Characteristics of Municipal Solid Waste Incineration Bottom Ash (MSWI) and Production Status in South Korea

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Abstract: In general, solid waste arises from lot of human activities such as domestic, agricultural, industrial, commercial, waste water treatment, construction, and mining activities etc. If the waste is not properly handled and treated, it will have a negative impact on the hygienic conditions in urban areas and pollute the air with greenhouse gases (GHG) and surface and ground water, as well as the soil and crops. The present objective of our study is to characterize the municipal solid waste incineration bottom ash and case study of MSWI production status in South Korea. Currently, wide variety of smart technologies available for MSWI management in developed countries. Recycling is the other major alternative process for MSWI landfill issues.

Index Terms: municipal solid waste, production, characteristics, South Korea

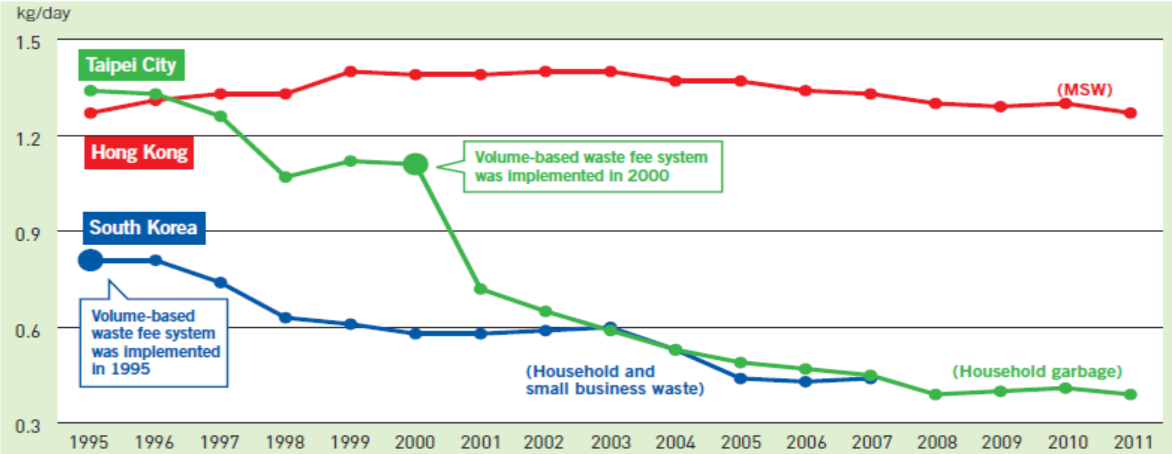
ACKNOWLEDGEMENTS

This research was supported by a grant (2013) from the Energy Technology Development Program (2013T100100021) funded by the Ministry of Trade, Industrial and Energy of the Korean government.

I. INTRODUCTION

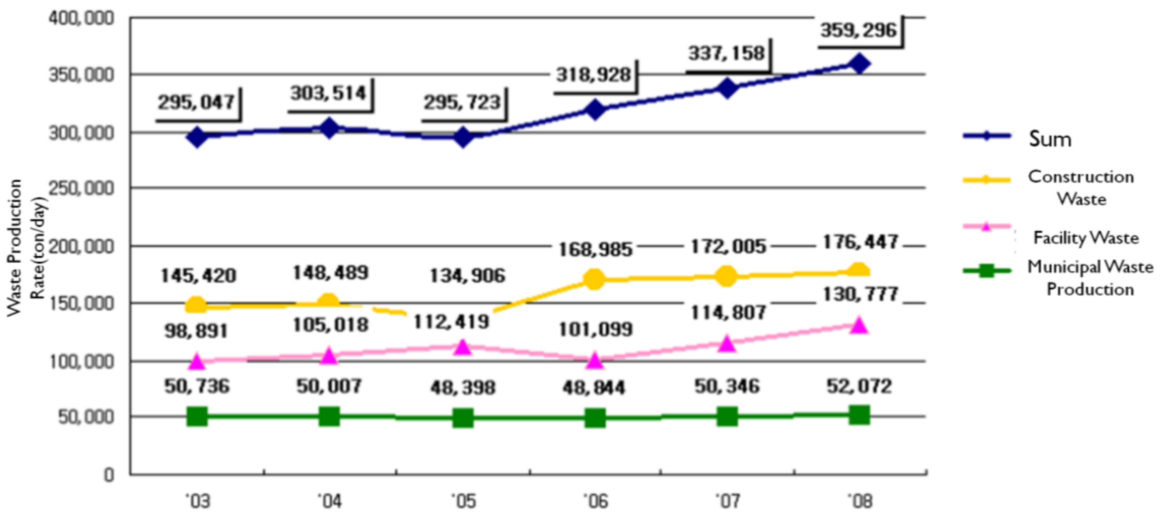
In the case of South Korea as a whole, the waste disposal rate on a per capita basis dropped by 40% from 1995 with the remaining waste treated by incinerators and then landfilled. [1,2] The capital city – Seoul, with a population of more than 10 million, has built four incinerators for treating MSW with a daily capacity of 2,850 tonnes in total. [3]

Fig.1. (a): Asia MSWI production



(Source: Taiwan Environmental Authority; Hong Kong Environmental Protection Department)

Fig.1 (b): MSWI production in Asia



(Source: Jeon, Introduction of MSW ppt, 2008)

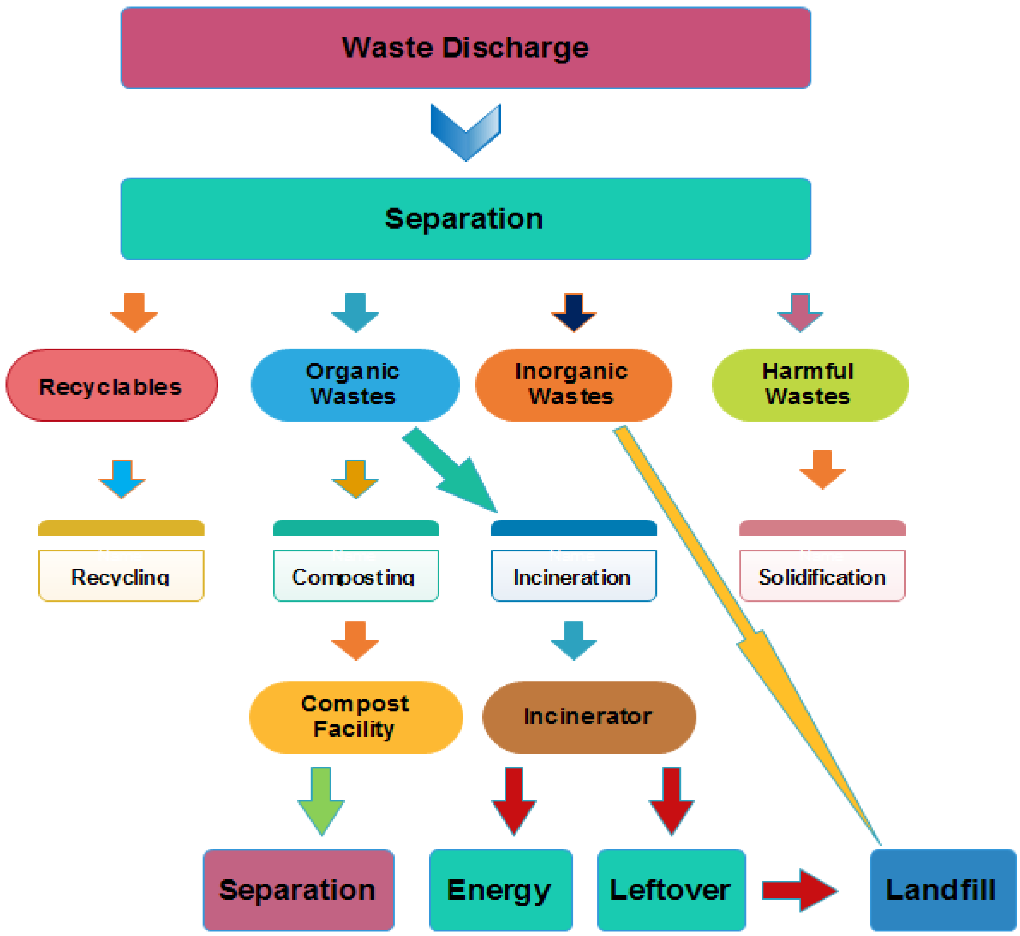
II. Waste Treatment Process

The South Korean Government has been promoting the 3R (Reduce, Reuse and Recycle) policy in recent years. Major policy initiatives implemented on the part of waste recycling include:

(a) Waste Charge System (applicable to products not easy to recycle or containing hazardous materials); and

(b) Extended Producer Responsibility System. Disposal of municipal wastes (i.e. wastes other than industrial wastes) in South Korea is by way of landfilling, recycling, composting and incineration. The waste treatment process is illustrated in (Fig.2).[4]

Fig.2. Waste treatment process flow sheet in South Korea



(Source: Korea Development Institute (2012)

III. Municipal Solid Waste Incineration (MSWI) Bottom Ash

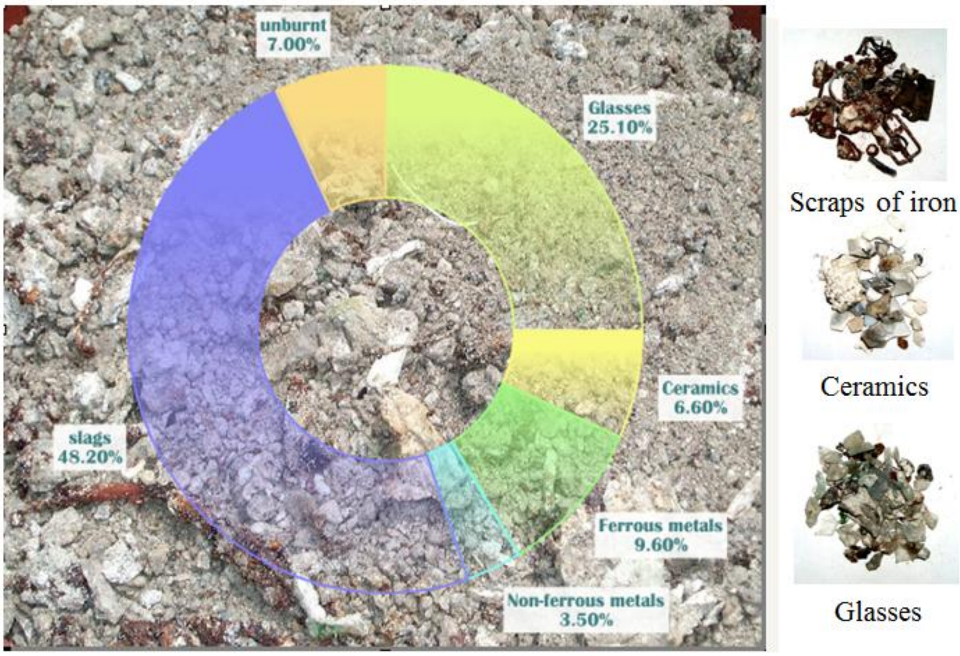
i) By-product that is produced during the combustion of municipal solid waste in solid waste combustor facilities.

ii) Category : Bottom ash(Grate ash, siftings), fly ash(boiler ash, precipitator or bag house ash)

iii)Bottom ash

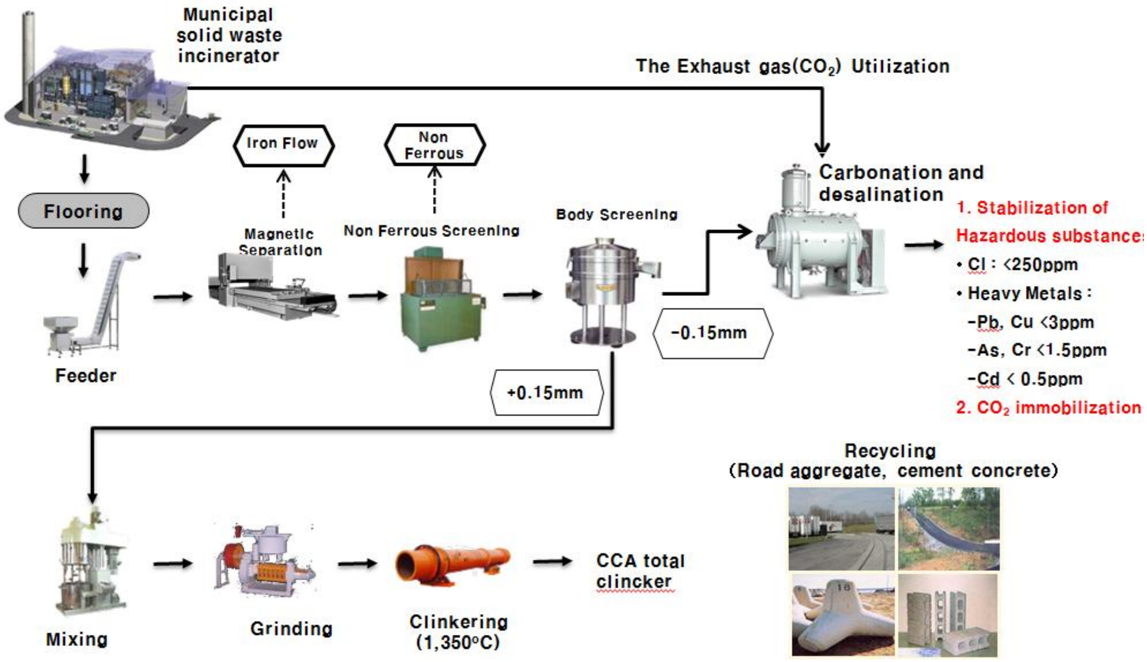
- Approximately 75 to 80 percent of the total combined ash stream (Fig.3)
- Similar in appearance to a grayish, silty sand with gravel
- Consists primarily of glass, ceramics, ferrous and nonferrous metals, and minerals. It will used for the neutralized residue as a soil amendment.

Fig.3. Composition of municipal solid waste incineration bottom ash



(Source: Gide for recycling of municipal solid waste incineration bottom ash, 2007)

Fig.4. Municipal Solid Waste Incineration Bottom Ash Processing Technology



IV. Experimental procedure

Fig.5 shows the flow sheet of municipal solid waste bottom ash and Fig.6 shows the experimental set up with schematic diagram of accelerated carbonation with water to solid ratio. The major composition of MSWI is characterized by XRF analysis and presented in Table-1. Figure 7 showed the XRD patterns of MSWI bottom ash based on particle size.

Fig.5. Experimental flow sheet of MSWI bottom ash

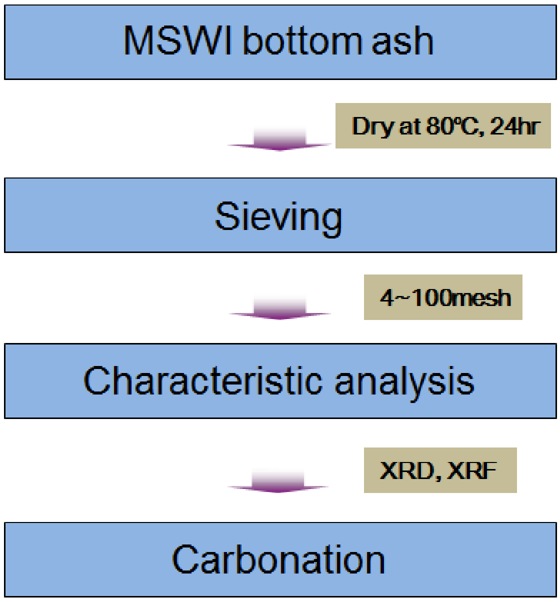


Fig.6. (a) Experimental setup (b) Accelerated carbonation with water-to-solid ratio

(a) (b)

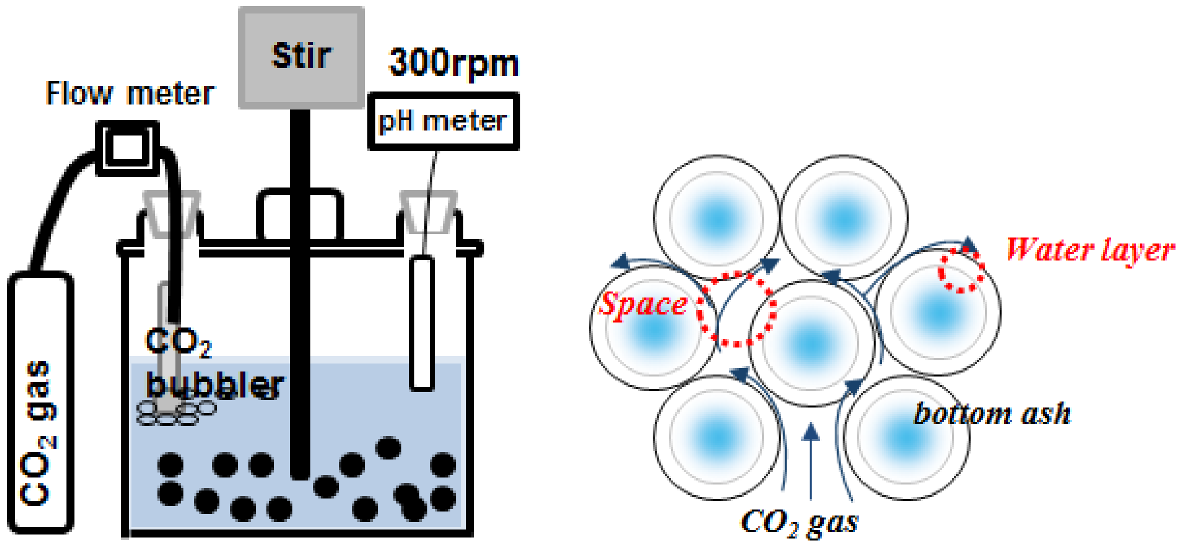
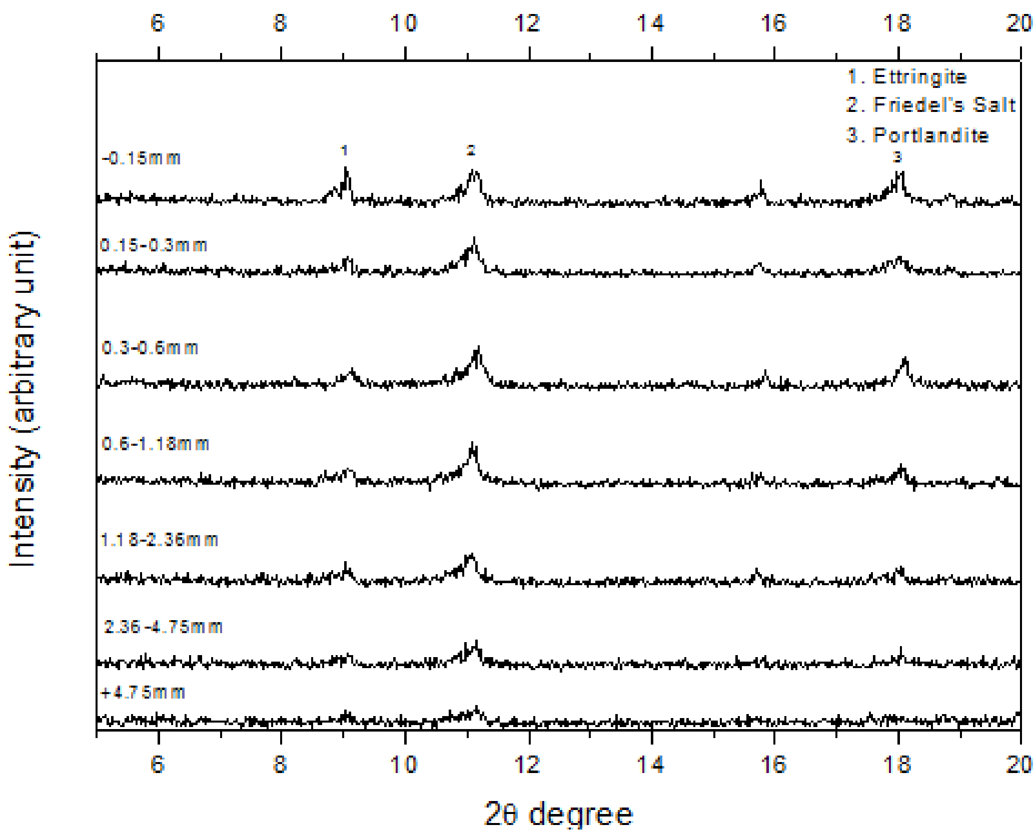


Table-1. Characteristics of MSWI bottom ash

Particle size (mm)	Elements										
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5	Igloss
+4.75(+4mesh)	40.10	9.28	4.04	22.89	1.30	1.11	5.37	0.62	0.07	4.53	8.39
4.75/2.36(4-8mesh)	33.18	11.38	1.74	25.71	1.67	1.27	3.53	0.81	0.07	5.39	11.59
2.36/1.18(8-16mesh)	33.91	10.68	1.77	25.25	1.44	1.31	2.92	0.90	0.18	4.54	13.44
1.18/0.6(16-30mesh)	29.52	11.55	2.69	26.52	1.37	1.17	2.36	0.88	0.09	3.72	15.63
0.6/0.3(30-50mesh)	25.18	9.34	1.86	31.41	1.34	1.00	2.12	0.80	0.09	4.93	18.84
0.3/0.15(50-100mesh)	15.08	7.87	1.84	37.58	1.42	0.65	1.77	0.84	0.11	5.31	24.69
-0.15(-100mesh)	9.97	7.12	1.47	40.41	1.43	0.79	2.10	0.75	0.15	4.06	28.56

Fig.7. XRD patterns of MSWI bottom ash based on particle size



Determination of metals distribution based on different particle size fractions

For the determination of metal oxides distribution in different particle size fractions, the bottom ash and fly ash were dry sieved by Vibratory Sieve Shaker (FRITSCH, Germany) through stainless-steel sieves using a stack of nested sieves (DIN 4188, Retsch 5657, Haan, Germany) with the following particle sizes: 31.5–16, 16–8, 8–4, 4–2, 2–1, 1–0.5, 0.5–0.25, 0.25–0.125, 0.125–0.074 and < 0.074 mm. The weight of each size fraction both for the bottom ash and fly ash was recorded and the percent distribution of weight in each fraction was calculated. For the determination of total metal concentrations in the different particle size fractions, the preparation of each fraction as well as heavy metal measurements were carried out in the same way as described in the previous paragraph

Basic Reactions

Ettringite

$$6Ca^{2+} + 2Al^{3+} + 3SO_4^{2-} + 38H_2O \rightarrow 12H^+ + Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$$

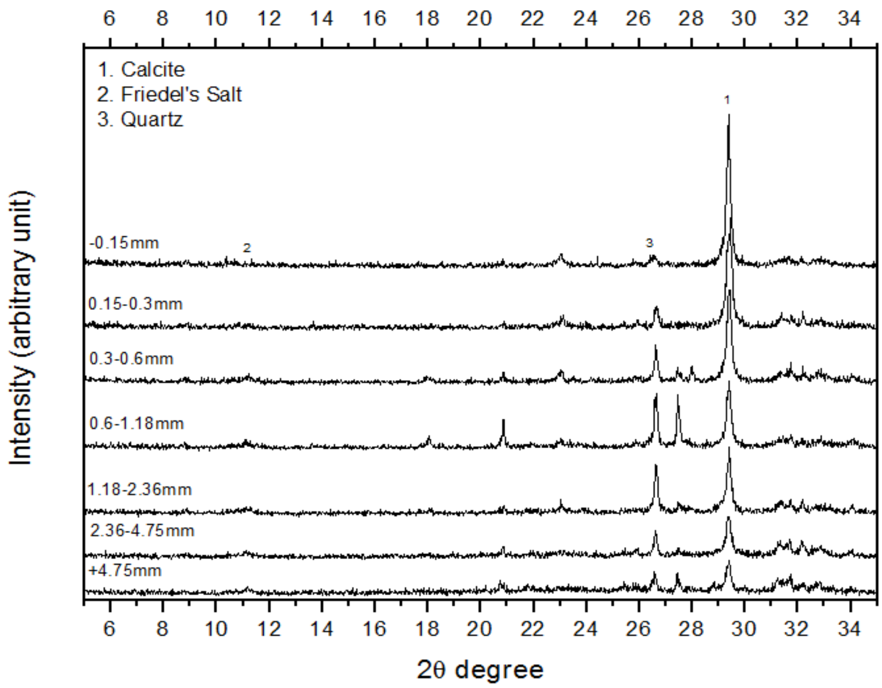
Friedel's salt

$$2Ca^{2+} + Al^{3+} + Cl^- + 13H_2O \rightarrow 6H^+ + Ca_6Al_2(OH)_{12}Cl\cdot 7H_2O$$

Portlandite

$$CaO + H_2O \rightarrow Ca(OH)_2$$

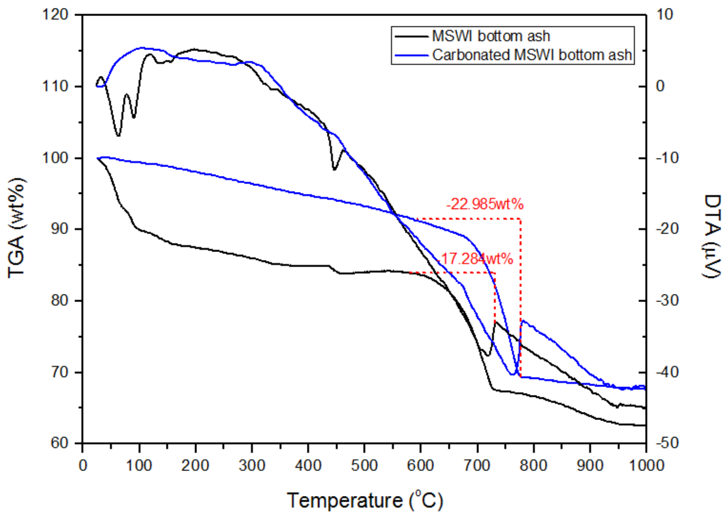
Fig.8. XRD patterns of MSWI bottom ash carbonated at different reaction times (99% CO_2 concentration, 1.0L/min CO_2 flow rate, 20°C reaction temperature, 10 dm^3/kg water-to-solid ratio)



V. Accelerated carbonation of MSWI bottom ash

Accelerated carbonation has been developed and it has been commercialized CO_2 is artificially injected into the target material, the waste, to accelerate the carbonation reaction and the treatment is not limited by space. Therefore, time and space are saved compared to natural carbonation.[5-10] In addition, the main culprit of the greenhouse effect, CO_2, is produced in many areas. Using CO_2 to accelerated carbonation is a significantly effective method from the perspective of CCS. The TG/DTA analysis of MSWI bottom ash results in Fig.9.

Fig.9. TG/DTA of MSWI bottom ash and carbonated MSWI bottom ash (99% CO_2 concentration, 1.0L/min CO_2 flow rate, 20°C reaction temperature, 10 dm^3/kg water-to-solid ratio, and a particle size <0.15 mm).



VI. Stabilization of MSWI bottom ash by carbonation process

Fig.10. Cu leaching concentration of MSWI bottom ash and carbonated MSWI bottom ash (99% CO_2 concentration, 1.0L/min CO_2 flow rate, 20°C reaction temperature, 10 dm^3/kg water-to-solid ratio)

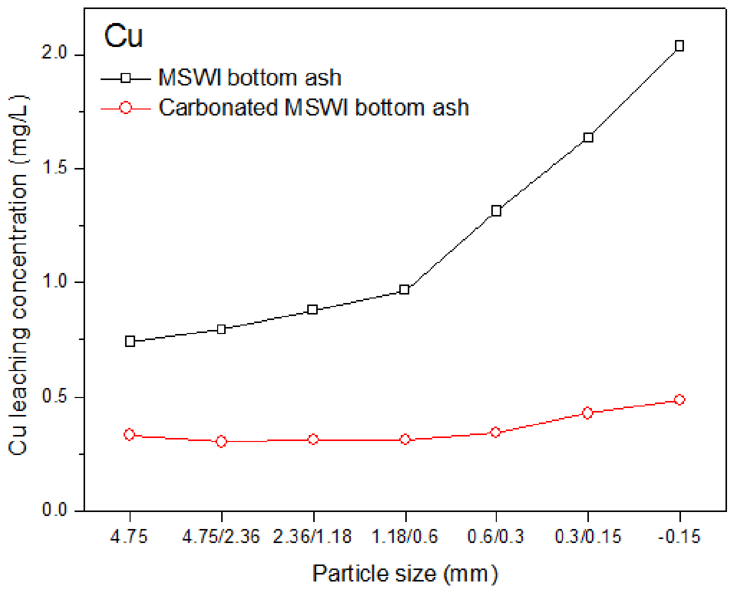
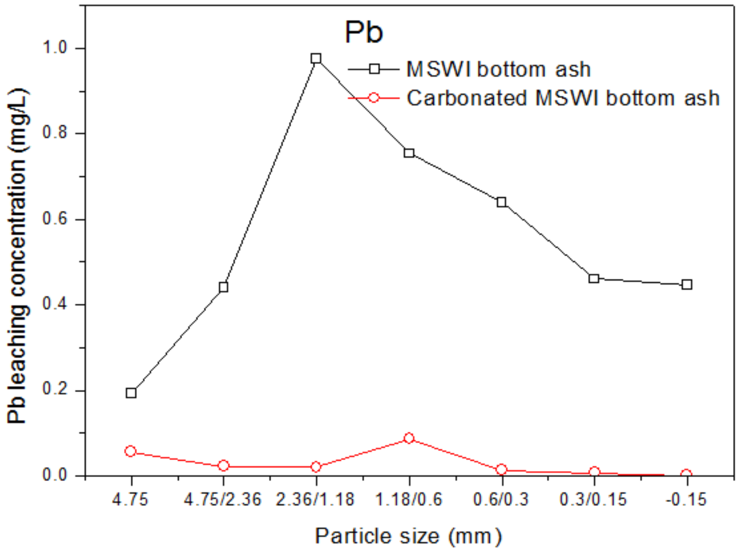


Fig.11. Pb leaching concentration of MSWI bottom ash and carbonated MSWI bottom ash (99% CO_2 concentration, 1.0L/min CO_2 flow rate, 20°C reaction temperature, 10 dm^3/kg water-to-solid ratio)



CONCLUSIONS

The study presents the brief idea about MSWI waste production in South Korea and waste management system and process for reducing green gas emissions and landfill problems. The accelerated carbonation treatment performed on MSWI bottom ash and stabilized the heavy metals by this process successfully.

To this regard, an additional washing treatment could be appropriated to remove salts from the material, especially if performed after a carbonation step. Accelerated carbonation treatment can be considered as potentially viable option in order to improve to reduce the CO_2 emissions from Waste.

ACKNOWLEDGEMENTS

This research was supported by a grant (2013) from the Energy Technology Development Program (2013T100100021) funded by the Ministry of Trade, Industrial and Energy of the Korean government.

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