



# Management Strategies of Livestock Waste Minimization and Resource Conservation

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## ABSTRACT

There is no simple method to solve livestock waste problems satisfactorily. For a successful solution, various methods should be well organized orderly depending upon the situation. Even in the livestock waste management, integrated waste management principle should be applied. Minimization of livestock waste generation is the first priority. It is also important to distribute fairly livestock farms throughout the nation. Efficient management of permit system is equally important. Permit should be given only when the farmer have enough grass-land on which the farmer can apply more than two thirds of livestock waste generated or when the farm have an anaerobic digester in which store livestock waste generated for at least 3 months. In principle, livestock waste should be treated in the farm and it is desirable to operate composting facilities in the farm site too.

**Key words:** Livestock Waste, Minimization, Permit

## 1. INTRODUCTION

If we look back in the past, there was no livestock waste problem in Korea. Even only 50 years ago, almost all of the livestock waste generated was applied to the soil for agricultural use. However, the situation has been changed greatly since then. With a remarkable economic development, the demand for meat and dairy product has increased sharply. Consequently, livestock farming has grown remarkably in recent years.

The expanded livestock farming created a significant waste disposal problem. It is because a big portion of livestock waste is currently not adequately managed. Most of livestock waste generated is not applied to the soil because sufficient grassland area or nearby agricultural field is lacking in Korea. Naturally, a considerable amount of livestock waste has been stacked outdoor causing surface and groundwater pollution. This is partly due to the fact that agricultural labor force has been decreased rapidly in recent years and the price of chemical fertilizer is relatively cheap.

Traditionally, agricultural area in Korea was clean with no environmental problem. However, in these days, the environment

of our countryside became seriously deteriorated mainly due to poor management of livestock wastewater and solid waste generated from the area. In the past, there was no need of managing livestock waste. However, in these days, since a very large quantity of it is generated, there is absolute need of livestock waste management to prevent environmental pollution and conserve resources. Livestock waste could be a resource when it is adequately treated and utilized. However, it could be waste causing various environmental problems when it is inadequately handled and disposed of.

Currently, various ways of livestock waste management exist. Among them, composting of livestock waste has been considered as one of most practical methods of recycling organic waste.

## 2. COMPOST PRODUCTION FOR

In Korea, organic farming has been the traditional way of agriculture for some thousand years. Due to the organic farming practice, soil fertility was maintained with agricultural ecosystem almost undisturbed. However, in recent years, chemical farming

has been greatly expanded with the marked development of fertilizer industry. The use of chemical fertilizer has been almost doubled during the last decade and the use of livestock waste slurry or compost has been remarkably decreased. This was primarily due to lack of labor force in rural area caused by rapid emigration to urban area and the rapid development of capital-intensive chemical farming. Commercialized chemical farming is based upon the ample supply of chemical fertilizer and synthetic pesticides.

Thus, many wildlife species were disappeared with species diversity decreasing. Beside of decreasing species diversity, synthetic pesticides and chemical fertilizer cause various harmful effects on human health, deteriorate the soil fertility and accelerate the soil erosion.

The problems of modern chemical farming can be summarized as follows;

- (1) High price of fuel energy and chemical fertilizer, unstability of supply
- (2) Increase of pest's and weed's resistance to the pesticides or herbicides
- (3) Environmental deterioration due to the serious soil erosion and natural water pollution
- (4) Risk increase of human and animal's health and food safety
- (5) Depletion of limited and concentrate form of resources such as phosphate mineral salt

When the livestock waste as slurry or compost is utilized as a soil conditioner, we can help relieving the above mentioned problems. The livestock waste, especially manures, has some nutritional values which can substitute considerable portion of chemical fertilizer. [Table 1] shows the content of nutrients in the livestock manure.

Some advantages of compost using livestock waste are as follows;

- (1) It is a good soil conditioner improving physio-chemical

characteristics of soil

- (2) It can supply some plant nutrients
- (3) It can improve handling of livestock waste
- (4) It can decrease soil erosion
- (5) It can decrease the soil-borne plant pathogen thereby allowing to decrease the application amount of synthetic pesticides on soil
- (6) It can decrease the surface water contamination preventing wash-out caused by inadequate disposal

On the other hand, composting livestock waste has some disadvantages as the following ;

- (1) It needs time and cost for composting
  - (2) It needs corresponding land area for application
  - (3) It can cause odor problem
  - (4) It needs more labor force or cost than chemical fertilizer in soil application since it is bulky.
  - (5) Some of nitrogen can be lost from the livestock manure
- Although composting livestock waste have some disadvantages, it seems that it seems a practical method of livestock waste management since the disposal cost and environmental problems caused by inadequate management will be increasing significantly in the future.

### 3. COMPOSTING POTENTIAL OF LIVESTOCK WASTE

In Korea, the number of livestock animal increased rapidly after 1985 with increase of meat consumption. Especially, the number of pigs will be increasing since the export is increasing with the governmental support. As of September 1997, the number of cow is 3,139,000, that of pig is 6,439,000, and that of chicken is 89,247,000 (Table 2). Total amount of manure and urine generated from them is 44,409,000 tons per year.

Calculating the amount of nutrient in total livestock manure and urine, total nitrogen content is 343,000 tons, total

[Table 1] Nutrient content in the livestock manure

Division	Nitrogen	Phosphorus	Potassium
Raw manure			
Cow	2.8	1.4	3.5
Pig	3.9	5.3	3.5
Dry manure			
Cow	4.7	2.4	5.9
Pig	6.7	5.8	3.7
Chicken	10.7	9.5	4.8

Source : Bae (1996)1 p. 46

[Table 2] Estimation of livestock manure and urine generation

	No (million)	Waste generation per animal (kg)			Total generation per year (million tons)		
		Manure	Urine	Total	Manure	Urine	Total
Korean Cow	2.588	15	5	20	14.169	4.723	18.892
Cow	0.551	30	10	40	6.033	2.011	8.044
Subtotal	3.139	-	-	-	20.202	6.734	26.936
Pig	6.490	3	3	6	7.107	7.107	14.214
Chicken	89.247	0.1		0.1	3.259		3.259
Total				30.568	13.841	44.409	

Source: Ministry of Agriculture and Forestry(1997), Internal Data

[Table 3] Fertilizer value of livestock manure and urine

Livestock	Annual generation 1000 tons/Year : raw waste	Nutrient content in livestock manure and urine (ton/year)		
		Nitrogen	Phosphorus	Potassium
Cow	26,936	156,228	78,113	171,716
Pig	14,214	113,713	124,374	103,762
Chicken	3,259	72,990	61,260	39,102
Total	44,409	342,942	263,747	314,580

Source: Bae(1996) p.46

phosphorus is 264,000 tons and total potassium content is 315,000 tons[Table 3].

Comparing these amount with the total nutrient amount in chemical fertilizer consumed, the total amount of nitrogen is much lower than that in the chemical fertilizer, which is 475,000 tons. However, the total amount of phosphorus and potassium is higher than those in chemical fertilizer consumed, which is 114,000 tons and 168,000 tons, respectively. Taking into account the recommended application amount by the Korean Office of Agricultural Development, which is annual consumption of 260,000 tons for nitrogen, 114,000 tons for phosphorus and 168,000 tons for potassium each other, these amount are enough to meet the nutrient demand for agricultural utilization. This means that agricultural fertilizer demand can be met purely by livestock waste2).

[Table 4] shows the nutrient load of livestock manure and urine per unit cultivated area by province calculated from number of livestock animals and waste generated. As shown in [Table 4], Kyonggi province having high number of livestock animals, has also high nutrient load ; 311 kg of nitrogen, 253.3 kg of phosphorus and 271.4 kg of potassium per hectare. While, nutrient load of livestock manure and urine in Kangwon province is about 1/2 of that in Kyonggi province. Thus, there is high

variation in nutrient loading among the provinces.

Although we have ample source of compost material using livestock waste, relatively small amount of it is composted now6).

#### 4. LIVESTOCK WASTE MANAGEMENT OF SOME FOREIGN COUNTRIES

##### 4.1. Netherlands

In Netherlands, the area used for livestock farming is 61% of total area for agricultural use. Among the livestock farms 54% has adequate grass land for livestock waste application. Their goal of livestock waste management is to produce a good quality compost and export it to the foreign country. Total nitrogen loading on the agricultural land is 507 kg per hectare; 280 kg by livestock waste and 227 kg by chemical fertilizer. They set the maximum application limit of livestock waste on soil based upon phosphorus content, which is 250 kg per hectare for grassland and 125 kg per hectare for crop land, respectively. The annual generation of livestock waste is 82 million tons. Based upon the maximum limit, they estimated that 66 million tons could be consumed within their country and the rest 16million tons should be exported to the foreign country3).

Livestock waste which is to be exported, is dried and pelletized to improve handling and easy transport. Currently, the excess

[Table 4] Nutrient loading by livestock manure and urine per unit cultivated area

City and province	No. of livestock (1000 individuals)				Cultivated area (100 ha)		Nutrient loading		
	Korean Cow	Cow	Pig	Chicken	Paddy field	Field	N	P	K
Seoul	0.3	0.3	1.4	2.4	0.9	1.2	29.0	21.4	29.3
Pusan	3.5	2.7	36.1	193.8	7.0	1.6	135.6	117.5	125.0
Daegu	24.6	6.6	39.1	360.8	2.6	3.4	425.1	296.0	418.8
Incheon	20.3	9.7	124.8	889.2	4.6	1.9	711.7	594.9	655.7
Kwangju	7.5	1.8	14.0	260.5	12.6	4.5	54.6	40.1	50.3
Daejeon	5.8	1.1	6.6	233.0	4.9	3.3	79.0	55.7	71.1
Kyonggi	225.4	229.2	1,743.2	28,160.8	175.8	89.5	311.0	253.3	271.4
Kangwon	164.6	26.5	240.4	4,041.9	62.2	73.5	123.3	88.4	116.0
Chungbuk	171.6	27.1	288.6	5,132.4	78.5	69.9	126.8	93.2	117.1
Chungnam	395.6	83.8	1,225.6	12,013.8	196.9	78.1	200.6	158.8	185.7
Jeonbuk	214.1	34.0	523.5	9,553.8	183.8	52.0	122.7	95.7	108.9
Jeonnam	452.4	34.5	579.4	7,159.2	219.9	112.6	114.5	81.4	110.3
Kyongnam	504.6	48.0	721.8	12,688.3	189.7	143.1	145.6	106.0	135.4
Kyongnam	362.9	41.2	719.3	7,437.3	158.7	68.0	165.7	125.0	156.6
Cheju	34.8	4.3	226.6	1,116.9	0.2	54.0	123.9	111.0	113.0
Average	2,587.9	550.9	6,490.5	89,247.2	1,298.3	756.5	166.9	128.4	153.1

Source : Chung(1995), pp. 42-53

amount of livestock waste is 16 million tons. It is estimated to be generated 20 millions in 2000. They made a plan to export up to 50% of the excess amount of livestock waste to Japan and Labia in a dry pelletized form.

To do this, the government subsidize 35% of building cost of processing facility and that of operation. The transportation cost is paid by farmers. They employ several methods in the application of livestock manure and urine on soil; application in slurry form, direct application with drainage water on grassland and mixing with soil. They prohibit the application of livestock waste on soil from September to February.

#### 4.1. Netherlands

In Denmark, livestock manure and urine are usually applied on grassland. However, the application rate is strictly controlled by the government. If farmers want to apply livestock waste on soil, they should prepare a decent storage facility.

The livestock farm which has less than 31 livestock unit [Table 5] should have a storage facility capable of 40-45% of livestock waste generated for 6 months. And the bigger farm which is greater than 31 livestock unit and less than 120 livestock unit should have a storage facility capable of 25-37.5% of livestock waste generated for 9 months. The

livestock farm which has greater than 120 livestock unit can not be run without the resident's agreement and should have a decent grass or crop land for livestock waste application<sup>4)</sup>.

The application rate is strictly controlled by the government.

[Table 5] One livestock unit

- One cow with no calf
- Three pigs with a piglet weighing up to 25kg
- Eight sheep with baby sheep
- 150 chickens for laying eggs,
- 150 chickens for producing meat

Source : Gilberton (1989)

The maximum application limit on agricultural soil is shown in [Table 6]. In the land with no vegetation cover, livestock waste should be mixed with soil before October 1st. The application is prohibited on frozen or snow-covered soil (Ruszlerand Carson, 1974).

[Table 6] The maximum application limit in Denmark (livestock waste produced from the following livestock unit/hectare)

Cow	Pig	Others	Farms with no livestock
2.3LU	1.7LU	2.0LU	1.7LU

\* Livestock Unit

source : Gilberton, 1989

The application is also prohibited within 200 meters from the neighbouring farms on Sunday or holiday. Small farms with no sufficient grassland should transport to their livestock waste to a common treatment facility with anaerobic digestion system.

#### 4.3. Japan

In Japan, the primary goal of livestock waste management is to apply it on the agricultural soil. However, it tries to minimize the generation because too much livestock waste is generated which cause overload problems on soil. To minimize livestock waste generation, they are attempting to discourage import of feed stuff for livestock. They planned to improve the self-supply ratio of the feed stuff to 37% in 2000. Currently the self supply ration of it is 26%<sup>4)</sup>.

On the other hand, there are many research activities to minimize livestock waste. Animal scientists are studying how to raise livestock animals with less feed stuff and trying to find out the optimum amount of water supply to decrease urine generation. Mixing with manure excess washing water is carefully controlled and the livestock waste is dried by heat to decrease the quantity.

### 5. SOME PROBLEMS ASSOCIATED WITH COMPOST PRODUCTION FROM THE LIVESTOCK WASTE

As of April 1997, the number of joint compost facility for livestock waste run by agricultural co-operative society is 35 in Korea. Many composting facilities are using saw dust for bulking agent. The production capacity of individual compost facility is between 6 and 90 tons per day and total annual production is likely to be 220,090 tons. These joint composting facilities are expected to be increased in the future.

Recently, more livestock waste composting facilities have been built by agricultural co-op. Currently about 300 plants are running with annual production of 1,533,000 tons. Composting plants run by agricultural co-op supply their production to the members at cost. This kind of plant is expected to be increased in the future.

The price of compost from livestock waste is varied. The joint compost facility sells their product 150~175 won per kg and individual farmer sells their compost 75~100 won per kg. Currently, both forms of the composting business are run in deficit since their production cost exceeds selling cost. The reason is that the costs of saw dust and additives such as limestone are expensive. The depreciation cost for the composting facility and the interest rate for fixed property are also high<sup>6)</sup>.

The problems of compost production from livestock waste are as follows;

#### 5.1. Financial difficulty

Currently, most of the joint composting facility are encountering financial difficulty. The main reason is that the payment for compost product sold is usually done after 6 months due to seasonal demand.

#### 5.2. Significant variation of compost price between different composting facilities

Considerable difference in compost prices among compost facilities is related to the difference of raw material, processing and production techniques.

#### 5.3. Difficulty in procuring bulking agent

The most common bulking agent used for livestock waste is now saw dust in Korea. However, it is becoming more difficult to obtain sufficient amount of saw dust with the growing demand. Currently, only 40~50% of the demand can be met with the price of saw dust soaring.

#### 5.4. Compost are heavy, bulky and inconvenient to handle

Since compost from livestock waste is bulky, it is inconvenient to transport and apply on soil. This is a fundamental inferiority to chemical fertilizer. Due to the inconvenience of handling, many farmers favor chemical fertilizers also having higher nutrient content.

#### 5.5. Unstable market

Currently, the sales of compost from livestock waste is not promising due to unstable market. This is because there is no sufficient information about the customer, and the compost price is variable. Another important reason for unstable market is that the demand for the compost is seasonally variable. In growing season, the demand is high. While, the demand of compost is almost nothing in the Winter.

### 6. SOME STRATEGIES TO IMPROVE LIVESTOCK WASTE MANAGEMENT

#### 6.1. Self-supply of feed stuff

Now, approximately 90% of feed stuff for livestock is imported from foreign countries, especially from USA. Consequently, the imported feed-stuff is converted to livestock waste and disposed in the rural area in Korea. This causes high organic loading on the

agricultural soil. To improve this problem, it is desirable to increase gradually self-supply rate of feed-stuff.

### 6.2. Even distribution of livestock farms

[Table 4] shows the number of livestock in each province. As we can see, there are big differences in their numbers among the provinces. Crowding of livestock in the limited area can cause some difficult problems; huge amount of livestock waste can be accumulated in the specific area. To improve this situation, it is necessary to distribute rather evenly livestock farms all over the area. Thus, it is possible to provide some land area for soil disposal of livestock waste(Jung, 1995).

Korea is a mountainous country. [Table 7] shows the area for agricultural use and the mountain area which can be developed. As we can see, the cultivated land area for agriculture use is 1,950,000 hectare, while the mountain area is 6,310,000 hectare, which is more than three times larger than the former. Among the mountain area, the slope less than 30% can be developed; 220,000 hectare can be developed to crop field, 310,000 hectare orchard or mulberry garden and 2,000,000 hectare grass land. The total mountain area which can be developed is bigger than the total cultivated area.

Therefore, it is desirable for the Korean government to allow cattle to graze on the mountain area with low slope. Thus, the feed-stuff import can be cut and significant grass land area for livestock waste application can be obtained.

### 6.3. Anaerobic digestion of livestock waste

Now, only a few percentage of livestock waste is anaerobically digested. Anaerobic digestion of livestock waste has some

advantages compared with the aerobic composting; the amount of final product is less than the aerobic composting and it doesn't need bulking agent such as saw dust.

### 6.4. Use of Pop-rice-hull or tire chips as bulking agent

There are several kinds of bulking agent for aerobic composting of livestock waste. Among them, saw dust is most commonly used now. With the increasing demand for the livestock waste composting, the price of saw dust is soaring and it become more difficult to get supply on time(6).

Thus, it is necessary to develop alternative materials. Pop-rice-hull is a good candidate and tire chip another. It is shown that the efficiency of Pop-rice-hull as bulking agent is almost equal to saw dust. Pop-rice-hull can be amply produced in the rice processing plants.

Another alternative is to use tire chip as a bulking agent, which can be recycled many times.

### 6.5. Governmental support in technology development of composting plants

There are about 400 composting plants which are in part financially supported by the Korea government. However, most plants lack well-trained technicians. Consequently, the quality of compost is variable among the plants and most plants are encountering odor problems facing resident's complaints. To help eliminating these problems, governmental support is necessary especially in composting technology development.

Some systematic and intensive education and training program would be greatly helpful.

[Table 7] Cultivated land area and the mountain area which can be developed for cultivation

(unit : 1000 hectare)

Province	Cultivated land area	Mountain area	Mountain area which can be development				Reserved wood land
			crop	orchard or mulberry garden	gress-land	subtotal	
Kyonggi	265	602	36	57	225	318	284
Kangwon	134	1,278	20	12	305	337	941
Chungbuk	148	510	12	19	155	186	324
Chungnam	275	488	26	68	223	317	171
Jeonbuk	236	472	44	26	151	221	251
Ueonnam	333	730	42	59	292	393	337
Kyongbuk	333	1,419	22	37	392	451	968
Koungnam	227	813	13	27	262	302	511
Total	1,951	6,312	215	305	2,005	3,525	3,787

Source : Ministry of Agriculture and Forestry(1997), Internal Data.

### 6.6. Financial support by the government

Most of composting plants in Korea are now running in deficit. The average compost selling price is 1,963 won per 20 kg bag, while the break-even point price is 2,102 won with deficit 139 won.

In Netherlands, the government subsidize 35% of capital cost and 35% of operation cost. This kind of governmental subsidy would also greatly helpful for compost business.

### 6.7. Reserve system for stable market

Compost is mainly used in growth period, Spring and Fall. In these period, the compost is sold well but almost no sales is achieved in the other times. Due to the intermittent demand, the compost market is unstable. Naturally, many plants are running in deficit especially in the Winter. Thus, it is desirable to have a reserve system at the time with little demand. For this, agricultural co-op can take a role to buy compost at the time with little demand and sell it at the time with high demand.

### 6.8. Difference of compost quality

The compost produced from livestock waste varies in quality. It is desirable to differentiate at least "clean" compost and "less clean" compost. If we classify compost into class I(clean compost) and class II (less clean compost), we can differentiate the usage of the compost; class I compost can be used food-chain crops such as cereals and vegetables and class II compost non-food-chain crops such as flowers and turf.

### 6.9. Co-composting of food waste with livestock waste

Recently, food waste composting has been a big issue in Korea. The waste comprises approximately 30% in weight in municipal solid waste. To recycle and divert it from landfill site, significant concern is growing about the composting of food waste.

However, composting of food waste as sole raw material is technically difficult; it has high salt and moisture content and it is heterogeneous. Thus, it would be a practical methods to co-compost food waste with livestock waste to relieve some problems and improve the product quality. The location of the composting plant is desired to be at the suburban area for the convenience of transportation. In some cases, it would be desirable for composting plants to be located in the green belt area under the governmental permit.

## 7. CONCLUSION

There is no single panacea to solve livestock waste problems in Korea. A variety of method can be applied by depending upon the

situation. However, the first priority should be given to the minimization and the next is even distribution of the livestock farming over the country. If some grassland is available around the farm, anaerobic digestion of livestock waste is a practical way of treatment followed by land application.

When there is no sufficient grassland, then composting of livestock waste would be a practical way of treatment.

## ACKNOWLEDGEMENT

This study was performed with the financial support by Yonsei University. The Authors Express thanks to the University.

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