CHEMICAL WEATHERING INDICES OF MSWI RESIDUES IN A LANDFILL

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1. INTRODUCTION

Municipal solid waste incinerator（MSWI）residues generated under relatively high temperature, usually were disposed in landfills in Japan. Under landfill conditions, the occurrences of weathering of MSWI residues were recognized. However, the proper weathering indices to estimate the weathering processes in a residues landfill have not been well studied yet. In this research, 9 chemical weathering indices of MSWI residues from two landfills were studied. The relations of weathering indices with depth were analyzed. Combined with the results of the mineralogical analysis, weathering potential index (WPI) was considered as an effective index for short term weathered MSWI residues. Isovolumetric geochemical methods were proved difficult to apply on boring samples at different depth due to the slight changes of density.

2. SAMPLING AND ANALYSIS

Two bore samplings were implemented at O landfill site located in northern Kyushu in Dec 2003 (Bore1 samples) and F landfill site located in Franklin, UNH, American in May 2004 (FL94 samples). The samples properties are shown in Table 1. The details of the samples analysis were described in the following papers (R. Zhang, 2004). In this paper, the total composition analyzed by XRF, mineralogical compositions analyzed by XRD, and density data were used to calculate the chemical weathering indices.

Chemical weathering indices are commonly used for characterizing weathering profiles by incorporating bulk major element oxide chemistry into a single metric for each sample. Generally, on homogeneous parent rocks, weathering indices change systematically with depth. Isovolumetric geochemical methods, which treat bulk density measurements as indicators of extent of weathering, have proven to be very useful for investigating uniform weathering profiles (Jason R. Price, 2001, 2003). Due to the heterogeneous, amorphous compositions and the complicated situation of landfills, it is necessary to study the proper indices for MSWI residues in a landfill. Calculation of 9 chemical weathering indices (see Table 2): Weathering Potential Index (WPI), Product Index (PI), Chemical Index of Alteration (CIA), Chemical Index of Weathering (CIW), Silica to Aluminum Ratio (R), Weathering Index of Parker (WIP), Vogt's Residual Index (V), Plagioclase Index of Alteration (PIA), and Silica-Titania Index (SIT) were conducted for the different depth core samples. Isovolumetric geochemical methods were applied as indicators of extent of weathering. Mineralogical compositions of the boring samples were used to assess the chemical indices.

Table 1 Boring core samples from the two landfills

Landfill name	Landfill depth(m)	Sampling depth(m)	Main compositions	Samples age (years)
O landfill	6-6.5	0m, 0.5m, 1m, 2m, 3m, 4m, and 5m	MSWI residues (99%)+incombustable waste (1%)	<3m, 2-3 yr.; >3m, 9-10 yr.
F landfill	9-10	0m, 0.5m, 1m, 2m, 3m, and 4m	MSWI residues	1-2 yr.

Table 2 Summary of Weathering Indices evaluated in this study *

Index		Formula	Ideal trend of index up-profile
WPI	Weathering Potential Index	$(100)(K_2O+Na_2O+CaO+MgO)/(SiO_2+Al_2O_3+Fe_2O_3+TiO_2+FeO+CaO+MgO+Na_2O+K_2O)$	
PI	Product Index	$(100)\ SiO_2/(SiO_2+TiO_2+Fe_2O_3+FeO+Al_2O_3)$	
CIA	Chemical Index of Alteration	$(100)[Al_2O_3/(Al_2O_3+CaO+Na_2O+K_2O)]$	Positive
CIW	Chemical Index of Weathering	$(100)[Al_2O_3/(Al_2O_3+CaO+Na_2O)]$	Positive
R	Silica to Aluminium Ratio	SiO_2/Al_2O_3	Negative
WIP	Weathering Index of Parker	$100[(2Na_2O/0.35)+(MgO/0.9)+(2K_2O/0.25)+(CaO/0.7)]$	Negative
V	Vogt's Residual Index	$(Al_2O_3+K_2O)/(MgO+CaO+Na_2O)$	Positive
PIA	Plagioclase Index of Alteration	$(100)[(Al_2O3-K_2O)/(Al_2O_3+CaO+Na_2O-K_2O)]$	Positive
STI	Silica-Titania Index	$(Al_2O3+K_2O)/(MgO+CaO+Na_2O)$	Negative

* The indices were calculated using molecular proportions of elements oxides

** The ideal trend of index (increase in weathering)

3. RESULTS

Total compositions and density

For the 2-3 years weathered residues from O landfill, when the weight loss and volume decrease for a unit weight samples were neglected, major compositions analyses (see Fig.1) indicated an accumulation of insoluble elements such as, Si, Al, Fe, and K and a loss of soluble elements, such as Ca, Na, and Mg at 1-2m depth. Around the water level, the insoluble elements had a sharp decrease due to the stronger leaching compare with the other samples. For the 1-2 years weathered residues from F landfill (see Fig.3), the total composition changes within near surface 0-2m had a similar trend with the samples from O landfill. Because there is no water accumulated in the landfill, so there is no special change around 3m depths. The density of the bore samples were around 2.6-2.8g/cm3, the weathering extent calculated by Isovolumetric geochemical methods didn't give reliable trends.

Chemical Weathering Indices

For Bore1 samples, V, CIA, CIW, and PIA had similar trends, R, STI, and PI had similar trends within the profile, however, WPI had a totally reversed trend with the V group indices (see Fig.2). However for the FL94 samples, except WPI, all the other indices had similar trends along the profile (see Fig.4). As the mineralogical analysis of the 1-2m samples by XRD showed some specific peaks at 2 θ <10° , which was identified as minerals generated after weathering and had a strong binding of Si. So WPI was considered as the suitable index for the short-term weathering MSWI residues.

4. CONCLUSIONS

Chemical weathering indices are important for the assessment of the weathering extent of MSWI residues in landfills, from the analysis of the two landfill boring samples, weathering potential index (WPI) was considered as an suitable weathering index for short-term weathering. However, because of the hetergeneou properties of the residues, the works include further mineralogical study to prove the chemical indices and the study of long-term weathering indices are necessary and will be conducted in the future.

REFERENCES

Jason R. Price, Michael A. Velbel. (2003) Chemical weathering indices applied to weathering profiles developed on heterogeneous felsic metamorphic parent rocks, *Chemical Geology* 202, pp. 397– 416.

Ruina Zhang, Shogo SAKITA, Takashi HARAGUCHI, Takayuki SHIMAOKA. (2004). Weathering processes of MSWI residues in a landfill, *2nd International Workshop on Earth Science and Technology*, pp.201-208

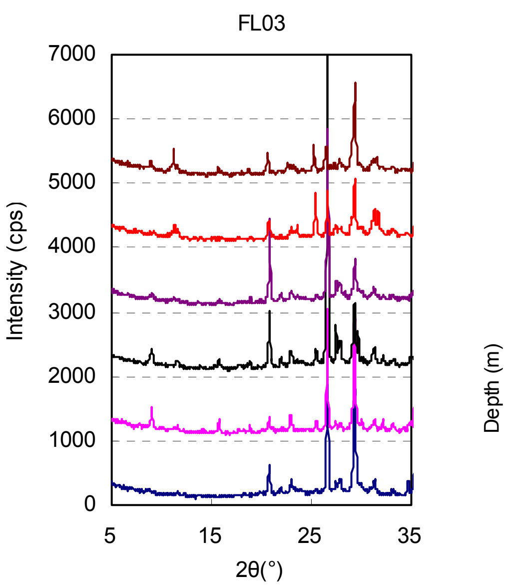

Figure 5 XRD analyses of the FL03 samples

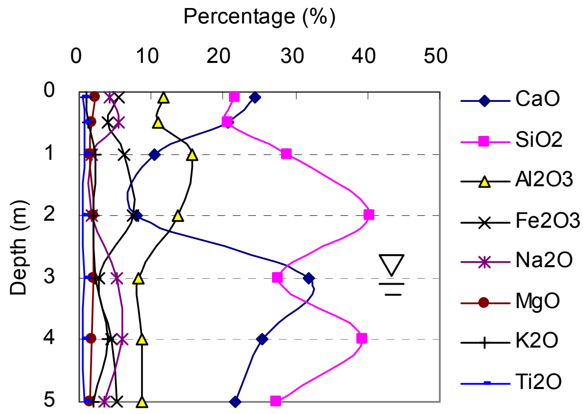

Figure1 Chemical analysis of Boring samples from Bore1 by XRF

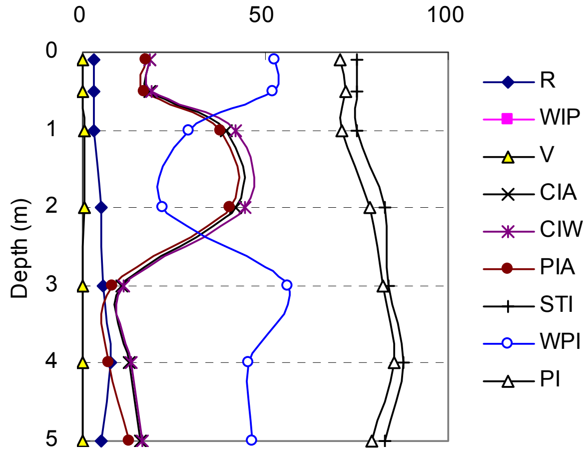

Figure2 Chemical indices for vertical profile of Bore1, O landfill

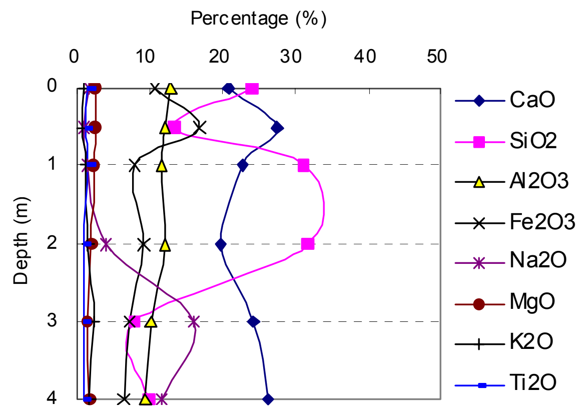

Figure3 Chemical analysis of Boring samples from BoreFL94 by XRF

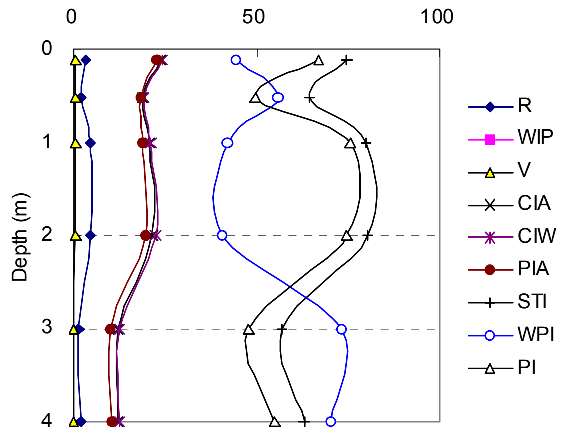

Figure4 Chemical indices for vertical profile of Bore FL94, O landfill