Environmental Technology & Innovation 7 (2017) 152–159

Contents lists available at ScienceDirect

Environmental Technology & Innovation

journal homepage: www.elsevier.com/locate/eti

Investigation of characteristics and leaching behavior of coal fly ash, coal fly ash bricks and clay bricks

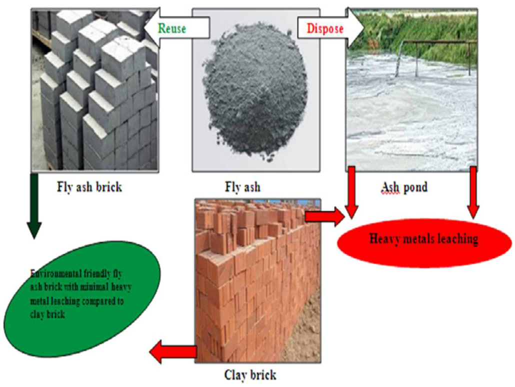
Nidhi Gupta [a], Vidyadhar V. Gedam [b,*], Chandrashekhar Moghe [a], Pawan Labhasetwar [a]

[a] CSIR-NEERI, Nagpur, 440020, India
[b] PIET, Nagpur, 440019, India

HIGHLIGHTS

- Four laboratory leaching test (TCLP, SPLP, CAL-WET and DWLP) were investigated.
- Detail characteristics of collected samples were also evaluated.
- Leaching tests shows concentrations of 12 heavy metals in collected samples.
- Study encourages used of fly ash bricks compared to clay bricks.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 22 August 2016
Available online 20 February 2017

Keywords:
Coal fly ash
Clay bricks
Heavy metals
Extraction
Leaching

ABSTRACT

The leaching potential of heavy metals from Coal Fly Ash (CFA), Coal Fly Ash Bricks (CFAB) and Clay Brick (CB) were assessed through four laboratory batch leaching procedures. The concentration of 12 heavy metals were analyzed to study heavy metal leaching from CFA, CFAB and CB in surrounding environment. The heavy metal concentrations of CFA, CFAB and CB through various leaching studies conducted were compared with those estimated through acid extraction/digestion including physico-chemical, mineralogical and morphological characterization. The comparative assessment between CFAB and CB were also undertaken to study the leaching of heavy metals vis-a-via laboratory batch leaching procedures. The major compounds present in collected samples were SiO_2, Al_2O_3 and Fe_2O_3 while minor compounds include such as K_2O, TiO_2, CaO, MgO, P_2O_5 and SO_3. The most abundant heavy metals leached out during laboratory batch leaching studies were Al>Fe>Mn>Zn followed by other heavy metals. The study also emphasized the

* Corresponding author.
E-mail address: vgedam@yahoo.com (V.V. Gedam).

http://dx.doi.org/10.1016/j.eti.2017.02.002

use of CFAB compared to CB in and around thermal power stations due to environmental suitability in the terms of leaching behavior.

1. Introduction

Green technologies are significant to address issues of environmental pollution and sustainability. Technological advancements have greatly improved human life, but at the expenses of forming many by-products and wastes which are harmful not only to people but also for flora and fauna. Sustainable use and disposal of industrial wastes will help to reduce negative effects on the environment. In India coal fly ash generation from coal based thermal power plants are nearly 131 million tonnes (Mt) (CEA, 2010–11) and is expected to increase up to 300–400 Mt/Year in 2016–17. India utilizes 38% of Coal Fly Ash (CFA) out 112 Mt generated during the year 2013, while other countries like Denmark, Italy and Netherlands utilize 100% (TIFAC, 2013). Nearly 80 Mt of CFA was utilized out of 160 Mt generated during 2009 for cement, brick production, mine filling and road side embankments (DST, 2009), and there is still significant quantity of CFA that is currently stored in ash ponds, thus, can result in risk to the surrounding environment. The CFA contains many trace heavy metals with different mobility (Prasad and Mondal, 2008; Kloseoglu et al., 2010) as well as different major and minor constituents such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MnO etc. The extent of these heavy metals and constituents depends on volatilization, melting, decomposition and the formation of new materials as well as oxidation (Kim et al., 2003).

The nature of interactions that occurs in the CFA and materials made up of the CFA, includes precipitation/dissolution, complex formation, adsorption, desorption and redox reactions, which are bound to control the mobilization of major and minor elements in solution (Silva et al., 2012; Lieberman et al., 2016). Leaching rate and amount of element released into solution depends on the concentration and distribution of elements in the CFA and the CFA based materials (Silva and Boit, 2011). The factors which affect leaching potential are type of extraction fluid, solid to liquid ratio, number of extractions and length of test duration (Lackovic et al., 1997; Sarode et al., 2010). The heavy metals leached during such interactions from the CFA and CFA based materials can lead to health and environment problems (Baba et al., 2003; Baba and Kaya, 2004). Such risks, warrants to conduct extensive studies on physico-chemical, mineralogical, morphological characteristics and leaching behavior of the CFA and CFA based products (Sarkar et al., 2006; Kronbauer et al., 2013; Lieberman et al., 2016). Detail Coal Combustion Residues (CCRs) characteristics and its effect on the technical properties of fire clay masonry bricks were investigated by Holanda (2015), Leiva et al. (2016), Shinde et al. (2016), but the leaching behavior and detail characterization were rarely discussed. CFA is waste material in huge quantity which not only occupy the large area of land, but also cause many environmental issues and effects due to heavy metal leaching. One of the alternatives for CFA management is its use in brick manufacturing. Such alternative use may also have some environmental issues and such studies on CFA incorporated bricks were rarely done.

The objective of the present research work was to study physico-chemical, mineralogical and morphological characteristics of collected waste; so that relevant and useful information on basic characteristics can be generated and may help further investigating researchers to understand the utilization of these wastes as potential substitutes. The study focused to investigate the concentration of 12 heavy metals present in Coal Fly Ash (CFA), Coal Fly Ash Bricks (CFAB) and Clay Brick (CB) vis-a-via acid digestion method as well as four different laboratory batch leaching test which are well developed. The four laboratory batch leaching test includes Toxicity Characteristic Leaching Procedure (TCLP), Synthetic Precipitation Leaching Procedure (SPLP), California Waste Extraction Test (CAL-WET) and De-ionized water leaching procedure (DWLP). The study provides in-depth information about, the actual concentration of heavy metals in collected samples and the concentration values of these heavy metals leached out during respective laboratory batch leaching test. The study also focused on the concentration of heavy metals leached out from CFAB and CB; so as to study the comparative environmental suitability vis-a-via leaching studies.

2. Materials and experimental methods

2.1. Materials

CFA samples were collected from Electrostatic Precipitator of Thermal Power Stations (TPS) located at Badarpur, Delhi and Khaparkheda, Maharashtra, India. Individual samples were collected from Electrostatic Precipitator (ESP), hopper and then composite samples were prepared by mixing equal amount of CFA. CFAB samples were collected from a brick manufacturing facility of Daksh Enterprises fly ash brick manufacturing unit near Badarpur and Baba Ram Dev fly ash brick manufacturing unit near Khaparkheda TPS and CB was collected from a Smile Enterprises clay brick manufacturing facility near Khaparkheda. The geographical locations of CFA, CFAB and CB collection sites are shown in figure S1 (supplementary material). The collected samples were stored in air tight polyethylene bags prior to analysis. To examine different properties of collected bricks, oven dried samples were ground by mortar and pestle manually to fine grain size ($<$2 mm). The grind