Leaching behavior of elements from municipal solid waste incinerator ash under natural environment: an experimental approach

Kyoko Saito[1]; Kosei Komuro[2]; Ken-ichiro Hayashi[3]

[1] Life and Environmental Sciences, Tsukuba Univ.; [2] Life Environment. Sci., Univ. Tsukuba; [3] Graduate School of Life and Environmantal Sci., Univ. Tsukuba

In order to clarify leaching behavior of elements from municipal solid waste incinerator ash under natural hydrogeological environment, simple leaching experiment analogous to natural hydrogeological environment for two typical municipal solid waste incinerator ashes, i.e., bottom ash and fly ash was conducted with mineralogical and chemical characterization for these ashes. In the leaching experiment, 100 mg of ash was sealed in the polypropylene bottle with 100 ml solution containing various reagents, and left at room temperature and pressure. For each ash, four series of experiments with changing reagents (distilled water, sodium bicarbonate: $1.0\text{x}10^{-2}$ mol/l, sulfuric acid: $5.0\text{x}10^{-4}$ mol/l and nitric acid: $1.0\text{x}10^{-3}$ mol/l at initial concentrations) were performed with changing the reaction periods from 1 to 32 days. For sulfuric and nitric acid series, the runs with changing concentration of acid (up to 0.63 mol/l at initial concentration) were prepared for understanding the effect of pH. The run products were filtered by 0.20 micrometers membrane filters, and the filtrated solution was analyzed by ICP and ICP-MS. Important conclusion derived from the present study is summarized as follows:

(1) In the analytical results of leachates from the series of experiments for bottom ash, pH and concentration of elements have remained fairly constant after a few days. The final pH values for the distilled water, sodium bicarbonate, nitric acid, and sulfuric acid are 10.8, 9.0, 9.5, and 8.7, respectively. The every leachate is enriched in Ca with higher concentration of Na and K. The leaching ratios of heavy metals such as Fe, Cu, Zn, and Mn are low.

(2) In the analytical results for fly ash, pH and concentration of elements have also remained fairly constant after a few days. The final pH values for the distilled water, sodium bicarbonate, nitric acid, and sulfuric acid are 11.8, 8.2, 11.7, and 10.6, respectively. The every leachate is extremely enriched in Ca with higher concentration of Na and K. The leaching ratios of heavy metals such as Fe, Cu and Mn are also low.

(3) In the runs of nitric and sulfuric acid series with changing concentration of acid, the leachates for acidic runs are enriched in Fe, Al, Cu, Zn, Mn, and Co, as compared to those for neutral and alkali runs, being well explained by chemical behavior of elements in solution shown in pH-Eh diagrams.

(4) Thermodynamic calculation for Ca-H_2O system indicates that pH and concentrations of Ca in the leachates of the runs with distilled water, sodium bicarbonate ($1.0\text{x}10^{-2}$ mol/l), sulfuric acid ($5.0\text{x}10^{-4}$ mol/l), and nitric acid ($1.0\text{x}10^{-3}$ mol/l) are well explained by the dissolution of portlandite which is the major constituent in both ashes.

(5) Considering that present rain water is acidic and that shallow groundwater contains various components such as Ca, Na and bicarbonate, the municipal solid waste incinerator ash at any disposal sites after public management is inferred to be exposed to acidic conditions, resulted in neutralization and removal of $Ca(OH)_2$ in the ashes, leading to increased leaching of heavy metals. Introduction and development of the appropriate management system or stabilization such as solidification of ashes, together with appropriate assessment of leaching behavior under natural hydrogeological environment are necessary for confirmation of the safety in the long term.