Arsenic Leachability and Speciation in Fly Ashes From Coal Fired Power Plants

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1. Introduction

Various trace elements such as arsenic are contained in fly ash (FA) generated from the pulverized coal combustion process. It is important to find leachability of arsenic from the fly ashes for various coal types to control the arsenic emission.

In this paper, arsenic leachability was investigated for various coal fly ashes collected from two different power plants. Effects of Ca and boiler types on As leachability were discussed.

2. Experimental

2.1. Fly ash samples

Six fly ash samples were carefully collected from each coal fired power plants (Unit A and Unit B: 600 MWe). Fig. 1 depicts the process flow of the plants, ash collection locations, and typical gas temperatures between the boiler exit and the low temeprature electrostatic presipipator (ESP). The burner type is different in both boilers. The unit B has a DeNOx (SCR) system.

To prevent contamination of samples, after enough time from coal switching, the ash sampling was began at each chamber (#1, #2, and #3).

Table 1 lists coal properties and ash composition. Coal F and G, and coal H and I were the same coal between unit A and B.

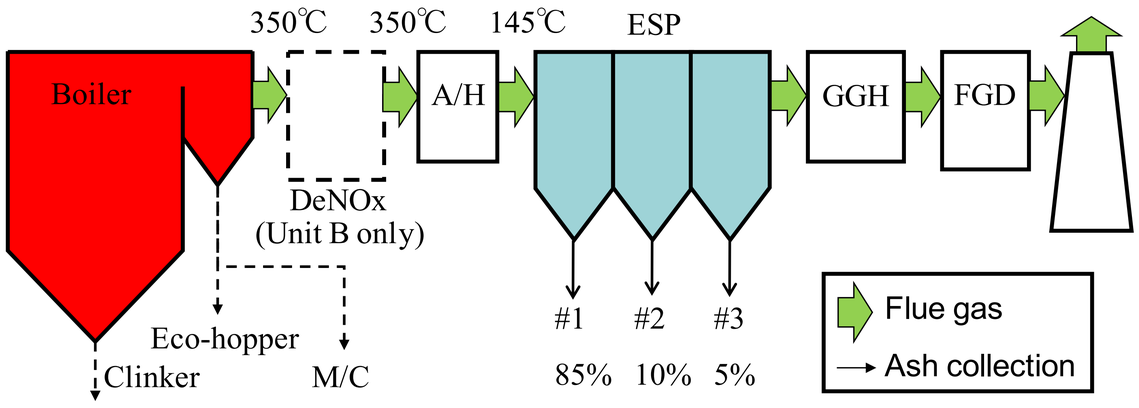


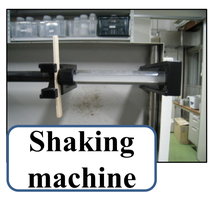
Fig. 1. Process flow of the coal fired power plants and ash collection points.

Table 1. Properties of raw coals and fly ashes collected from #1 chamber of ESPs.

Power station	Key	Raw coal (on dry basis) C wt%	Ash wt%	As mg/kg	Fly ashes (on dry basis) As mg/kg	SiO_2 wt%	Al_2O_3 wt%	Fe_2O_3 wt%	CaO wt%	Na_2O wt%	K_2O wt%	SO_3 wt%
Unit A	E	67.9	14.3	2.14	12.16	55.5	31.2	5.35	2.18	1.17	1.18	0.29
	F	71.5	13.3	0.84	3.16	67.0	26.2	2.26	0.68	0.26	0.60	0.24
	H	68.3	10.4	3.69	26.46	59.3	25.6	7.49	2.05	0.60	1.56	0.42
	O	69.6	9.7	1.45	15.65	75.7	17.2	2.79	0.97	0.47	0.94	0.00
	P	70.9	13.0	0.78	4.96	62.1	26.5	4.77	1.68	0.95	0.98	0.15
	R	76.5	9.5	0.88	8.23	62.6	28.7	3.86	0.93	0.45	0.69	0.00
Unit B	G	71.5	13.3	0.84	4.53	65.4	26.5	3.18	0.93	0.28	0.56	0.64
	I	68.3	10.4	3.69	39.22	59.0	26.0	7.25	2.09	0.65	1.50	0.51
	K	67.9	13.9	1.35	8.85	56.1	20.6	7.80	9.46	0.71	2.04	0.80
	L	73.1	10.3	0.87	9.46	58.1	21.4	6.40	8.24	0.83	1.86	0.84
	M	73.0	9.7	1.53	10.41	64.5	22.9	6.31	1.46	0.51	1.74	0.34
	Q	74.0	9.5	1.02	7.48	62.3	27.8	4.04	1.39	0.73	0.89	0.04

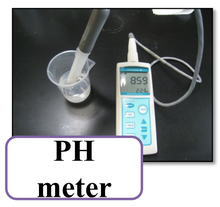
2.2. Leaching tests

●To simulate pH of the excess water, a buffer solution adjusted pH = 10 was prepared as a leaching solvent. The ash sample (1.0 g) was added to the leaching solvent (10 mL).



●The ash/solvent mixture was shaken for 30 minute at 200 rpm.

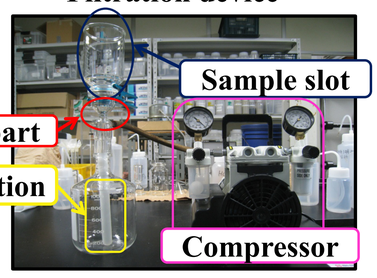
●After shaking, the solid and the solution were separated by filtration.



●The solid was dried for three hours at 107℃.

●Arsenic concentration in the solution was analyzed by ICP-AES.

●The solid composition was analyzed by XRF.



3. Results & Discussion

3.1. Arsenic concentration

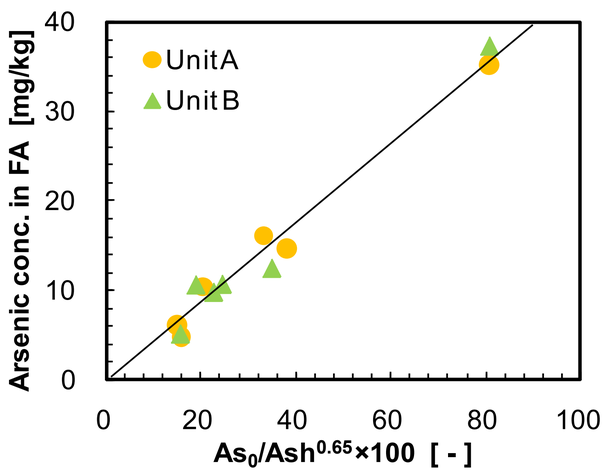


Fig. 2. Relation between modified As concentration in the raw coals and As concentration in the fly ashes for the unit A and B.

To compare arsenic partitioning in the unit A and B, relation between modified arsenic concentration in the raw coals, $[As_0/Ash^{0.65}]$, and arsenic concentration in the fly ashes, As_{FA}, is shown in Fig. 2. Where, As_0 and Ash are As concentration and ash content in the raw coals, respectively.

As_{FA} can be accurately estimated by $[As_0/Ash^{0.65}]$, and arsenic partitioning was same behavior between the unit A and B.

3.2. Arsenic leachability

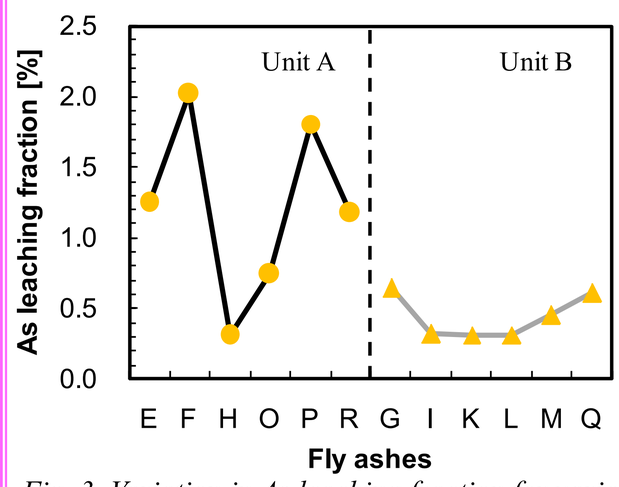


Fig. 3. Variation in As leaching fraction for various fly ash samples and for the unit A and B. (pH of the leaching solvent was fixed on 10.)

With the unit A, L_{As} was observed in the range of 0.3−3.0%, which was a wide range distribution comparing the unit B. Particularly, L_{As} of fly ash F and G (same coal) significantly differed. It clarify that arsenic leaching is affected by boiler types.

3.3. Dominant factors on As leachability

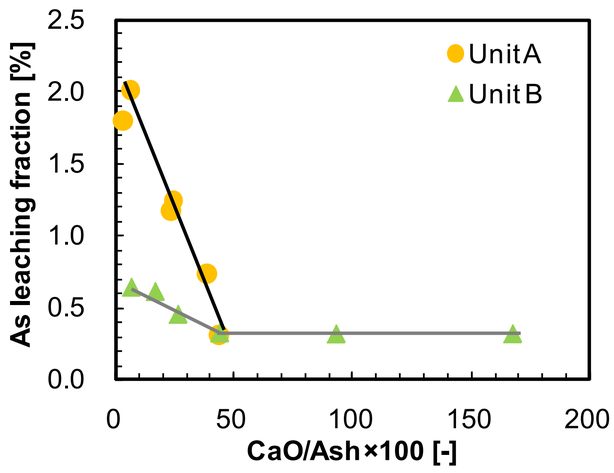
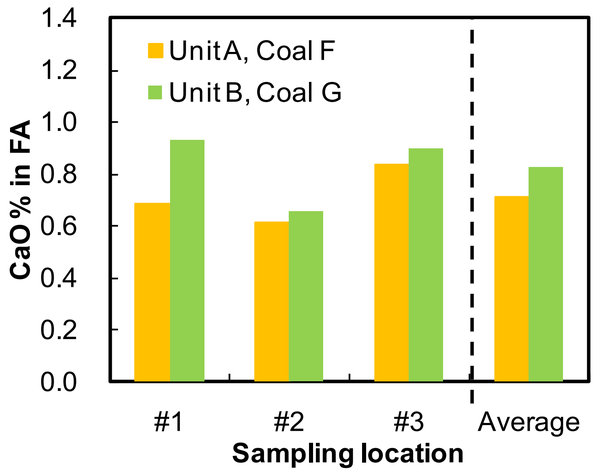


Fig. 4. Variation in L_{As}% as a function of CaO/Ash ratios for the unit A and B.

It was presumed that an arsenic chemical form was $Ca_3(AsO_4)_2$ in FA from the equilibrium calculation. Therefore, Ca and ash content are controlling factors on arsenic leaching.

Arsenic leaching fraction was correlated with *CaO/Ash ×100* . Arsenic leaching fraction of the unit A was higher than that of the unit B. The difference was 4 times at lower Ca content.



It found that the fly ash F from the unit A indicated low CaO% compared to the fly ash G from the unit B. Therefore actual CaO/Ash ratios of the fly ash F was much lower as shown in Fig4. It is supposed that high L_{As} of the fly ash in unit A is owing to the loss of calcium during combustion.

4. Conclusions

Arsenic partitioning in the unit A and unit B represented the same behavior. Most amount of arsenic in the raw coal associated with the fly ash for various coal types. However, arsenic leaching fraction of the fly ashes in the buffer solution (pH = 10) was strongly affected by coal types and boiler types. It was found that arsenic content, calcium content, and ash content were the dominant factors controlling As leachability.