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Published in:
Proceedings of the 13th Symposium on Electrokinetic Remediation

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Chen, W., Ottosen, L. M., Jensen, P. E., Kirkelund, G. M., & Schmidt, J. W. (2014). Electrodialytic removal of heavy metals from fly ash from co-combustion of wood and straw – influence from prewash. In *Proceedings of the 13th Symposium on Electrokinetic Remediation* (pp. 115-116)

Nº REF.: O659

Electrodialytic removal of heavy metals from fly ash from co-combustion of wood and straw – influence from prewash

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The heavy metal content in the fly ash from biomass combustion, such as straw, wood and sludge, often needs to be lowered before the ash can be used as fertilizer at agricultural land or in construction materials. In this study, fly ash from a boiler fueled with wood chips and straw was either treated directly by electrodialytic remediation (EDR) or a combination of prewash in water and EDR to lower the heavy metal content (Figure 1). Different experimental set-ups (Figure 2 under different experimental conditions in Table 1) were tested for treatment of the ash suspended in distilled water in order to investigate the heavy metal removal. The investigation focuses on Cd and Pb removal as these are the major problems in relation to the limiting values, but also other heavy metals are reported: As, Cr, Cu, Ni and Zn.

Prewashing caused an increase in total concentrations of most heavy metals compared to the ash before wash. This is because the high soluble fraction (around 80 %) is removed and thus the heavy metals are concentrated in the ash as these are generally little soluble in water.

After prewash, the limiting concentration of Pb (120 mg/kg) was exceeded. The concentration in the washed ash was not lowered sufficiently during EDR in a 3 compartment cell (Figure 2-a), but after treatment in the EDR cell with 2 compartments (Figure 2-b) the concentration met the requirement. The two compartment cell was probably better (Table 2) due to the fast acidification process. However, this fast acidification may in turn affect the leaching property of the treated ash, which has As, Se and Ni exceeding the limiting concentrations. Ni needs attention in the ashes treated in 3-compartment cell. The Cd concentration was reduced to below 2 mg/kg, no matter how high the concentration was before the treatment.

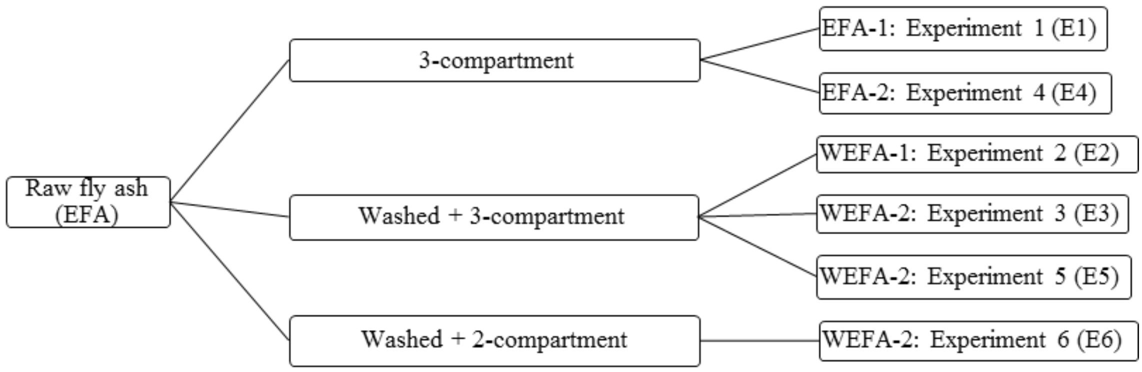

Figure 1. Experimental design.

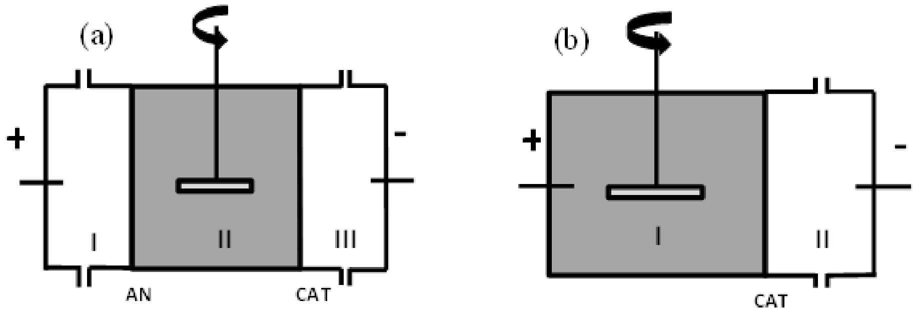

Figure 2. The schematic drawing of the types of EDR cells used in the experiments: (a) 3-compartment, and (b) 2-compartment. (AN: anion exchange membrane; CAT: cation exchange membrane).

Table 1. The experimental conditions.

No.	Sample	Current (mA)	EDR cell (compartment no.)	L/S (L/kg)	Duration (days)	Charge (Coulombs)
E1	EFA-1	50	3	7	14	60480
E2	WEFA-1	50 (Day 1)[1] to 10	3	7	~ 67	60480
E3	WEFA-2	10	3	7	70	60480
E4	EFA-2	50	3	7	10	43200
E5	WEFA-2	40	3	7	10	34560
E6	WEFA-2	40	2	7	10	34560

[1]The voltage between the two working electrodes went up to the maximum voltage of the power supply on Day 1, so the current was changed to 10 mA from Day 2.

Table 2. Cd and Pb removal from the EDR experiments.

		E1	E2	E3	E4	E5	E6
Cd	Removal efficiency[1],%	98	96	96	98	94	98
	Mass balance[2], %	91	102	100	106	105	93
Pb	Removal efficiency,%	67	18	25	48	12	47
	Mass balance, %	94	96	91	122	94	83

[1]The removal efficiency was calculated from the mass difference of the element in the ash before and after treatment divided by the initial mass in the ash.

[2]Mass balance was defined as the percentage of the total final mass of the element, found in all parts of the cell (electrodes, electrolyte, membranes, ash suspension), in its initial mass input from the ash.