

Effect of Particle Size on Leaching

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Abstract—The disposal of coal ash as a by-product of Thermal power stations, results in significant Environmental problems. The leaching of coal ash during disposal is of concern for possible contamination. Coal is the most abundant and widely spread fossil energy resource in the world. Coal ash is a by-product of incineration of coal. More than 150 million tons of coal ash is produced annually worldwide from the combustion of coal in power plants. Coal ash is utilized in cement and construction industry. However, the rate of production is greater than the consumption. The unused coal ash is disposed into the holding ponds, lagoons, landfills and slag heaps. Disposal of huge amounts of coal ash in landfills and surface impoundments or its re-use in construction materials is of environmental concern. Lignite and sub bituminous coal ashes may have a higher amount of sulphate compounds than bituminous coal ashes. In order to study this chemical composition, particle size of coal ash and specific gravity test were conducted. Results showed that leaching occurs more in acidic condition.

1. INTRODUCTION

Leaching ability and environmental consideration

Coal ash is typically used in embankments, structural fills, and unbound or stabilized granular bases and sub-bases. Therefore, the dilution, fixation, and adsorption of trace elements that would occur if Coal ash were mixed with native soils are not expected. Leaching of metals during construction are still environmental issues associated with using Coal ash in encapsulated applications, such as asphalt pavement. Coal ash consists of the same chemical components as coal ash; therefore there exists the potential to leach trace elements. Because Coal ash has larger particles and less surface area per unit Volume, the potential to leach trace elements is reduced.

Batch test method covers a procedure for leaching of solid waste to obtain an aqueous solution to be used to determine the materials leached under the specified testing conditions. This test method provides for the shaking of a known weight of waste with water of specified composition and the separation of the aqueous phase for analysis. This test method is intended as a rapid means for obtaining an extract of solid waste. The extract may be used to estimate the release of certain constituents of the solid waste under the laboratory conditions.

If water contacts or passes through a porous media, each constituent present in the matrix dissolves into pore water at

some finite rate because there is no such thing as a completely insoluble material. Permeation of the contaminated pore water out of the porous matrix due to any driving force is called “leaching”. The contaminated water that is generated as water passes through a porous matrix is called “leachate”. The capacity of the waste material to leach is called its “leachability”. The leaching test may provide a reasonable approximation of environmental leaching behavior of coal Bottom Ash. In the study two leaching test were carried out i.e. batch leaching test and column leaching test. The leachate obtained from these tests were collected, stored and analyzed for various elements determination.

The component of coal ash varies significantly, which depends on the makeup of coal being burned. But all the coal ash includes some amount of silicon dioxide (SiO_2) both amorphous and crystalline and calcium oxide (CaO). Coal contains various trace elements in various quantities and during combustion process of coal they all get enriched as a result of carbon loss as carbon dioxide and trace elements get associated on the surface of ash particles due to evaporation and condensation. The characteristics of the coal used and the type of installations used for the generation of a coal ash have a direct influence on chemical and mineralogical composition of coal ash (Benito et al., 2001).

Coal ash (FA) is a by-product of the combustion of pulverized coal in thermal power plants. It is removed by the dust collection systems from the exhaust gases of fossil fuel power plants as very fine, predominantly spherical glassy particles from the combustion gases before they are discharged into atmosphere.

The size of particles is largely dependent on the type of dust collection equipment. The major chemical constituents in coal ash are silica, alumina and oxides of calcium and iron. Because of its fineness and pozzolanic and sometimes self-cementitious nature, coal ash is widely used in cement and concrete.

2. MATERIAL AND METHODOLOGY

The coal ash was collected from the Udupi Power Corporation Limited (UPCL). The coal used by UPCL is imported from Indonesia. UPCL has established 2 X 600 MW coal based

power project in Udupi district Karnataka. Class-c sub-bituminous coal is used and circulating fluidized bed boiler is used in UPCL.

Sl no	Experiment name	Referred code
1	Chemical composition	IS:1355-1984
2	Sieve analysis	IS:2720(Part IV)-1965
3	Batch leaching test	ASTM D 3987-06
4	p ^H	ASTM D4972-95a

3. METHODS OF DETERMINATION OF CHEMICAL COMPOSITION OF BOTTOM ASH: IS 1355-1984

SiO₂:

1g of Bottom ash is dissolved in approximately 20 ml of water and approximately 10 ml of conc. HCL, & is kept on heater & evaporated till dryness, for this dry powder, 5ml of conc. HCL and 30ml of water is added & kept for boiling. Once it is boiled, it is removed cooled & filtered using number 41 filter paper & series of washing is done to residue with help of hot water. The residue with filter paper is kept in platinum crucible, and ignited using electric burner and weight is recorded which gives SiO₂ the residue in platinum crucible is treated with Hydrofluoric acid, in order to remove silica impurities, which is present as additive.

R₂O₃:

To the filtrate, which is obtained from SiO₂, and approx. 1 spoon of Ammonium Chloride and 2-3 drops of methyl orange indicator is added which gives blood red colour. To this ammonia solution is added till colour changes to yellow & little excess of ammonia solution is added, till ammonia smell persists. Then boil for 2 min & filter using no.42 filter paper. Series of washing is done for residue with hot water. The residue with filter is ignited using burner weight gives R₂O₃.

Fe₂O₃:

The filtrate which is obtained from SiO₂ and approx. 1 spoon of Ammonia Chloride 2-3 drops of methyl orange indicator is added which gives blood red colour. To this, Ammonia solution is added till its colour changes to yellow & little excess of ammonia is added, till ammonia smell persists. Then boil it for 2 min and filter using No.42 filter paper. Series of washing is done to residue with hot water. The residue obtained with filter paper is dissolved in 10ml of conc. HCL and approximately 30ml of water & it is allowed to boil for further 10 min. Then filter it using No. 41 filter paper. Wash the residue with hot water many a times. Residue is ignited and weight is noted as Fe₂O₃. From sum of R₂O₃, Fe₂O₃ weight is subtracted and Al₂O₃ is determined.

CaO:

To the filtrate obtained from R₂O₃ conc. HCL is added, until colour turns pink. Then ammonia oxalate solution is added in excess until slit ammonia smell persists. Then solution is heated little bit & allowed to stand for one day in order to

precipitate CaO, then the solution is filtered through no.42 & series of washings is done with hot water for the residue in filter paper. The residue is ignited and weight is expressed as CaO.

MgO:

The filtrate obtained from CaO is evaporated. Nearly when 25% of the filtrate gets evaporated, the ammonia which is highly volatile will volatilize which is present in filtrate. Then for the solution some amount of dill. HCL is added until the color changes to pink, then for the filtrate 20 ml of diammonium

CaO:

To the filtrate obtained from R₂O₃ conc. HCL is added, until color turns pink. Then ammonia oxalate solution is added in excess until slit ammonia smell persists. Then solution hydrogen phosphate solution and 20ml of conc. Ammonium solution is added. The solution is kept overnight & is filtered through no.42 filter paper. The residue is ignited and weight is expressed as MgO.

4. METHOD OF DETERMINATION OF SIEVE ANALYSIS OF BOTTOM ASH- IS:2720(PART IV)-1965

Sieving is performed by arranging the various sieves one over the other in order of their mesh openings, the largest sieve being kept at the top and the smallest aperture sieve at the bottom. A receiver is kept at the bottom and cover is kept at the top of the whole assembly. The soil sample about 1000gm is put on the top sieve and the whole assembly is fitted on sieve shaking machine. The amount of shaking depends upon the shape and the number of particles. At least 10 minutes of shaking is desirable for sample with small particles. The portions of the soil sample retained on each sieve are weighed. The percentage of soil retained on each sieve is calculated on the basis of the total weight of the sample taken and from these results; percentage passing through each sieve is calculated.

5. BATCH LEACHING TEST

Description and Sample Preparation (ASTM D 3987- 06)

This test method covers a procedure for leaching of solid waste to obtain an aqueous solution to be used to determine the materials leached under the specified testing conditions. This test method provides for the shaking of a known weight of waste with water of specified composition and the separation of the aqueous phase for analysis. This standard does not purport to address all of the safety problems, if any, associated with its use.

Significance and use

This test method is not intended to provide an extract that is representative of the actual leachate produced from a solid waste in the field or to produce extracts to be used as the sole basis of engineering design. The intent of this test method is that the final pH of the extract reflects the interaction of the extractant with the buffering capacity of the solid waste.

Procedure

Initially 50gms of sample is dried in oven at 104oC for 20hrs and cooled to room temperature. For this sample 1000ml water is added and kept for agitation at 74.6rpm for 7hrs. Later mixture is allowed to settle for 5 min, bulk of the aqueous phase from the solid phase is separated by centrifugation. This liquid is again passed through Whatman No.42 filter paper to remove the suspended particles if any. This filtrate was collected and preserved for element analysis. Various analysis of leachate was carried out like pH, temperature and electric conductivity. Some elements like Fe, Pb, Cu, Ni, Mn, Cd, Cr and Co were analyzed by using AAS to understand the leaching behavior of Bottom Ash sample.

6. RESULTS AND DISCUSSION

Chemical composition of 1st week sample –

1st trail

Sl no	Compound name	Weight (gms)	Weight in %	Range in %
1	SiO ₂	0.70	70	20-70
2	R ₂ O ₃	0.12	12	-
3	Fe ₂ O ₃	0.008	8	4-10
4	Al ₂ O ₃	0.004	4	15-30
5	CaO	0.025	2.5	5-30
6	MgO	0.02	2	0-6

2nd trail

Sl no	Compound name	Weight (gms)	Weight in %	Range in %
1	SiO ₂	0.655	65.5	20-70
2	R ₂ O ₃	0.14	14	-
3	Fe ₂ O ₃	0.09	9	4-10
4	Al ₂ O ₃	0.05	5	15-30
5	CaO	0.031	3.1	5-30
6	MgO	0.015	1.5	0-6

Chemical composition of 2nd week sample –

1st trail

Sl no	Compound name	Weight (gms)	Weight in %	Range in %
1	SiO ₂	0.66	66	20-70
2	R ₂ O ₃	0.16	16	-
3	Fe ₂ O ₃	0.065	6.5	4-10
4	Al ₂ O ₃	0.095	9.5	15-30
5	CaO	0.019	1.9	5-30
6	MgO	0.008	0.8	0-6

2nd Trail

Sl no	Compound name	Weight (gms)	Weight in %	Range in %
1	SiO ₂	0.672	67.2	20-70
2	R ₂ O ₃	0.143	14.3	-
3	Fe ₂ O ₃	0.064	6.4	4-10
4	Al ₂ O ₃	0.079	7.9	15-30
5	CaO	0.026	2.6	5-30
6	MgO	0.019	1.9	0-5

Reference range taken from coal bottom ash in field of civil engineering

7. SIEVE ANALYSIS

Sieve analysis of 1st week sample (2 trails) -1000gms

Sieve size	Weight retained (1 st trail)	Weight retained (2 nd trail)
10 mm	44	54
4.75 mm	145	191
4 mm	44	51
2 mm	262	210
1 mm	307	112
425 µm	151	65
250 µm	18	50
125 µm	15	123
75 µm	6	69
Pan	6	72

Sieve analysis of 2nd week sample (2trails)-1000gms

Sieve size	Weight retained (1 st trail)	Weight retained (2 nd trail)
10 mm	31	7
4.75 mm	152	169
4 mm	41	75
2 mm	261	244
1 mm	309	160
425 µm	160	205
250 µm	30	9
125 µm	7	89
75 µm	5	26
Pan	4	8

8. BATCH LEACHING TEST

Category -1(4.75-1mm) SAMPLE 1

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
7.73	BDL	0.0299	BDL	BDL	BDL	0.0232

Category -1 (4.75-1mm) SAMPLE 2

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
7.53	BDL	0.0257	BDL	BDL	BDL	0.0119

Category -2 (425microns-PAN) SAMPLE 1

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
7.85	BDL	0.0320	BDL	BDL	BDL	0.0131

Category -2 (425MICRONS-PAN) SAMPLE 2

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
7.93	BDL	0.0274	BDL	BDL	BDL	0.0125

Category -3 (4.75-PAN) SAMPLE-1

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
8.42	BDL	0.0395	BDL	BDL	BDL	0.0255

Category -3 (4.75-PAN) SAMPLE-2

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
8.17	BDL	0.0285	BDL	BDL	BDL	0.0129

Category-2 (425microns-PAN) SAMPLE 2 @ACIDIC CONDITION

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
4.12	BDL	0.0418	0.0130	BDL	BDL	0.0530

Category-2 (425microns-PAN) SAMPLE 2 @ALKALINE CONDITION

P ^H	Pb	Cu	Fe	Ni	Cd	Cr
12.08	BDL	0.0254	BDL	BDL	BDL	0.0256

9. CONCLUSION

The metals in coal ash can be characterized into different fractions by the sequential extraction procedure. The operational species can help us to better understand the mobility and bioavailability of toxic metals in coal ash. However, more suitable and reliable interpretation is required and depends on further study in the future.

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