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Fly Ash Residue Revolution: Environmental Evolution of Leaching Trash Elements

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Abstract
Coal occupies an important position in India. Combustion of coal to produce electricity produces singnificant quantities (>120 million tonnes) of coal ashes particularly fly ash which accumulate in on-site piles and ash ponds leading to severe environmental challenges, particularly contamination of ground and surface waters due to leaching of trace elements. This study addresses the long-term leaching of trace elements from fly ash from some thermal power plants in Rajasthan(India). The aim of this work is to provide the basic scientific data for bulk utilization of fly ash and for reducing environmental pollution. Environmental assessment through open column percolation experiments carried over eighteen months envisaged that fly ash is environmentally benign as there does not occur significant leaching of trace elements.
Keywords: *Fly ash, Trace Elements, Leaching Studies, Open Column, Percolation Experiment*

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I. INTRODUCTION

India is the second most populous country in the world and it is expected that its population would reach 1.15 billion by 2010 (US Census Bureau, 1999). With the population showing sharp rise and modernization taking its hold in the every nook and corner of the society, the demand of electricity has also shown a sharp increase. Coal is the prime source of electricity generation and it accounts for about 70% of electricity generation (Anon, 2001/02). Indian coal is rich in ash content containing ash between 30-60%.

Most of the power plants in India follow the wet system of disposal. In this system of disposal, fly ash collected in the hoppers is taken to the collector tank where it is mixed with water to form slurry and via pipeline sent to the disposal ponds called ash ponds. In India, annual generation of coal ash is about 110 million tonnes from more than 70 thermal power stations of which about 80% is fly ash and rest is bottom ash. By the year 2012, this is predicted to increase to 175 million tonnes per annum (Ministry of Power, 2007). Disposal of such a huge quantity of coal ash is a major problem from environmental point of view. Such a huge quantity of coal ash, besides having several environmental implications of its own, demands for huge tract of land for its disposal. In India nearly 65,000 acres of land is needed for the disposal of coal ash (Sharma, Mansavi et. al., 2001. Maiti, et. al., 2005). Contamination of surface and groundwater due to trace metal leaching in the disposal environment is one of the major problems associated with the holding of coal ash in the ash ponds (Singh, 2000, Bhatnagar, 2011). Utilization of the fly ash is the prime need and is approached for from the view point of resource conservation and minimal disposal (Singh, 1996, Singh, 2005).

II. EXPERIMENTAL METHODOLOGY

SAMPLING

The study area includes two coal-based thermal power plants in Rajasthan. Standard sampling methods were used for collecting fly ash (FA 1 and FA 2). The samples were collected on five different days and a final homogenized sample in each case was prepared while mixing appropriate portions.

OPEN COLUMN PERCOLATION EXPERIMENTS

In open column percolation experiments, diionised water is percolated through a packed column of fly ash in the presence of oxygen at a rate, which depends on the natural permeability the material. The open columns for leaching experiments were made of PVC pipes 10 cm in diameter and 60 cm in length. The column set-up involved packing of the fly ash at an optimum moisture and density conditions as determined by the proctor test. Each packed material was sacrified, by lightly scraping the top with a long thin rod to ensure proper interlocking of the material. The top 7.5 cm of the column was left unpacked to allow for addition and maintenance of the leaching medium. About 200 ml of leaching medium (diionised water) was added to the top of the column once every alternate day to maintain sufficient supply of water to the packed fly ash material. The top end of the column was exposed to the atmosphere and the bottom end was connected to quarter inch tubing. The columns discharged the leachates through this tubing into 250 ml polypropylene beakers. The leachates were collected in these beakers and analysed.

ANALYSIS OF THE LEACHATE SAMPLES

The leachates from open column percolation experiments were subjected to potentiometric and elemental analysis.

Potentiometric Analysis of Leachates

The leachats collected from open column percolation experiments were potentiometrically analyzed for pH, Conductivity and TDS. The insturments were first calibrated with solution of the known concentrations and then the samples were taken for analysis.

Elemental Analysis of Leachates

The leachates after potentiometric analysis were filtered and poured into the polypropylene sampling bottles and then acidified with 2 ml of HNO_3. The leachates were then stored in a refrigerator at 4°C until further analysis. Analysis of trace elements was carried out as per American Public Health Association (APHA, 1985).

III. RESULT AND DISCUSSION

The summarised results of the leachate analysis using open column percolation experiment are presented in Table 1 along with the comparison with the Indian Standards for effluent discharge in the Inland Surface Water and On land for Irrigation (IS:2490).

The pH of leachates of FA1 and FA2 varied from 6.82 to 8.49 and 7.12 – 9.01 respectively. Leachates from FA1 and FA2 were mostly neutral to alkaline in nature. Comparison with IS:2490 shows that the pH is well within the permissible limit. This indicates that the leachates from the fly ash when getting discharged into the surface water bodies are not likely to cause any pollution problem from pH point of view.

In the initial stages of leaching, conductivity was observed to be maximum at 2.042 and 1.982mmhos/cm of FA1 and FA 2 respectively. In both the cases, the conductivity decreases with time. The total dissolved solid (TDS) varied from 74 – 890 ppm and 66 – 884 ppm in case of FA1 and FA2 respectively. The TDS content is within the permissible limit of 2100 mg/L as per IS:2490. Initial higher values of conductivity and TDS are due to the washout of the surfacial elements. As the surfacial elements got washout, the values of conductivity and TDS were found to decrease.

Elemental analysis of leachates with respect to twenty three elements were carried out and summarized results along with IS:2490 are presented in Table 1. Nine elements namely magnesium, calcium, sodium, potassium, iron, lead, zinc, manganese, and copper were observed to be leaching during the study period. Others such as chromium, nickel, cobalt, cadmium, selenium, aluminium, silver, arsenic, boron, barium, vanadium, antimony, molybdenum and mercury below the detectable limit in the entire study period. Elements such as magnesium, sodium, calcium and potassium were observed in the leachates in the entire study period. Their concentration, however, decreased considerably in the long run. Elements such as iron, lead, copper, zinc and manganese did not show regular leaching trend. Manganese and copper showed initial regular leaching, the intermittent leaching and finally reduced to BDL. Iron, lead and zinc showed intermittent leaching behaviour. Comparison with IS:2490 for Effluent Discharge in Inland Water Bodies shows that the concentration of all the elements under study in the leachates were well within the permissible limits and so the leachates discharged to surface water bodies will not cause any contamination of surface water bodies.

Table 1: Summary of the Leachate Analysis (Open Column Percolation Experiment) of Fly Ash Samples

Parameter	FA 1	FA 2	IS:2490, 1981	
			Inland Surface water	Onland for Irrigation
pH	6.82–8.49	7.12–9.01	5.5–9.0	5.5–9.0
Conductivity	0.174–2.042	0.144–1.982	–	–
TDS	74–890	66–884	2100	–
Iron	BDL–1.678	BDL–0.998	–	–
Lead	BDL–0.380	BDL–0.436	0.1	–
Magnesium	BDL–40.00	0.06–38.36	–	–
Calcium	1.74–48.0	1.120–68	–	–
Copper	BDL–0.070	BDL–0.980	3	–
Zinc	BDL–0.364	BDL–0.246	5	–
Manganese	BDL–0.078	BDL–0.094	–	–
Sodium	4–52	2–51	–	60
Potassium	3–46	4–44	–	–
Chromium	BDL	BDL	2	–
Nickel	BDL	BDL	3	–

Cobalt	BDL	BDL	–	–
Cadmium	BDL	BDL	2	–
Selenium	BDL	BDL	0.05	–
Aluminium	BDL	BDL	–	–
Silver	BDL	BDL	–	–
Arsenic	BDL	BDL	0.2	2
Boron	BDL	BDL	2	2
Barium	BDL	BDL	–	–
Vanadium	BDL	BDL	–	–
Antimony	BDL	BDL	–	–
Molybdenum	BDL	BDL	–	–
Mercury	BDL	BDL	0.01	–

BDL– Below Detectable Limit, Concentration of Elements in ppm, TDS in ppm, Conductivity in mmhos/cm.

IV. CONCLUSION

From the long-term leaching study it is found that fly ash leachates as generated from open column percolation experiments as such do not pose any adverse environmental impact in its disposal system. This open column percolation experiment closely resembles coal ash leaching in the field. In the column there are chances that the material will develop preferential pathways for the water due to cracks. This possibility exists in the field too.

Overall, fly ash does not seem to pose any environmental problem during its utilization and/or disposal and can be used in a benign manner for various purposes. As a bulk utilization, it can be used for mine backfilling, and this way putting back the material from where it came can solve the problem of disposal.

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