Different Leaching Methods for Coal Combustion Residue

Radha Rani[1] and Manish Kumar Jain[2]

[1]*Junior Research fellow*
Department of Environmental Science and Engineering
Indian School of Mines, Dhanbad-826004, Jharkhand, India
[2]*Department of Environmental Science and Engineering*
Indian School of Mines, Dhanbad-826004, Jharkhand, India

Abstract: Disposal of Coal combustion residue (CCR) generated during the combustion of pulverized coal in coal-fired power stations is a big environmental issue. Huge amount of fly ash (FA) is generated annually from burning pulverized coal in thermal power plants (TPPs) in India and worldwide. Its production has been increased from 40 Mn T/yr in 1994 to about 220 Mn T/yr in 2012 in India. It is projected to be 350 Mn T/yr in 2017. The fly ash generation is expected to grow further as coal would continue to remain as major source of energy. The fly ash contain toxic metals much higher concentrations than soil background levels that can be released into the environment through coal combustion processes. Some of the problems associated with fly ash are huge amount of land required for disposal and toxicity associated with heavy metal leached to groundwater. There are more than one hundred leaching methods applied to the characterization of fly ash by using them we assess the use of fly ash in a variety of sectors. But there is no agreement on which method is most appropriate to estimate the environmental consequences of the use or disposal of fly ash. This review provides an extensive look at the four types of leaching methods assess the leaching behaviour of fly ash: (i) Batch leaching tests (ii) Toxicity Characteristic Leaching Procedure (TCLP) (iii) Column/flow-through and (vi) Acid extractions.

Keywords: Coal combustion residue (CCR), Thermal power plants (TPPs), Fly ash (FA), Coal, Leaching.

1. INTRODUCTION

Dependence on coal based thermal power plants for electrical generation causes ongoing environmental challenges worldwide. Burning pulverized coal in thermal power plants (TPPs) generates large amounts of fly ash (FA) that must be disposed off or otherwise handled, in an environmentally sound manner [1]. Since wide scale coal firing for power generation began in the 1920s [2]. Coal fly ash (CFA) is generated during the combustion of pulverized coal in coal-fired power stations; as such it is an industrial by-product that if not put to beneficial use, is a recognized environmental pollutant [3]. It's generation in the country has increased from 40 Mn T/yr. in 1994

to about 220 Mn T/yr in 2012. It is projected to be 350 Mn T/yr in 2017, 500 Mn T/yr in 2022 and 1000 Mn T/yr in 2032. The fly ash generation is expected to grow further as coal would continue to remain as major source of energy.

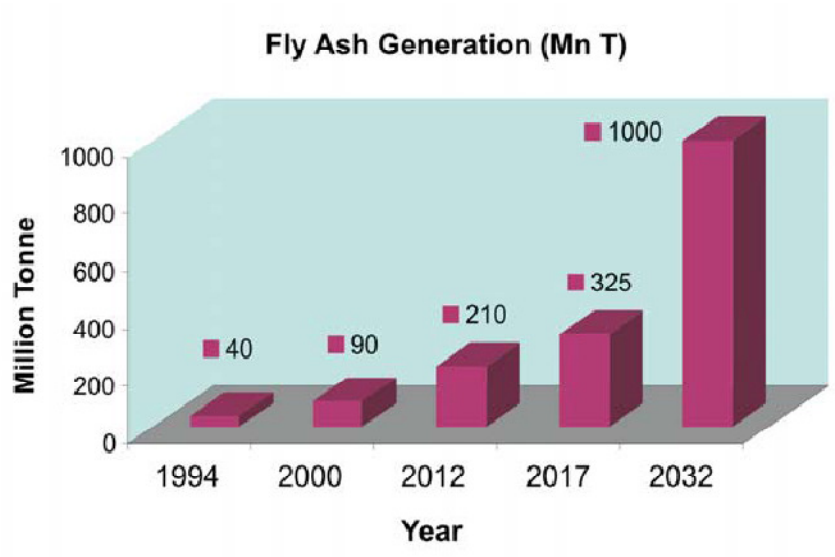
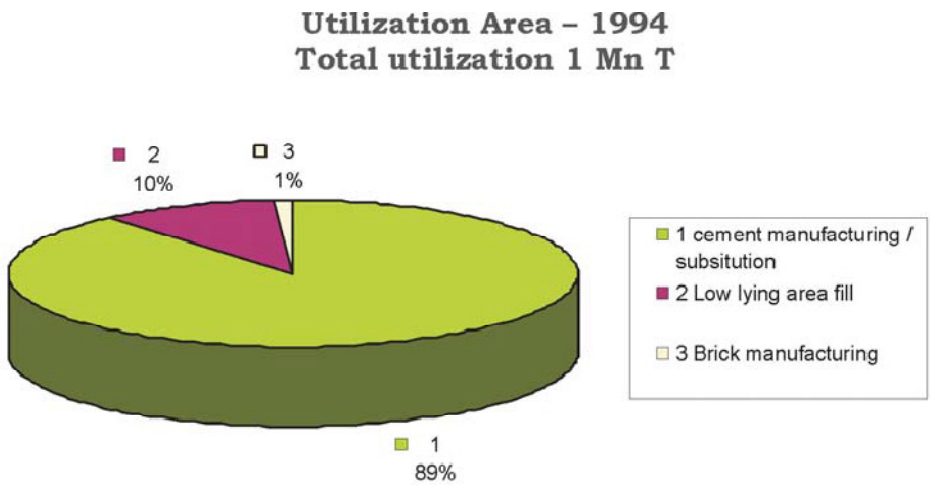


Fig. 1 Fly ash generation at different years in India (DST 2012-2013)

It has been proved to be a useful material with collective efforts initiated under Fly Ash Mission of Govt. of India (1994) [4]. The problem of FA disposal is only expected to get worse as the demand of energy grows. Overall production and utilization status of the fly ash has been illustrated in fig (2).



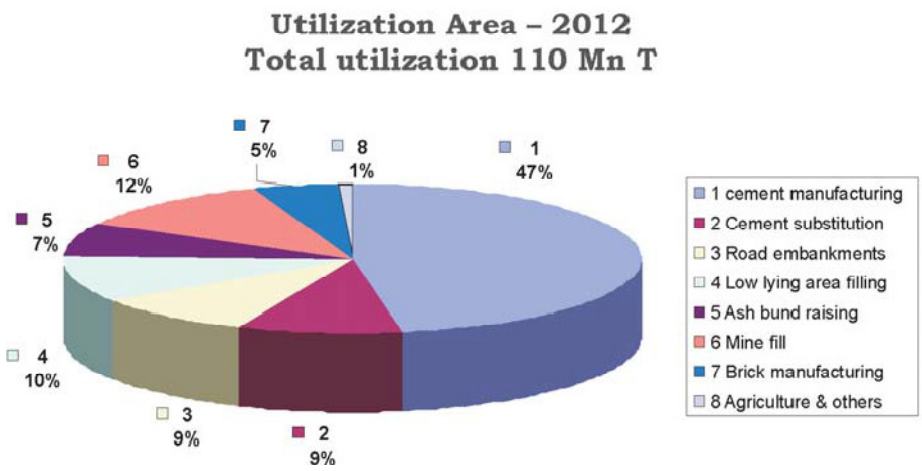


Fig. 2 Utilization of fly ash for various applications (DST 2012-2013)

Data shown in above figure clearly depict that the fly ash utilization in cement manufacturing is high. Mine void filling is another area where one can utilize fly ash in bulk volume.

Characterization of fly ash for their better utilization

The most common mineral constituents of fly ash are the clay minerals, illite and kaolinite, sulfides, such as pyrite and marcasite, carbonate like dolomite, ankerite, calcite and siderite and quartz. The fly ash alkalinity attenuates the release of a large number of elements of concern such as Cd, Co, Cu, Hg, Ni, Pb, Sn or Zn among others, but at the same time, it enhances the release of oxyanionic species such as As, B, Cr, Mo, Sb, Se, V and W throughout leaching process [5].

Leaching

Leaching is a method to remove soluble components from a solid matrix.

Leaching (chemistry), the process of extracting minerals from a solid by dissolving them in a liquid.

Leaching (Metallurgy), a widely used extractive metallurgy technique which converts metals into soluble salts in aqueous media.

Describing leaching by a very simple equation:

material (leachee) + leachant → leachate.[6]

Among the variety of available leaching procedures, four types are commonly used in the literature to assess the leaching behaviour of coal ash:

(i) Batch leaching tests

(ii) Toxicity Characteristic Leaching Procedure (TCLP) and

(iii) Column/flow-through

(vi) Acid extractions.

Batch leaching test

Batch leaching methods are those in which a sample is placed in a given volume of leachant solution for a set period of time. At the end of the leaching period, the liquid is removed and analyzed. Most of these methods require some type of agitation to insure constant contact between the sample and the leachant.

Toxicity Characteristic Leaching Procedure (TCLP)

TCLP requires the use of an extraction fluid made of buffered acidic medium to run the test. 1M sodium acetate buffer was used as an extraction liquid; pH was maintained at 4.99 as per United States Environmental Protection Agency (USEPA) procedure [7]. Taken 4 g coal combustion residue sample and then extraction fluid equal to 20 times the amount of sample taken was added to it.The system was tightly closed and then placed on the rotary shaker for 18 hours, rotating at 30±2 rpm at a room temperature of about 25ºC. Heavy metal analysis was carried out on AAS [8].

Column/flow-through

Column leaching tests are designed to simulate the flow of percolating groundwater through a porous bed of granular material. 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 basic assumption in column leaching is that the distribution of the leaching solution is uniform and that all particles are exposed equally to the leachant solution. Precipitation or sorption within the column may affect the results.

Acid extractions

Performed under aggressive conditions (pH<2) that are difficult to relate to field conditions, but are aimed at gaining an in-depth knowledge of the ash chemistry.

2. CONCLUSION

The selection of a leaching method is not a simple or trivial task. In the absence of an accepted protocol, the project objective and the type of data desired determine what method is most appropriate. Critical variables include the sample size and particle size distribution, the leachant volume and pH, and the duration of the leaching test.

REFERENCE

[1] Ram L C and Masto R E. *An appraisal of the potential use of fly ash for reclaiming coal mine spoil.* J Environ Manage 2010; 91:603-617.

[2] Ahmaruzzaman M. *A review on the utilization of fly ash.* Prog Energ Combust 2010; 36 (3): 327–363.

[3] Blissett R S, and Rowson N A. *A review of the multi-component utilisation of coal fly ash.* Fuel 2012; 97: 1–23.

[4] Information on http://www.dst.gov.in/about_us/ar12-13/annual-report-2012-13.pdf

[5] Izquierdoa M, Querolb X. *Leaching behaviour of elements from coal combustion fly ash: an overview*

[6] Kim A G. *Leaching Methods Applied to the Characterisation of Coal Utilization By- products.*

[7] USEPA, 1990c. *Toxicity Characteristic Leaching Procedure.* Federal Register 1990; 55 (61): 11798.

[8] Sarode D B*, Jadhav R N, Khatik V A, Ingle S T, Attarde S B. *Extraction and Leaching of Heavy Metals from Thermal Power Plant Fly Ash and Its Admixtures.* Polish J. of Environ. Stud 2010; 19. (6): 1325-1330