CONVERTING IGCC FLY ASH IN AN INERT LANDFILLING MATERIAL

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ABSTRACT

Puertollano IGCC fly ash produced are characterised by a high water solubility of a number of trace elements, including As and Sb, that may be of a relevant environmental concern. Currently the whole production of the Puertollano IGCC fly ash is used in the cement industry with all environmental aspects covered in the process. Due to the strong economic crisis which primarily affects the construction sector in Spain, the cement consumption falls to the levels of 1963. This may results in a reduction of the fly ash use in the cement industry and the increase of fly ash lanfilling. Reducing As, Sb, and Ni leachability would be then mandatory for the landfilling of IGCC fly ash. Given the slightly acidic pH of IGCC fly ash, mixtures of IGCC fly ash with alkaline PCC fly ash was tested for neutralizing the pH and reduce the leachability of the As, Sb and Ni. Several PCC fly ashes (high and low Ca PCC fly ash, including that from Puertollano PCC plant) were mixed with different IGCC fly ash produced in different operational conditions and using different IGGC/PCC fly ash ratios according the fly ash production (80% PCC and 12% IGCC). A high decrease of the As, Sb, and Ni is reached when mixing with IGCC and PCC fly ash, attaining inert and non-hazardous ranges for lanfilling according the limits from 2003/33/EC Decision. The mixture with Puertollano IGCC and PCC fly ash need higher amount of PCC to reach the above ranges due to the lower Ca content.

1. INTRODUCTION

The 335 MW Puertollano IGCC power plant is the largest IGCC plant worldwide. It is fed with a mixture of a local high volatile bituminous coal rich in metals and semi-metals and pet-coke, supplied by an oil refinery. Limestone is added (2–4%) to the feed fuel blend as a fluxing agent. The gasification is carried out in a pressurized entrained flow gasifier working at 1200-1600^{o}C and 25 bars. The high slag/fly ash (FA) ratio and the high metal content of the local coal fed in the IGCC facility give rise to a rich metal and semi-metal FA, with high glass content (>97%) and a great variety of fine condensed reducing species (metal-sulphides and arsenides) [1]. When leaching the fine grain size results in a slightly acidic pH and fast oxidation of sulphides to sulphates and arsenides to arsenates giving rise to high extractable contents of As, Sb, and Ni, which exceed the limits of hazardous material for landfilling (Decision EU/33/2003)

Currently the whole production of the Puertollano IGCC fly ash is used in the cement industry. The potential increase of IGCC FA lanfilling in the near future due to the strong crisis in the construction sector in Spain may imply important environmental issues due to the high leachable potential of As, Sb, and Ni.

The main objective of the present work is to develop are methods for reducing leachability of As, Ni and Sb from IGCC FA at least down levels of non-hazardous material in view of potential landfilling, disposal in ponds or for its acceptable use in novel applications in the near future.

2. METHODOLOGY

Given the slightly acidic pH of IGCC fly ash, mixtures of IGCC fly ash with pulverised coal combustion fly ash (PCC FA) were made. Three different Puertollano IGCC FA, with different As, Sb, and Ni bulk content and leachability, were mixed with several PCC fly ashes of different lime content (Table 1) using IGCC/PCC FA ratios of 1:1 and 1:2. Subsequently the leaching test EN 12457 (desionised H2O single batch, L/S = 10 L/kg, 24 h agitation time) was subsequently applied to the mixtures. The pH of the resulting leachates was measured by conventional methods and the

concentration of major and trace elements by ICP AES and ICP-MS respectively.

3. RESULTS

The results of leaching tests applied to the IGCC/PCC FA mixtures are summarised in Table 2. A non-hazardous material may be achieved mixing IGCC FA with Lime-rich PCC FA at IGCC/PCC ratios of 1:2. High reduction percentages (96-99.9% reduction) of extractable potential of As, Sb, and Ni are achieved when mixing with lime-medium and lime-rich PCC FA.

Table 1. Characteristics of the IGCC and PCC FA samples selected for the tests.

IGCC FA	**bulk content**	**As, Sb, and Ni in FA leachability (%)**	
FA7	Low	Highest	
FA10	Highest	High -intermediate but highest concentration in ppm	
FA13	Intermediate	Lowest	
PCC FA	**lime content (%)**	**pH**	**Distance to IGCC plant**
Lime - poor	0.003	Neutral/acidic (6-7)	Metal -rich & close to IGCC plant
Lime - medium	0.2	Alkaline (11)	Far from IGCC plant
Lime - rich	0.5	Alkaline (12)	Far from IGCC plant

This reduction allows to As and Ni leachable levels below the non-hazardous limits for landfilling, but not for Sb (extremely low limit values in EU/33/2003 Decision).
The reduction of the leachability of As, Sb and Ni while from IGCC FA blend while increasing pH suggest the precipitation of insoluble (Ca, Mg) arsenates, antimoniates, and Ni hydroxide. Thus leachable Ca play more significant role than pH. The slight increase of Ni leachability at pH 12 is due to the formation of Ni complexes with OH [2].

Further investigations are needed to ensure an acceptable IGCC FA product for its landfilling, especially focused on the leachable potential of Sb.

Table 2. As, Sb, and Ni extraction yields (mg/kg) from IGCC and PCC FA blends

PCC FA	Lime-poor		Lime-medium		Lime-rich	
IGCC/PCC FA ratio	1:1	1:2	1:1	1:2	1:1	1:2
mg/kg			IGCC FA7			
As	86	59	0.2	0.3	0.1	0.1
Sb	86	60	0.9	0.4	0.6	0.4
Ni	3.9	0.5	<0.001	0.01	0.02	0.03
			IGCC FA10			
As	98	71	1.2	0.5	0.2	0.1
Sb	122	79	6.5	2.4	1.0	0.6
Ni	35	3.8	0.01	0.01	0.01	0.02
			IGCC FA13			
As	18	16	1.3	0.6	0.2	0.02
Sb	41	29	9.0	3.9	1.9	0.6
Ni	5.5	0.9	0.01	0.01	0.01	0.01

REFERENCES

[1] Font O, Querol X, Huggins FE, Chimenos JM, Fernández I, Burgos S, García Peña F. Fuel, 2005; 84, 11:1364-1371.

[2] Rotting T, Cama J, Ayora C, de Pablo J, Corina JL. Environ. Sci. Technol. 2006, 40, 6438-6443