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

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

Abstract

By surveying the 70 composting plants in Gyeonggi Province, the total commercial production of livestock faeces composts (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 faeces 29.2%, pig+chicken faeces 23.1%, pig faeces 20.0%, livestock faeces+oil cake 12.3%, pig+chicken+cattle faeces 10.8% and pig+cattle faeces 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 LFCs quality standard (LQS) due to inadequate content of water (5), OM/N (1), NaCl (2) and Zn (3). The OM/N declined by adding chicken faeces and oil cake, while Ca content increased by the addition of chicken faeces and NaCl increased by adding cattle faeces.

Introduction

Gyeonggi Province surrounding Seoul is the largest area of livestock industry in Korea. In 2010, Gyeonggi Province produced livestock faeces amounting to about 8.5Tg which was 19% of the total production in Korea. Therefore, the environment-friendly management of livestock faeces is one of the greatest issues in order to preserve the rural environment in this area. Livestock faeces 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 and some other ones about determining the application rate of livestock compost for crop cultivation. 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 LQS and the current official standard was revised in March 2010. The main factors of LQS are the contents of water, organic matter, inorganic matter, NaCl and 8 kinds of heavy metals, and the ratio of OM/N, etc. This survey was conducted to promote the environment-friendly recycling or proper use of livestock faeces as a nutrient supplying material for organic farming by obtaining information about the current state of livestock faeces compost manufactured in Gyeonggi Province. Therefore, some aspects of quality and manufacturing techniques of LFCs were examined especially in relation to the LQS.

Materials and methods

76 samples of commercial 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

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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

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% (Tab. 1).

Tab. 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 faeces, Ch; chicken faeces, Ca; cattle faeces, Li; livestock faeces, O; oil cake, S; sawdust

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 (Tab. 2).

Tab. 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

† 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%)
- IOM; inorganic matter content
- NaCl content; dry weight basis (others; fresh weight basis)
- Heavy metal content (mg kg^{-1}, DW); Cu 117.5±73.4 (22.4-379.2), Zn 457.2±241.9 (97.1-1445.4)

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 ones (80.7%) made by civil factories met the LQS and the first grade in quality 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 (Tab. 3).

Tab. 3: Quality degree distribution of composts by the types of manufacturers

Quality degree of compost		Sum	Farmer`s co-operative soc.	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)

OM/N declined in the composts made from chicken faeces and oil cake because of their high N content. Ca content increased by the addition of chicken feces and NaCl by adding cattle faeces, 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 (Tab. 4).

Tab. 4: Chemical properties of composts by the raw materials

Raw materials	OM (%)	OM/N	T-N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)	Na_2O (%)	NaCl (%)	Cu (mg/kg)	Zn (mg/kg)	Water (%)
P	39.6^{ns}	32.7^{ab}	1.30^{b}	1.63^{ns}	1.22^{ns}	2.74^{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	6.63^{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	4.81^{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	4.23^{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	5.63^{ab}	1.00	0.46^{a}	0.76^{ab}	68	261	28.3^{b}

P; pig faeces, Ch; chicken faeces, Ca; cattle faeces, Li; livestock faeces, O; oil cake.
* DMRT ($p<0.05$), values in the same column with different superscripts differ significantly.

Discussion

Pig and chicken faeces were mainly used as the raw materials of commercial livestock faeces composts, while cattle faeces occupied only a small part. This seems to be caused by the low nutrient content of cattle faeces and resultant safety in private use as a soil ameliorator. The average contents of N, P_2O_5 and K_2O in LFCs were 1.5%, 2.0% and 1.5%, respectively. This result implies that P_2O_5 content in both compost and soil is most important factors when the compost application rate is 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 generally farmer's cooperative society 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 subsidiary financial support from government and the operators are relatively less experienced. The result of chemical properties of composts by the raw materials may be useful when manufacturer should adjust the mixing ratio of the raw materials for improving their compost quality.

In Korea, 'environment-friendly agricultural products certification' has been enforced since 1997. This certification system is on the legal basis of "environmentally-friendly agriculture fosterage act" Organic agriculture is the highest step among the environment friendly agricultural systems of Korea. For the production of environment-friendly agricultural products, this act emphasizes the recycling of plant and animal origin wastes as the Codex guideline. Livestock faeces is very important renewable resources particularly in Korea suffering the lack of agricultural by-products as the source of crop nutrients. Since Korea has intensive farming system due to the limited arable land resulting in a few of organic livestock farms derived mainly from short of pastures or small size of farm lands, it is very hard to secure the faeces from organic livestock farms. So it is permitted temporarily to use the faeces from traditional livestock farms as an organic agricultural materials as far as it is proven to be free from antibiotics and to be below a half of LQS's upper limit concentration of eight kinds of heavy metals. Though this measure was introduced as a locally adapted system by taking account of the current state of insufficient nutrient materials and resultant dependence on imported vegetable oil cakes for organic farming, this act is in the process of revision this year in order to fulfill the international "equivalency" in the certification system of organic agricultural products. At present, anyway, the results of this survey would be informative information on the quality of LFCs and for making a good choice of LFCs for organic farmers.

Conclusions

The proportion of the main raw materials of surveyed compost products was in the order of chicken faeces 29.2%, pig+chicken faeces 23.1%, pig faeces 20.0%, livestock faeces+oil cake 12.3%, pig+chicken+cattle faeces 10.8% and pig+cattle faeces 4.6%. Chemical properties of surveyed LFCs 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(total 23) 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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