ANALYSIS OF LEACHATE BEHAVIOR IN DIFFERENT MIX RATIO OF MINE OVERBURDEN AND FLY ASH

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Abstract: Fly ash is a major problem for disposal. To solve such problems Ministry of Environment, Forest and Climate Change (GoI) issued various methods such as brick making, use in cement manufacturing, use in road making etc. In continuation of this efforts Ministry of Environment, Forest and Climate Change (GoI) has given approval to use fly ash for backfilling of opencast mines, stowing of abandoned mines and filling of low laying areas. But heavy metals found in fly ash—nickel, cadmium, arsenic, chromium, lead, etc—are toxic in nature. They leach into the surrounding soil and can enter food-chains, ground water. An experimental investigation has been carried out to convert fly ash in combination with another waste material for mining applications. This paper highlights leaching characteristics of the developed fly ash and mine overburden. Fly ash from a local unit and mine overburden from nearby mine, India were collected, characterized, mixed in different ratios. The leachate effluents collected from leaching study were analyzed for the metals, Ni, Cr and Pb by an atomic absorption spectrophotometer.

Key-words: *Fly ash, leachate, mine overburden.*

1. INTRODUCTION

During the combustion of pulverized coal in power stations more than 80% of the ash residue exits the furnace and dispersed in the combustion product gases and is designated 'fly ash'. This fly ash is removed from the furnace exit gases, either by electrostatic precipitators or bag filters, before the latter are vented to the atmosphere. The current annual production of fly ash worldwide is estimated around 600 million tons, with fly ash constituting about 500 million tons at 75-80% of the total ash produced [1]. In India, over 230 millions of tonne of fly ash are produced yearly. Fly ash has been considered as a "Polluting Industrial Waste" till about a decade back and was being disposed off in ash ponds occupying large areas of land [2]. But it has been reconsidered as a resource material over a period of time and is being widely used for manufacture of cement, part replacement of cement in mortar and concrete, manufacture of bricks, blocks. tiles, roofing sheets and other building components, construction of roads /embankments, reclamation of low-lying areas, back-filling of mines, agriculture and related application, etc. In all of this backfilling and stowing of mine voids has highest consumption capacity of fly ash. This is the reason for which Ministry of Environment, Forest and Climate Change (GoI) has given approval to use fly ash for backfilling of opencast mines, stowing of abandoned mines and filling of low laying areas in compulsory mode for thermal plants located near by mines area. But this idea also comes with another environmental problem i.e. leachate generation. Leachate is a toxic mixture of heavy metals that is found in fly ash and percolates from backfilled area with fly ash. It can contaminate ground water and may results serious health hazards. In the present paper, utilization of fly ash in India in the fields of mine back filling is reviewed. The aim of this study is to understand leachate behavior in different mix ratio of mine overburden and fly ash.

2. METHOD

The column test is run in up-flow mode. The leachate is de-mineralized water (DMW). The test material should have a particle size < 4 mm. This procedure addresses both inorganic and organic contaminants. Column leaching tests are considered as simulating the flow of percolating groundwater through a porous bed of granular material as shown in figure 1. The flow of the leaching solution may be in either down-flow or up-flow direction and continuous or intermittent. The flow rate is generally accelerated when compared to natural flow conditions. However, it should be slow enough to allow leaching reactions to occur. A basis assumption in column leaching is that the distribution of the leaching solution is uniform and that all particles are exposed equally to the leachate solution. Precipitation or sorption within the column may affect the results. Column experiments more closely approximate the flow conditions, particle size distribution and pore structure, leachate flow, and solute transport found in the field (3). Column experiments can be conducted in both saturated and unsaturated conditions. Unsaturated conditions are usually intended to mimic vadose zone placement. Intermittent addition of a given volume of leachate solution at the top of the column can provide uniform distribution of the fluid and approximate a constant fluid front moving through the unsaturated column. Saturated columns are obtained by a constant fluid flux and allowing the fluid to pond at the top of the column. Variables, such as leachate collection, sampling frequency, leachate flow rate, and duration of the experiment are determined by the experimental objectives (4). In a report to EPRI, static (batch) and dynamic (column) methods were compared. Based on a review of the literature, batch systems tend to be inexpensive, simple, and they generate chemical data for mechanistic applications. Column methods are more expensive and more operationally complex, but they generate results that reflect real systems subject to fluid flow and solute transport.

Continuous column leach tests are typically conducted by filling a length of pipe or tubing with a solid sample and continuously passing water (or another leachate) through the sample for a specified period. Leachate samples can be collected at any desired frequency and analyzed for any constituent of interest. There are many variables in column leach test design, including:

- Column length and diameter
- Flow type (forced flow from bottom or gravity flow from top)
- Flow rate/residence time
- Sample pretreatment (particle size reduction, oxidation, bacterial inoculation)
- Leachate composition (water or other reagent to remove O2, etc.)

Column tests are well-suited to determining the concentrations of constituents that can be released over a relatively small number of pore volumes, which corresponds to shorter time periods. The design of a typical column leach test apparatus is depicted in Figure 1.

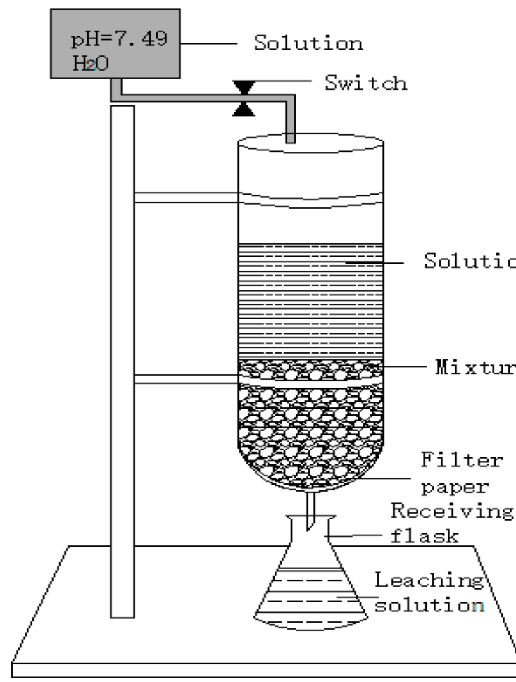

Fig.-1: Typical arrangement of column test

Samples of mine overburden were in boulders form which are crushed and sized to suit column test. For this study fly ash and mine overburdens were mixed in different ratio and separate column tests were performed for each mixture. The samples are allowed to mix with demineralized water so that it mix thoroughly and leachate can be produced. For the purpose of the same test duration is kept for approximately 7 days. The setup for column test is shown in figure 2. The leaching effluents coming out from specimens through the outlet of the permeability moulds were collected. The leachate samples were analyzed for the metals Pb, Ni and Cr by an Atomic Absorption Spectrophotometer.

Fig-2: Laboratory setup for column test

The sample of fly ash was collected from nearby local thermal power plant and sample of mine overburden was collected from near by mines area. The samples were collected in a manner that they represent to whole volume. The chemical composition of and physical properties of fly ash and mine overburden are represented in table 1 and table 2 respectively. After observation of chemical composition of fly ash and mine overburden it is found that major chemical component are silica, aluminum and iron. However, from physical composition it is found that silt is major component in fly ash and overburden both.

Table-1: Chemical Composition of Mine Overburden and Fly Ash (Weight %)

Constituents	Mine Overburden	Fly Ash
SiO_2	47.5	51.5
Al_2O_3	31.2	34.6
Fe_2O_3	8.0	5.78
CaO	1.35	0.52
K_2O	0.41	1.21
MgO	1.45	0.49
TiO_2	0.76	3.3
Na_2O	0.2	0.21
LOI	9.13	2.39

Table-2: Physical Composition of Mine Overburden and Fly Ash

Property	Mine Overburden	Fly Ash
Specific Gravity	2.3	2.18
Clay (<0.002 mm)	13.5	2.95
Silt (0.075 mm to 0.002 mm)	42.8	75.06
Sand (4.75mm to 0.075 mm)	30.36	21.99
Gravels (>4.75 mm)	13.34	---

3. RESULT

The analysis of leachates from different mixtures gives results as shown in table 3.

Table-3: Leachate Analysis After 7 Days of Flow

Mix Ratio in %		Metal (PPM)		
Overburden	Fly Ash	Pb	Ni	Cr
60	40	0.236	0.041	0.729
70	30	0.201	0.032	0.410
80	20	0.136	0.025	0.225
90	10	0.078	0.0072	0.143

Based on above results we can get a picture of leachate behavior in different overburden and fly ash mix ratio, which is presented in figure 4.

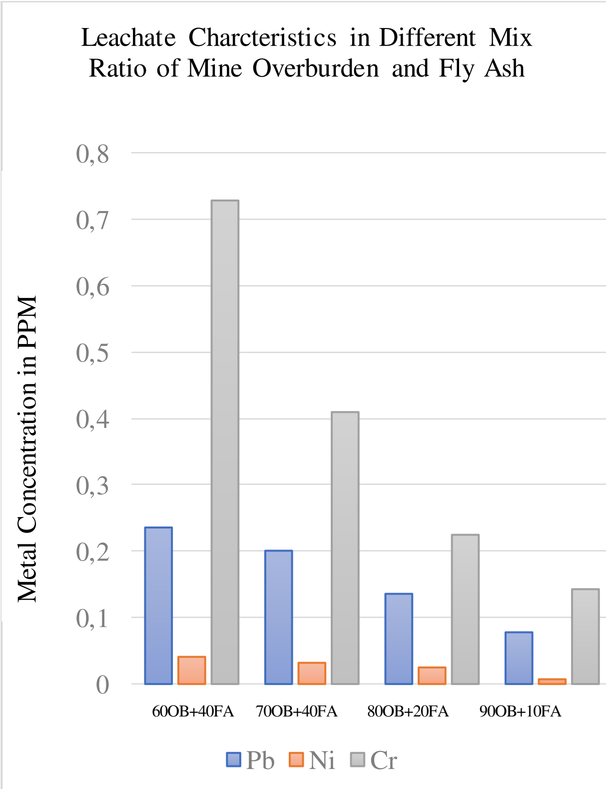

Fig-4: Leachate Characteristics in different mix ratio of mine overburden and fly ash

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4. DISCUSSION

Based on this study and after analyzing of results and leachate behavior following points are observed:

1. With increasing percentage if mine overburden in mix toxic metal compounds are decreasing.
2. Chromium having highest concentration among studied toxic metals.
3. Nickle having lowest concentration among studied toxic metals.
4. All metals presented in leachate are below the threshold limit. Threshold value for maximum contaminant level is considered as 100 times the allowable limit reported elsewhere [5], [6].

5. CONCLUSION

After getting results from this study, it can be concluded that the leachate toxicity is decreasing with increasing percentage of mine overburden. To get optimum mix ratio for lowest toxic leachate generation ground conditions, availability of mine overburden and fly ash, cost of transportation of fly ash etc. should be considered. This study shows that mix ratio of mine overburden (above 60%) and fly ash can be used for backfilling of mine voids as concentration of Pb, Ni and Cr are well below the threshold limit. Authors of this paper also suggest further study to find additives in mix ratio of mine overburden and fly ash which can minimize toxicity of leachate.

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