Mean	30.3	2.92	5.95	4.74	1.38	0.87	0.62	-
	Coefficient of variation	-	-	-	-	-	-	-	-
Compost with rice hull	Mean	60.5	2.27	3.67	1.21	4.00	1.16	-	38.8
	Coefficient of variation	13.3	9.3	15.1	80.1	-	-	-	-

Table 4. Chemical composition of poultry waste compost (% on dry matter)

			Dry matter	N	P_2O_5	K_2O	CaO	MgO	T-C
Layer	Compost with sawdust	Mean	45.9	1.94	3.74	2.44	7.13	0.85	32.6
		Coefficient of variation	17.3	28.8	34.0	105.1	-	-	2.1
Broiler	Compost with straw	Mean	56.4	4.00	4.77	2.79	5.47	2.53	34.0
		Coefficient of variation	25.7	37.7	42.8	48.9	54.2	138.3	21.4

Maturity

Many methods have been proposed to estimate the degree of maturity of composts from animal wastes (table 5)(Harada,1993). Only a few methods, however, are easy to use and reliable. Recommended quality index of animal waste composts was temporarily presented as shown in table 6 in 1993.

Table 5. Methods and indices of estimating the degree of maturity

A. Estimation based on microbial activity
1)Biochemical oxygen demand (BOD)
2)Chemical oxygen demand (COD)
3)Carbon dioxide evolution
4)Enzymatic activity

B. Biological estimation
1)Germination test
2)Seedling experiment
3)Pollen tube culture test

C. Physical estimation
1)Temperature in pile
2)Odor emission
3)Color change

D. Chemical estimation
1)C/N ratio of solid phase
2)C/N ratio of water extract
3)Ratio of carbon in reducing sugars to total carbon
4)Organic matter content
5)Detection of nitrate
6)Absence of ammonia
7)Gel chromatography of water extract
8)Cation-exchange capacity (CEC)

E. Estimation based on humic substances
1)Circular paper chromatography test
2)Content of humic compounds

Table 6. Recommended quality index of animal waste compost

A. Items to be indicated		B. Items not to be indicated	
Items	Standard	Items	Standard
Organic matter	more than 60%DW	Moisture	less than 70%FW
C-N ratio	less than 30	Electric conductivity	less than 5mS/cm
Total N	more than 1%DW		
P_2O_5	more than 1%DW		
K_2O	more than 1%DW		

1) As, Cd and Hg contents should be less than 50, 5 and 2mg/kgDW, respectively.
2) Abnormal growth should not be observed for the Komatsuna (*Brassica rapa*) seedling test.
3) Cu and Zn contents should be less than 600 and 1,800mg/kgDW, respectively.
4) DW:Dry weight, FW:Fresh weight

CONCLUSION

Large amount of animal wastes (about 90,00 0,000 t/year) is excreted in the limited area of Japan (Haga, 1993). Strict regulations about water pollution and offensive odor emission are enacted. Insufficient treatment and/or illegal dumping of excess animal wastes cause serious pollution problems. Agricultural use of animal wastes as compost is presently mainly recommended in Japan. Total amounts of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) contained in animal wastes are estimated to be 680,000, 450,000 and 550,000 tons per year, respectively. These amounts of nutrients are nearly equal to those of chemical fertilizers applied to arable land in Japan. Environmentally friendly use of both animal wastes and chemical fertilizer is recommended. Then, recycling of animal wastes without any environmental pollution will be closely related to the development of sustainable agriculture with organic fertilizer in Japan.

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