

Korea Recycling Situation and Policy for Municipal Solid Waste Ash

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To utilize municipal solid waste incineration ash as useful resources in Korea, studies on the present state of production and management of incineration ash and its effects on environment were made. And, it was intended to analyze the management conditions of incineration ash in many foreign countries and reflect them in domestic incineration ash policy. Korean incineration ash policy is based on the control of waste production, considering the difficulties in securing landfills and the small size of national land, and will be changed into recycling- and incineration-centered one. Furthermore, studies on the stabilization and recycling of incineration ash should be continuously conducted to overcome the concerns about environmental pollution.

1. Introduction

In 1999, the incineration ash generated from 14 domestic municipal solid waste incinerating facilities was composed of about 16,000 tons of fly ash and 160,000 tons of bottom ash. In case of bottom ash, some are filled-up in general waste landfills and others are recycled. Fly ash is filled-up in specified waste landfills.

According to the national strategies for nation-wide waste management revised and established in July 1995, the practical goals of Korean waste management are to increase recycling and reduce landfill by the order of priority of waste management. It considered the composition of waste and the domestic ability of recycling, and placed greater importance to incineration rather than landfill in case of the end waste which cannot be recycled. According to this plan, waste was managed at a ratio of 72% landfill, 24% recycling and 4% incineration, but in 1998, landfill was reduced and recycling and incineration were gradually increased, as 55% landfill, 30% recycling and 15% incineration. In 2001, it is planned to reduce landfill ratio to 45% and raise incinerating ratio to 20%. As waste incinerating ratio increases in accordance with government policy, the generation of incineration ash is expected to increase.

Bottom ash consists of iron, nonferrous metals, glass, ceramics, slag and other organic materials, and contains moisture in great quantities. Though it is possible to recycle bottom ash by proper treatment, most bottom ash is being filled-up because heavy metals were detected below standard by the leaching test of heavy metals. In fly ash, heavy metals were found above standard by the test, and it is being filled-up in controlled landfills as specified waste or after stabilization·solidification treatment. However, in the disposal of waste ash by landfill, it is expected that it becomes more difficult to secure landfills owing to the environmental problem caused by the leachate of heavy metals, NIMBY Syndrome, and the increase in the generated amount of incineration ash. Therefore, it is urgently needed to take a measure for the disposal of incineration ash.

The present state is that most of incineration ash generated in municipal solid waste incinerating facilities in large quantities is disposed by landfill. It is required to

develop a system for the creation of comfortable living environment and the recycling of waste as well as for the effective utilization of national land by the stable disposal of incineration ash and the minimization of landfill.

Therefore, this study aims to stabilize and recycle the incineration ash generated in municipal solid waste incinerating facilities, extend the life span of waste landfills which are restricted in number, prevent the second pollution, and popularize treatment technologies through the researches in those technologies and systems.

2. Changes in Municipal Solid Waste Management Policies in Korea

Waste management policies in Korea have been greatly changed since 1960's. After passing through the era of the sewage clean-up law(1961~1977), the era of environmental conservation law(1978~1986) and the era of the management law of waste(1987~1992), it reached the scheme for ministratation of waste(1993~present). In 1960's and 1970's, the treatment of waste and night soil based on a concept of cleaning was a pending problem. At the end of 1970's, as the environmental problems were visualized, the environmental conservation law(1978) was established, and the inauguration of the Ministry of Environment changed the concept of the existing passive defense into that of active preservation. However, even in this period, Municipal solid waste was still managed by the sewage clean-up law. The concept of recycling was introduced when the management law of waste was established in 1986 by integrating the regulations affecting waste. Since 1992, various laws and regulations have been improved to facilitate the recycling of waste resources, and since 1995, the reduction in the amount of waste has been facilitated by the enforcement of the volume-rate disposal system and the waste management polices have been changed to "treatment", "recycling" and "reduction of amount".

As internal and external circumstances were greatly changed, like the enforcement of the volume-rate disposal

Table 2 MSW Output by shape

(unit : ton/day)

Year	Division	Combustible (food, paper, wood, etc.)	Incombustible (briquet ash, metal, glass, etc.)	Recycling
1990		44,909	39,053	-
1991		52,617	39,629	-
1992		47,211	27,885	-
1993		44,558	18,382	-
1994		42,273	15,854	-
1995		36,192	11,582	-
1996		30,306	7,456	12,163
1997		28,737	6,674	12,482

system and the entry into the OECD, the Ministry of Environment revised and announced the national strategies for nation-wide waste management (established in 1993) with the intention of moving forward with the plan by 2001. Through this plan, it is expected to drop the landfill ratio to 45%, by raising the recycling ratio of municipal solid waste and the incinerating ratio up to 35% and 20%, respectively. The core of this plan lies in effective recycling treatment. For the construction of Integrated Waste Recycling System (IWRS), 512 waste management facilities in total including 9 urban comprehensive disposal facilities, 55 sanitary landfills, 9 incinerating facilities will be expanded and improved by 2001.

3. Generated Amount And Present State of Municipal Solid Waste in Korea

3.1. Present State of Municipal Solid Waste Generation in Korea

Table 1 displays the generated amount of municipal solid waste in Korea from 199 to 1998. The amount showed an annual increase of 9% by 1991, but it showed a gradually declining tendency on the whole after a rapidly decreasing trend since 1992 and a little increasing trend in 1996. The rapidly decreasing trend seems to be the result of the expansion of separate collection, the reduction in the amount of a used briquet and the continuous reduction policy.

Table 1 MSW Output by Year

Year	Division	Output (ton/day)	Output per day (kg/day)
1990		83,962	2.30
1991		92,246	2.40
1992		75,096	1.80
1993		62,940	1.50
1994		58,118	1.30
1995		47,774	1.07
1996		49,925	1.11
1997		47,895	1.05
1998		44,583	0.96

As shown in Table 2, Municipal solid waste is largely divided into combustible and incombustible waste. Combustible waste is classified into food, vegetable, papers, wood and others, and incombustible waste is divided into used briquet ash, metals, glasses and others. The relative importance of combustible waste is being continuously raised compared to incombustible one, and food and packing waste is absolutely the most in municipal solid waste.

3.2. Present State of Municipal Solid Waste Management in Korea

As shown in Table 3, the disposal by landfill is being gradually reduced every year. The amount of waste ash will increase because the difficulty in securing landfills made the Government plan to raise the incinerating ratio up to 20% by 2001. While the recycling ratio of municipal solid waste is being greatly increased, the incinerating ratio is on the very slow rise because of the shortage in local finance, NIMBY Syndrome, and the like.

Table 4 shows the management condition of combustible waste by elements in 1997. As shown in this table, landfill occupies the largest part, followed by incineration and recycling. Thus, it is needed to reduce landfill and incineration through the facilitation of recycling.

Table 3 MSW Management Situation by a Processing Method

(unit : ton/day)

Year	Amount	Landfill	Incineration	Recycling	Uncollected
1991	92,246	82,411 (89.3)	1,497 (1.6)	6,786 (7.4)	1,552 (1.7)
1992	75,096	66,965 (89.2)	1,132 (1.5)	5,912 (7.9)	1,087 (1.4)
1993	62,940	54,227 (87.7)	1,480 (2.4)	7,233 (11.5)	
1994	58,118	47,116 (81.2)	2,025 (3.5)	8,927 (15.4)	
1995	47,774	34,116 (72.3)	1,922 (4.0)	11,306 (23.7)	
1996	49,925	30,116 (68.3)	2,725 (5.5)	13,084 (26.2)	
1997	47,895	30,579 (63.9)	3,409 (7.1)	13,907 (29.0)	
1998	44,583	25,074 (56.2)	3,943 (8.84)	15,566 (34.9)	

Table 4 Management Situation of Combustible Waste by Component in MSW

Category Division	Amount		Food and Beverage		Paper		Wood		Rubber and leather		Plastic		Etc.	
	ton/day	%	ton/day	%	Ton/day	%	ton/day	%	ton/day	%	ton/day	%	ton/day	%
Landfill	23,917	83.2	10,974	84.0	4,947	81.7	1,391	73.0	85.9	85.9	1,861	82.9	3,797	87.0
Incineration	3,314	11.6	815	6.2	1,036	17.1	445	23.4	13.5	13.5	353	15.7	543	12.4
Recycling	1,481	5.2	1,275	9.8	73	1.2	69	3.6	0.6	0.6	31	1.4	25	0.6
Total output	28,739	100	13,063	100	6,057	100	1,905	100	100	100	2,245	100	4,365	100

3.3. The Shape of Municipal Solid Waste in Korea

The shape of municipal solid waste can be represented by density, physical composition, three components, specific gravity, elementary analysis (C, H, O, S, N, Cl), caloric value, etc. that are the foundations in establishing every plan for municipal solid waste. The physical properties of waste become a help to the understanding of generated conditions, and three components, caloric value, elementary analysis, etc. are reflected in the establishment of the operating conditions of incinerating facilities.

According to the average composition ratio during three years from 1997 to 1999, food took the largest part as 46.8%, and papers, vinyl·plastics, incombustibles, textiles·leather and wood·leather represented 22.2%, 17.0%, 5.6% and 3.1%, respectively.

According to the average values of specific gravity, caloric value and three components by incinerating facilities (1997~1999), they showed 0.4ton/m³ of specific gravity, 1,449 kcal/kg of caloric value, and 54% moisture, 34% combustible materials and 12% ash. When the values were compared by incinerating facilities, A and G had relatively higher gravity and caloric value, respectively, and others showed almost similar results. It is estimated that the high caloric value is due to the fact that vinyl·plastics are greatly included, and the high moisture content is caused by high food content hitting nearly 50% of the whole amount.

Fig. 1 shows the caloric values of waste by season in 1999. It was the lowest in summer while the highest in autumn. It is closely related to the moisture content in waste.

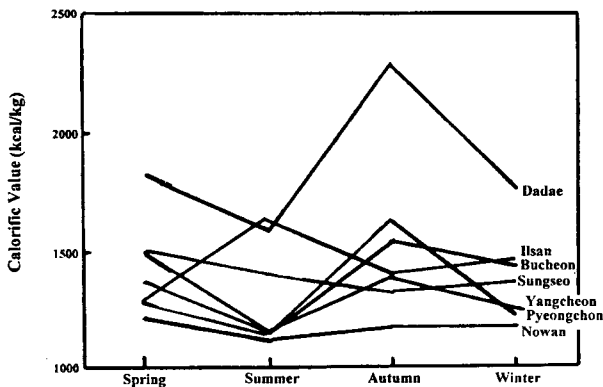


Fig. 1 Seasonal caloric value of waste carried in Domestic incineration places at 1999.

3.4 Incinerating Facilities and Management State of Municipal Waste in Korea

As of 1999, there are about 30~40 incinerating facilities that are in operation and a trial run, under construction or due for construction, and 15 of those facilities are in operation. Though the exhaust treatment equipment of facilities show some differences by the form and equipment of an incinerator, they are largely divided into semi-dry and wet type. All facilities which are in operation or under construction and due for construction are equipped with dioxin removing devices, and additional installation and supplementation is being made continuously. The incineration ash discharged in incinerating facilities can be divided into bottom ash and fly ash, and almost all bottom ash is filled-up. Most of fly ashes are filled-up in the facilities run by the Environmental Management Corporation and part of them are filled-up with general waste after chelate solidifying treatment. As of 1999, total 1,080,000 tons of waste were incinerated in 15 facilities nationwide.

The delivered and incinerated amount of municipal solid waste in large facilities during 1997.1~1999.12 were 695 tons in 1997, 715 tons in 1998, and 1,097 tons in 1999. The generated incineration ash was 117,000 tons of bottom ash and 251 tons of fly ash in 1997, 109,000 tons of bottom and 2,967 tons of fly in 1998, and 162,000 tons of bottom and 15,747 tons of fly ash in 1999. The great increase in the generation of fly ash in 1999 is caused by the policy which required the incineration ash to be separated into bottom ash and fly ash and the discharging and managing devices to be equipped.

3.5 Characteristics And Recycling State of Incineration Ash of Municipal Solid Waste in Korea

If municipal solid waste is incinerated, the incineration ash is generated. According to the discharged parts, waste ash is largely divided into the bottom ash discharged from incinerators and the fly ash from dust removing devices which collect and remove dust included in combustion gas. Fly ash is subdivided into boiler dust and fly ash. On the basis of average moisture content, bottom and fly ash are generated 10~15% and 1~1.5%, respectively, of the total waste amount.

Generally, fly ash contains quite a high concentration of heavy metals, while bottom ash does a very small amount of them. Fly ash contains 0.3~3% of Pb and Zn, 20~40mg/kg of Cd and 200~500mg/kg of Cr, and bottom

ash does about 1/2 ~ 1/100 of those amounts. In bottom ash, metals with a low melting point like Cd, Hg, etc. are almost changed into exhaust gas and move with exhaust, and some other heavy-metallic and alkaline components are evaporated, condensed with the cooling of exhaust gas and changed into fly ash.

With the gradual increase of incinerating facilities, the amount of incineration ash which needs management is also rising. If environmental problems like the elution of heavy metals, the landfill which occupies a large portion in waste ash disposal in present is not considered as a desirable method. Therefore, the method which not only reduces management expenses but also seeks the environmental stability should be adopted by making heavy metallic elements resources without elution. Now in Korea, structural bricks, tiles, blocks, etc. are being produced with bottom ash.

3.6 Problems in Incineration Ash Management

About 45,000 tons of municipal solid waste were generated in Korea in 1998. About 4,000 tons, that is, about 9% of that amount were incinerated and waste ash was generated. The generation amount of incineration ash is expected to increase continuously, by the rise in municipal solid waste as well as the government policy which intends to raise the incinerating ratio of municipal solid waste to 20% by 2001. In incineration ash, bottom ash and fly ash occupy 10~15% and 1~1.5%, respectively. Bottom ash is filled-up as general waste or recycled. fly ash was filled-up after mixed with bottom ash, but since November 1998 when it was designated specified waste, it has been treated in specified waste treatment facilities or separate treatment devices in the facility. As fly ash contains heavy metals and dioxin in a larger amount than bottom ash, the environmental problem is being seriously pointed out. There's a limitation in landfill of incineration ash which continuously increases and there also exist effects on the environmental pollution. Therefore, to solve these problems, researches in the proper treatment methods of incineration ash are being actively made and the Government is continuously taking measures of proper utilization.

4. Direction of Municipal Solid Waste Management Policies in Korea

4.1. Prospects of Municipal Solid Waste Management

Though the generated amount of municipal solid waste is greatly reduced as mentioned above, it's difficult to expect more reduction and the life of consumption is thought to be on the rise from now on.

If municipal solid waste generated in 1998 is viewed by the management method, incineration, landfill and recycling were 8.9%, 56.2%, and 34.2%, respectively.

Korea's dependence on landfill is extremely higher than that of advanced countries. The estimated generation amount in 2001 and the present state of management are shown in Table 5.

Table 5 Management Situation and Prospective Output at 2001

Division	Year	2001	Remarks
Incineration rate (%)		20	
Recycling rate (%)		35	
Landfill rate (%)		45	
MSW output (ton/day)		64,431 (44,583)	() : output at 1998
Output per day (kg/day)		0.90 (0.96)	() : output at 1998

4.2. Direction of Municipal Solid Waste Management Policies

According to the waste management polices in Korea, mayors·county headmen·ward chiefs are responsible for the management of municipal solid waste among generated waste. Considering the overall structure of waste management, the landfill ratio is being greatly reduced while recycling is largely increased, and incineration is on a gradually increasing trend. In other words, the structure of waste management is being changed toward a desirable direction. For example, in 1991, 89.3% of 생활 waste was filled-up and only 7.4% was recycled, but in 1998, landfill was reduced to 56.2% and recycling was raised to 34.9%, with the help of the enforcement of the volume-rate disposal system and the recycling policies. (Table 3, fig. 2).

The collection, delivery and disposal of municipal solid waste is the duty of the competent mayors·county headmen·ward chiefs. The Government makes basic policies on overall waste management and takes charge of technological and financial support in self-governing bodies. Mayors·provincial governors are in charge of the mediation among the basic self-governing bodies and the financial support.

According to the basic principle of waste management in Korea, the order of priority is as follows: first, the radical control of generation; second, reuse; third, recycling; fourth, the retrieval of energy; fifth, incineration; sixth, landfill (The control of generation through the retrieval of energy is called "Waste Minimization"). Under this basic principle, each kind of system, for example, the reduction of waste in establishments at the stage of production, the share for the environmental improvement of products, and the like, is in operation.

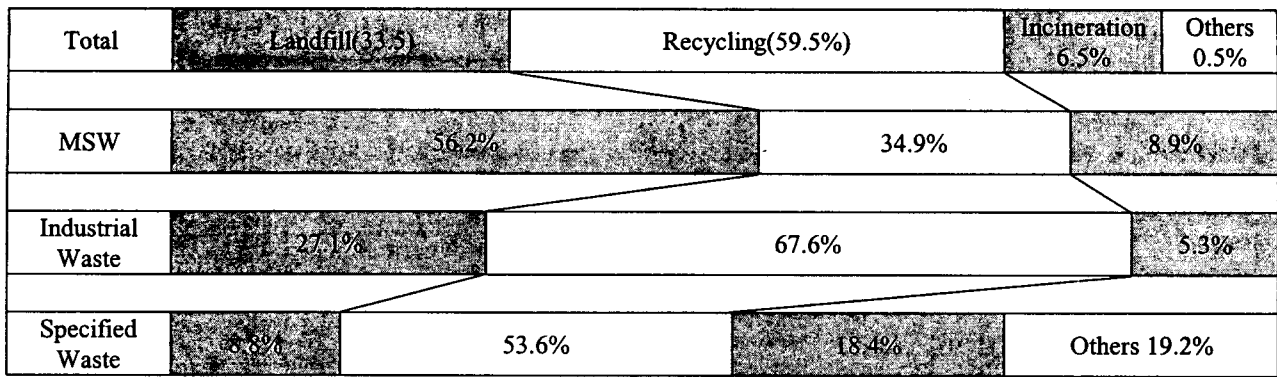


Fig. 2 Waste management situation at 1998.

And, to facilitate waste reduction and recycling, a performance-oriented policy will be adopted by constructing a management system by the stream of waste and making it clear who is responsible by stages of collection·delivery·selection·recycling. Particularly, in packing waste, electric home appliances, etc. that occupy a large part of both municipal solid waste and recyclable waste, the introduction of the extension maker quality assurance scheme which clearly specifies the roles and duties of producers and consumers and manages waste by giving a recycling goal to producers will be considered.

5. Conclusions

As of 1998, Municipal solid waste in Korea was about 45,000 tons/day, of which about 9%, that is, about 4,000 tons/day was incinerated. The incineration ratio will be continuously raised, with the difficulty in securing landfills and as the focus is on the control of waste generation and the encouragement of recycling and incineration in the waste management policy, considering small size of national land. The incineration ash generated in municipal solid waste incinerating facilities is 10~20% of the incinerated amount, and the concern about environmental pollution is raised, because most incineration ash is filled-up in landfills, and thus, causes the life span of landfills to be shortened and the heavy metals to be exhausted. Therefore, the suggestion for proper management methods on incineration ash stabilization and recycling is needed.

In advanced countries including Europe and Japan, active studies are being carried out on the methods of protecting environment as well as extending the life span of landfills by reusing incineration ash as effective resources after proper treatment and reducing the amount filled-up, and those technologies are put to practical use.

Therefore, it is urgently needed to find the optimum management method which is applicable to Korea, by examining and analyzing the generation features and the properties of incineration ash, and on the basis of the investigation and appreciation of domestic and foreign stabilization and recycling technologies.