Pacification of Fly Ash by the Geochemical Active Clay Sediments Processing

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The principal solid residues from the combustion of coal are bottom the fly ash. The latter contains large amounts of silicon, aluminium and calcium oxides and heavy metals and has been classified as hazardous material. Despite the fact that according to the literature fly ash can be used in a number of applications (Dwivedi and Jain, 2014; Yao *et al.*, 2015), in practice, most fly ash is disposed in special landfills for hazardous materials (at high cost). The main problem regarding fly ash management is the potential to release heavy metals and other hazardous materials to the environment. The present work presents a novel method for the stabilization of fly ash, through the Geochemical Active Clay Sediments (GACS) process, a process, which has been used for the treatment of a number of wastes, through the irreversible adsorption of various pollutants (Gikas, 2016a,b).

Fly ash from a hydroelectric plant, operating with lignite combustion, has been used for the experiments. The composition of the fly ash is shown in Table 1.

Table 1. Chemical composition (w/w) of fly ash, before and after treatment with the GACS process

Compound	Initial concentration (w/w)	Final concentration (w/w)
SiO_2	42.14	28.40
Al_2O_3	19.86	22.93
CaO	14.01	15.81
Fe_2O_3	13.04	10.43
MgO	2.64	3.16
K_2O	1.36	1.83
SO_4^{2-}	3.14	2.50
Na_2O	0.00	12.84
IL (Ignition Loss)	3.81	2.10
Total	100.00	100.00

The treatment process is of batch mode and comprises of two-stage reaction with geopolymer agents, assisted by the addition of acidification, oxidation and polymerization agents (Fig. 1).

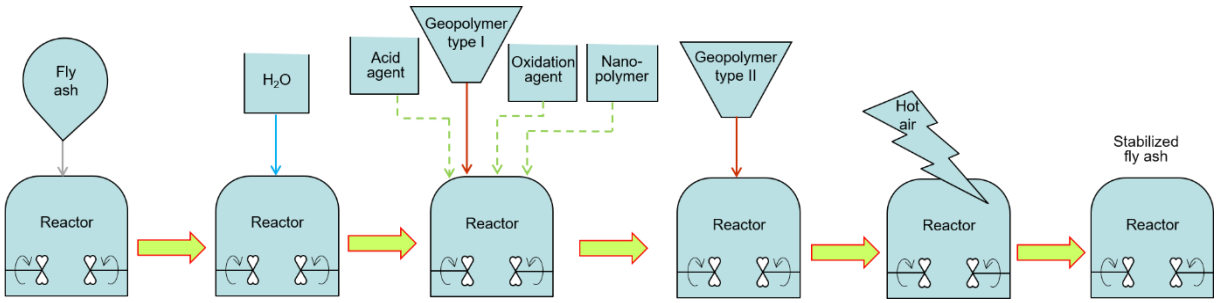

Figure 1. Batch sequence of the fly ash stabilization process, through the GACS process.

5 kg of fly ash have been used for the batch experimental trials. The sludge was initially moisturized by the addition of 5kg water. Then, the appropriate amount of geopolymer type I was added, along with acid solution nanopolymer and oxidation agent. The latter was used to ensure the complete oxidation of the fly ash components. The mixture was agitated for about 135 min. Then, geopolymer type II was added and the mixture was agitated for further 135 min. The product was dried by blowing hot dry air. The final composition of the fly ash, after treatment is shown in Table 1. After treatment with the GACS, the final product underwent leaching tests, according to the standards imposed by the 2003/33/EC Directive. The determination of the composition in the leachates was performed using XRD, FTIR and atomic absorption methods (Pecorini *et al.*, 2017).

Table 2. Concentration limits of the of various fly ash components at the leachate, according to the 2003/33/EC Directive, and the relative measured values, after the leaching and percolation tests

Compound	L/S = 2 L/kg		L/S = 10 L/kg		C_0 (percolation test)	
	Limit (mg/kg)	Measured (mg/kg)	Limit (mg/kg)	Measured (mg/kg)	Limit (mg/L)	Measured (mg/L)
Al	-	0.64	-	0.80	-	0.74
As	0.10	0.06	0.50	0.16	0.06	0.032
Ba	7.00	0.00	20.00	0.00	4.00	0.00
Cd	0.03	0.00	0.04	0.00	0.02	0.00
Cr (total)	0.20	0.11	0.50	0.27	0.10	0.093
Cu	0.90	0.10	2.00	0.10	0.60	0.11
Fe	-	0.46	-	0.37	-	0.19
Hg	0.003	0.00	0.01	0.00	0.002	0.00
Mo	0.30	0.08	0.50	0.09	0.20	0.16
Ni	0.20	0.19	0.40	0.33	0.12	0.075
Pb	0.20	0.00	0.50	0.00	0.15	0.00
Sb	0.02	0.00	0.06	0.00	0.10	0.00
Se	0.06	0.00	0.10	0.00	0.04	0.00
Zn	2.00	< 0.02	4.00	< 0.02	1.20	< 0.02
Cl^-	550	0.00	800	0.00	460	0.00
F	4.00	0.36	10.00	0.14	2.50	0.42
Phenol Index	0.50	0.00	1.00	0.00	0.30	0.00
TDS	2.500	1.900	4.000	3.400	-	2.800
SO_4^{2-}	560	480	1.000	980	1.500	1.105
DOC	240	0.00	500	0.00	160	0.00

From Table 2 it is obvious that all the parameters of concern, as they have been described by 2003/33/EC Directive are well below the limits. Thus, after the treatment with the examined GACS method, fly ash is stable, and can be classified a s non-hazardous material.

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