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Quality Characteristics of Livestock Feces Composts Commercially Produced in Gyeonggi Province in 2008

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This survey was conducted to promote the environment-friendly use and recycling of livestock feces by obtaining information about the current state of livestock feces composts manufactured in Gyeonggi Province. Therefore, some aspects of quality and manufacturing techniques of livestock feces composts (LFCs) were examined especially in relation to the LFCs quality standard (LQS). By surveying the 70 composting plants in Gyeonggi Province, the total commercial production of LFCs in 2008 was estimated to be about 480,000 Mg year^{-1} and they were manufactured mainly by using both mechanical mixer and bottom air blower. LFCs were composed mainly of chicken feces 29.2%, pig+chicken feces 23.1%, pig feces 20.0%, livestock feces+oil cake 12.3%, pig+chicken+cattle feces 10.8% and pig+cattle feces 4.6%. On the basis of the current official standard which was revised on March 2010, 11 composts out of surveyed 76 ones did not meet the LQS due to inadequate content of water (5), OM/N (1), NaCl (2) and Zn (3). The satisfaction rate to LQS by manufacturers was 100% in the composts produced by farmer's cooperative societies, 80.7% by civil factories, and 44.4% by farming guilds, respectively. The OM/N declined by adding chicken feces and oil cake, while Ca content was increased by the addition of chicken feces and NaCl was increased by adding cattle feces.

Key words: Livestock feces, Compost, Compost quality, Compost manufacture

Introduction

Gyeonggi Province surrounding Seoul is the largest area of livestock industry in Korea. In 2009, Gyeonggi Province produced livestock feces amounting to about 8.3Tg which was 20% of the total production in Korea. Therefore, the environment-friendly management of livestock feces is one of the greatest issues in order to preserve the rural environment in this area. Livestock feces is one of the important materials as an organic source for arable land. There are lots of reports on the application effects of livestock compost into arable soil (Yang et al., 2007; Jun et al, 2003; Jung, 2002; Song et al., 2001; Jo and Lee, 2001; Yun et al., 1996), and some other ones about determining the application rate of livestock compost for crop cultivation (Kim and Jung, 2000; Lee et al., 1999; Shayya et al., 1993). In this regards, the quality of livestock compost has been emphasized and the relevant official standard has been revised more strictly. In Korea, there has been an official quality standard of commercial LFCs and the current official standard was revised in March 2010. The main factors of livestock compost quality standard (LQS) are the contents of water, organic matter, inorganic matter, NaCl and heavy metals, and the ratio of OM/N, etc. This survey was conducted to promote the environment-friendly recycling or use of livestock feces by obtaining information about the current state of livestock feces compost manufactured in Gyeonggi Province. Therefore, some aspects of quality and manufacturing techniques of LFCs were examined especially in relation to the LQS.

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Materials and Methods

76 samples of commercial livestock feces composts (LFCs) were collected at the warehouse of 70 compost-manufacturing plants located in Gyeonggi Province where approximately 100 of commercial LFC manufacturing plants were in operation. The current production state of some LFC manufacturing plants was examined by questionnaire survey and LFC quality factors such as OM, OM/N, T-N, P_2O_5, K_2O, CaO, MgO, Na_2O, NaCl, water content, and heavy metals (Cu, Zn, Cd, As, Cr,

Ni, Pb, Hg) were analyzed by soil and plant analysis method recommended by the National Institute of Agricultural Science and Technology in Korea. Some analysis methods used in this study were as follows. Organic matter was determined by ashing method measuring a loss in weight. Nitrogen was obtained by Kjeldahl method after decomposing samples with conc. sulfuric acid. Cations such as potassium, calcium, magnesium and sodium were analyzed by decomposing them with strong acid (perchloric acid 9 + sulphuric acid 1) and determined by inductively coupled plasma spectrophotometer (ICP, GBC Integra XMP, Australia). Heavy metals except mercury were measured by decomposing them with nitric acid in microwave (Tekton Qwave 2000, Canada) and analyzed by ICP, and mercury was directly analyzed by mercury analyzer (Leco AMA254, USA).

Results and Discussion

The total production of livestock compost products was estimated to be about 480,000 Mg year^{-1} by surveying 70 plants and they were manufactured mainly by using mechanical mixer and bottom air blower. Major components of surveyed compost products were in the order of chicken feces 29.2%, pig+chicken feces 23.1%, pig feces 20.0%, livestock feces+oil cake 12.3%, pig+chicken+cattle feces 10.8% and pig+cattle feces 4.6% (Table. 1).

Chemical properties of 76 composts produced in Gyeonggi Province in 2008 were as follows; 41.8 ± 7.8% of OM , 29.2 ± 7.5 of OM/N, 1.53 ± 0.51% of T-N, 1.98 ± 0.81% of P_2O_5, 1.46 ± 0.57% of K_2O, 4.48 ± 1.95% of CaO, 0.87 ± 0.41% of NaCl, 37.9 ± 11.6% of water and 16.0 ± 2.8 of compost quality score (Table. 2).

On the basis of the current official standard which was revised in March 2010, 60 composts out of 76 composts surveyed in this study met the LQS and 5 products met the general compost standard, while 11 products did not meet the compost standard due to the violation of content limit in water (5), OM/N (1), NaCl (2) and Zn (3). But the violation in water content practically does not matter since it changes over the time during storage period. Consequently, the composts having problem in terms of chemical properties were 5 products, accounting for 6.6% of all the surveyed ones.

As for the compost quality by manufacturers, all the 10 composts produced by farmer's cooperative societies met the LQS and 50 percent of them was the first grade in quality degree and the rest was the second grade. Forty-six composts out of 57 (80.7%) made by civil factories met the LQS and the first grade in quality

Table 1. Share and component ratio by raw materials of livestock composts.

Raw materials[†]	P	Ch	P + Ch	P + Ca	P + Ch + Ca	Li + O
Share (%)	20.0	29.2	23.1	4.6	10.8	12.3
Component	P-S	Ch-S	P-Ch-S	P-Ca-S	P-Ch-Ca-S	P-Ch-Ca-S-O
Ratio (%)	57-43	64-36	31-32-37	38-32-30	35-14-24-27	18-6-29-24-23

[†]P; pig feces, Ch; chicken feces, Ca; cattle feces, Li; livestock feces, O; oil cake, S; sawdust.

Table 2. Chemical properties of composts produced in Gyeonggi Province in 2008.

Component	OM	T-N	OM/N	P_2O_5	K_2O	CaO	NaCl[†]	Water	IOM[‡]	QS[§]
	---------- % ----------			---------- % ----------						
Average	41.8	1.53	29.2	1.98	1.46	4.48	0.87	37.9	20.3	16.0
Minimum	26.4	0.58	15.2	0.24	0.31	0.62	0.36	13.4	2.5	7.0
Maximum	61.2	3.31	55.0	4.94	2.98	7.67	2.24	64.3	43.8	21.0
SD	7.8	0.51	7.5	0.81	0.57	1.95	0.41	11.6	1.5	2.8

[†]NaCl content; dry weight basis (others; fresh weight basis).

[‡]IOM; inorganic matter content.

[§]QS; quality score of compost, 1-23 (degree by scores 17-23 1st, 12-16 2nd, below 11 3rd).

- Quality component; OM (1-9, above 25%), IOM (1-9, below 55%), Water (1-5, below 55%)

[¶]Heavy metal content (mg kg^{-1}, DW, data is not shown in the table); Cu 117.5 ± 73.4 (22.4-379.2), Zn 457.2 ± 241.9 (97.1-1445.4)

Table 3. Quality degree distribution of composts by the types of manufacturers.

Quality degree of compost		Sum	Farmer's cooperative society	Farming guild	Civil
Sum		76 (100)	10 (100)	9 (100)	57 (100)
Livestock compost	1st grade	26 (34.2)	5 (50)	2 (22.2)	19 (33.3)
	2nd grade	30 (39.5)	5 (50)	2 (22.2)	23 (40.4)
	3rd grade	4 (5.3)	0 (0)	0 (0)	4 (7.0)
General compost		5 (6.6)	0 (0)	2 (22.2)	3 (5.3)
Substandard compost		11 (14.4)	0 (0)	3 (33.3)	8 (14.0)

Table 4. Chemical properties of composts by the raw materials.

Raw material‡	OM	OM/N	T-N	P_2O_5	K_2O	CaO	MgO	Na_2O	NaCl	Cu	Zn	Water
	%		%							mg kg^{-1}		%
P	39.6^{ns†}	32.7^{ab}	1.30^{b}	1.63^{ns}	1.22^{ns}	2.69^{cd}	0.69^{ns}	0.24^{b}	0.46^{c}	84^{ns}	287^{ns}	46.0^{a}
Ch	41.1	26.2^{c}	1.63^{b}	2.10	1.63	5.85^{a}	1.33	0.23^{b}	0.44^{c}	47	222	34.2^{ab}
P+Ch	40.3	27.9^{bc}	1.47^{b}	1.99	1.40	4.31^{abc}	0.92	0.27^{b}	0.49^{c}	80	306	40.2^{ab}
P+Ca	45.5	34.2^{ab}	1.34^{b}	1.57	1.87	1.99^{d}	0.81	0.47^{a}	0.89^{a}	86	444	38.8^{ab}
P+Ch+Ca	40.9	35.4^{a}	1.17^{b}	1.76	1.45	4.12^{bc}	1.07	0.31^{ab}	0.59^{bc}	83	269	41.3^{a}
Li+O	48.3	22.6^{c}	2.27^{a}	2.29	1.57	5.48^{ab}	1.00	0.46^{a}	0.76^{ab}	68	261	28.3^{b}

†Values within a column followed by the same letter are not significant at 5% level by DMRT test.
‡P; pig feces, Ch; chicken feces, Ca; cattle feces, Li; livestock feces, O; oil cake.

degree was 33.3%, the second grade 40.4%, the third grade 7.0%, general compost grade 5.3%, and substandard one 14.0%. Only 4 composts out of 9 ones (44.4%) made by farming guilds met the LQS and their quality was distributed evenly as 22.2% in each first, second and general compost degree, respectively and 33.3% in substandard one (Table. 3).

OM/N declined in the composts made from chicken feces and oil cake because of their high N content. Ca content increased by the addition of chicken feces and NaCl by adding cattle feces, while water content decreased in the composts mixed with oil cake due to the need of low water content to enable the compost to be formed in a pellet shape (Table. 4).

Pig and chicken feces were mainly used as the raw materials of commercialized livestock feces composts, while cattle feces occupied only a small part. This seems to be caused by the low nutrient content of cattle feces and resultant safety in private use as a soil ameliorator. The average contents of N, P_2O_5 and K_2O were 1.5, 2.0 and 1.5%, respectively. This result implies that P_2O_5 content in both compost and soil was most important factors when the compost application rate was determined as reported by Kim et al. (2000) and Jakob et al. (2002). Compost quality by manufacturer was better in the order of farmer's cooperative society > civil > farming guild. This seems to be derived from the fact that farmer's cooperative society generally has fine financing and facilities together with a sense of responsibility, and civil operators have abundant experience and know-how. Many farming guilds, however, are organized to get the subsidy or financial support from government and the operators were relatively less experienced. The result of chemical properties of composts by the source of raw materials may be useful when manufacturer tries to adjust the mixing ratio of the raw materials for improving their compost quality.

Conclusion

The proportion of the main raw materials of surveyed compost products was in the order of chicken feces 29.2%, pig+chicken feces 23.1%, pig feces 20.0%, livestock feces+oil cake 12.3%, pig+chicken+cattle feces 10.8% and pig+cattle feces 4.6%. Chemical properties of 76 livestock feces composts produced in Gyeonggi Province in 2008 were as follows; OM 41.8 ± 7.8%, OM/N 29.2 ± 7.5, T-N 1.53 ± 0.51%, P_2O_5 1.98 ± 0.81%, K_2O 1.46 ± 0.57%, CaO 4.48 ± 1.95%, NaCl 0.87 ± 0.41% and water 37.9 ± 11.6%. Compost quality score

was 16.0 ± 2.8 and the first grade compost was 34.2%, the second grade 39.5%, the third grade 5.3%, general compost grade 6.6% and substandard grade 14.4%, respectively. OM/N was lower in chicken and oil cake composts, while CaO content was higher in chicken compost and NaCl in cattle compost. Cu and Zn were tended to be high in pig compost.

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