

A geochemical study on the saline waters circulating in an ash disposal pond of Seocheon Power Plant, Korea

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Abstract

This study was carried out to understand the geochemistry of saline water circulating in an ash disposal pond of Seocheon power plant, Korea. For this study, ash pond waters, slurry water and seawater samples were collected and analyzed for major ions and trace elements. Results show that ash pond waters and slurry water are alkaline in nature due to high calcium content, and have high concentration of Ca, B, Li, As, Ba, Al, Si and Mn over seawater, suggest that these elements leached from fly ash even at high alkaline condition and ionic strength. Slurry water has high concentration of B, Ba, Li, Mn, Si and Sr compare to ash pond waters, expresses that these elements seem to be easily reached at initial stage fly ash-water interaction, and also might be associated with the surface of the fly ash particles. Additionally, PHREEQC program predicted several secondary solid phases, which are also influenced in the leaching of elements in to the saline water.

Key words : geochemistry, saline ash disposal pond, Seocheon Power Plant, Korea.

1. Introduction

Research in coal ash has increased in the last three decades. Trace elements, enriched in the coal ash, are easily leaching into the aquatic environment and potential threat to the environment (Eary et al 1990; Mattigod et al., 1990). In Korea, the power plants located mostly in the coastal region due to the lack of freshwater availability for boiler coolants, and seawater is used for this purposes. This study was carried out to understand the geochemistry of saline waters circulating in an ash disposal pond of Seocheon Power Plant located in western coastal region of Korea. Ash pond waters, slurry water and seawater samples were collected from the study site for chemical analysis. EC, pH, Eh and DO were measured in the field, and major ions and trace elements were analyzed in the laboratory. PHREEQC was used for speciation calculations (Parkhurst, 1995).

2. Results and Discussion

The pH of the water samples varies from 7.4 to 8.9, indicates the alkaline nature. Earlier studies reported that fly ash with excess calcium over iron and sulphur produce alkaline nature (Thesis and Wirth, 1977; Ainsworth and Rai, 1987). Major ion concentrations of ash pond waters and slurry water are less than the sea water concentration except calcium, indicates that calcium seems to be more leaching or soluble compare to other elements. In the case of other major ions, these mostly present in the glass matrix, which would reduce the leaching of these elements (Mattigod et al., 1990). Moreover, high alkaline condition and ionic strength may also be the reason for the non-leachability of these elements (Khanra et al., 1998). In the case of trace elements, ash pond waters and slurry water contain high concentration of B, Li, As, Ba, Al, Si and Mn over seawater. However, the difference is not consistent in the case of Fe and Sr. Among the trace elements, Li and B show high concentration in the ash pond waters and slurry water followed by As, Ba, Al and Mn. The variations in the concentration of these elements seem to be depending on the leaching properties and occurrence in the fly ash particles (surface or glass matrix). Further, the concentration of Cd, Co, Cr, Cu, Ni, Pb, and Zn is observed below detection limit in the water samples. Slurry water has high concentration of B, Ba, Li, Mn, Si and Sr compare to ash pond water. This indicates that these elements are being reached at initial stage of fly ash-seawater interaction (Mattigod et al., 1990).

Saturation states were checked because the leaching of elements also can be regulated by the secondary solid phases (Mattigod et al., 1990). Calculated saturation indices indicate that the water samples are oversaturated with respect to calcite, aragonite, and dolomite, and undersaturated with respect to gypsum and anhydrite (Table 1). Similar observations were reported in earlier studies (Kirby and Rimstidt, 1994), and suggested that the calcium concentration likely to be controlled by gypsum or anhydrite and not by the carbonate minerals.

Table 1. Saturation indices of different type of waters (Selected minerals)

	Ap1	Ap2	Ap3	Ap4	Ap5	Sp	BMS	S-Wat	SW
Magnesite	0.5	0.4	0.6	0.6	0.6	0.6	0.6	0.0	0.7
Dolomite	1.7	1.4	1.8	1.7	1.8	1.8	1.7	0.6	1.8
Calcite	0.7	0.5	0.7	0.6	0.7	0.6	0.6	0.1	0.6
Anhydrite	-0.7	-0.7	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Gypsum	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.6
Aragonite	0.5	0.3	0.5	0.5	0.5	0.5	0.5	-0.1	0.4
Al(OH) ₃ (a)	-1.7	-1.5	-1.8	-1.7	-1.8	-1.8	-1.7	-1.4	-1.8
Gibbsite	1.1	1.4	1.0	1.1	1.0	1.1	1.1	1.4	0.9
Brucite	-3.1	-3.2	-2.8	-2.9	-2.8	-2.9	-2.9	-3.9	-3.1
Celestite	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7
Barite	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	0.3
Ferrihydrite	2.2	2.0	1.4	1.7	1.8	1.4	1.7	0.5	0.7
Goethite	7.5	7.4	6.8	7.1	7.3	6.9	7.1	6.0	6.3

Ap – Ash pond water, Sp – Settling pond water, BMS – Water collected before making slurry, S-Wat – Slurry water, SW – Seawater

Table 1 shows that water samples are oversaturated with respect to gibbsite and undersaturated with respect to amorphous $\text{Al}(\text{OH})_3$ minerals (Table 1). In the observed pH range ($7 < \text{pH} < 9$), Al concentration might be controlled by amorphous $\text{Al}(\text{OH})_3$ (Roy and Griffln, 1984; Fruchter et al., 1990), however, samples undersaturated with respect to amorphous $\text{Al}(\text{OH})_3$. In the case of Iron, it is generally less soluble at alkaline condition (Roy et al., 1984) and mostly incorporated in the glass matrix (Crecelius, 1980). Table 1 shows that water samples are oversaturated with respect to amorphous $\text{Fe}(\text{OH})_3$, which seems to be the controlling factor in the case of iron content. Similar observations were reported by Fruchter et al. (1990) and Mattigod et al. (1990). The water samples are oversaturated with respect to barite and undersaturated with respect to celestite. Earlier studies reported the similar observations (Fruchter et al., 1990; Lee and spears, 1997) and suggested that barite and celestite are not controlling the concentration of barium and strontium individually, where as they exit as a solid solution ($(\text{Ba}, \text{Sr}) \text{SO}_4$). In the case of Mn, it is generally not associated with surface of the fly ash particles and occurs in the magnetic fraction (Eary et al., 1990), which would reduce the leaching of this element. In the existing alkaline and oxidizing condition ($\text{pH} > 7$, $\text{Eh} > 15$), dissolution of manganese oxides likely to be reduced, and Mn exist as Mn(II) state. Like Mn, alkaline and oxidizing environment are also an important factors in the case of arsenic and it is occur mostly in the surface of the fly ash particles (Crecelius, 1980). Ash pond water and slurry water contain high concentrations of B and Li compare to other trace elements. B and Li might be present in the surface of the fly ash particles (Hulett et al., 1980). Hollis et al (1988) reported that boron was controlled by co-precipitation with CaCO_3 at alkaline condition.

3. Conclusions

A study was carried out to understand the geochemistry of saline water circulating in an ash disposal pond of Seochon power plant, Korea. Ash pond waters, slurry water and seawater samples were collected and analyzed for this study. Ash pond waters and slurry water are alkaline in nature due to high calcium content. Further, both ash pond waters and slurry water have high concentrations of Ca, B, Li, As, Ba, Al, Si and Mn over seawater, suggests that these elements leached from fly ash even at high ionic strength and alkaline condition. Additionally, slurry water has high concentration of B, Ba, Li, Mn, Si and Sr compare to ash pond water, which shows that elements occurrence in the fly ash particles (surface or glass matrix) and initial stage ash-water interaction seem to be the major factors regulating the leaching of these elements. The trace elements such as Cd, Co, Cr, Cu, Ni, Pb, and Zn are observed below detection limit; suggest that high alkaline condition and ionic strength would reduce the leaching of these elements into the saline waters. Despite, several secondary solid phases were predicted by PHREEQC program, which are also influenced in the leaching of elements into the saline water.

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