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Coal combustion residues—environmental implications and recycling potentials

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Abstract

To meet the electric power requirement, the world population is greatly dependent on fossil fuel. Presently in India, about 75% of the total electrical energy (i.e. ∼100,000 MW) is generated from fossil fuel and about 105 million tons of coal combustion residues (CCRs) as solid waste/by-product is being released annually during combustion of pulverised bituminous, sub bituminous, and lignite coal. Indian coal typically has ash content of 30–60%, which results in low calorific value however low in sulphur, radioactive elements and heavy metals content.

Mostly, the CCRs is being disposed to the ash pond as thin slurry, and more than 65,000 acres of land is occupied in India for storage of this huge quantity of ash which leads ecological and environmental problems. Presently about 27% of the total CCRs produced in India is being recycled and used in various applications. The major utilisation is in cement, concrete, bricks, wood substitute products, soil stabilisation, road base/embankment, and consolidation of ground, land reclamation and for agriculture. In this paper, an attempt has been made to assess the global generation of CCRs, present utilisation and acceptability in Indian context, implications and future potentials to achieve environmental sound management.

Keywords: Coal combustion residues; Characterisation; Resources; Building materials; Conservation; Disposal; Recycling; Engineering applications; Utilisation and safe-management

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1. Introduction

Environmental pollution by the coal based thermal power plants all over the world is cited to be one of the major sources of pollution affecting the general aesthetics of environment in terms of land use, health hazards and air, soil and water in particular and thus leads to environmental dangers. Coal combustion residues (CCRs) is a collective term referring to the residues produced during the combustion of coal regardless of ultimate utilisation or disposal. It includes fly ash, bottom ash, boiler slag, and fluidised bed combustion ash and other solid fine particles (Asokan, 2003; Keefer, 1993). As per the ASTM standards, in India bituminous and sub-bituminous coal results in class 'F'ash and lignite coal produces class 'C' ash having high degree of self-hardening capacity. Physical, chemical and mineralogical, morphological and radioactive properties of CCRs in general vary as they are influenced by coal source/quality, combustion process, degree of weathering, particle size and age of the ash (Adriano et al., 1980; Asokan, 2000; McCarthy and Dhar, 1999).

In India, presently coal based thermal power plants are releasing 105 MT of CCRs which possess major environmental problems (Kumar and Mathur, 2004; Sharma et al., 2003)). Presently from all these thermal power plants, dry fly ash has been collected through Electro Static Precipitator (ESP) in dry condition as well as pond ash from ash ponds in semi-wet condition. In India most of the thermal power plants do not have the facility for automatic dry ash collection system. Commonly both fly ash and bottom ash together are discharged as slurry to the ash pond/lagoon.

Year wise CCRs generation for the past more than one decade in India is shown in Fig. 1. In 1995 CCRs generation in India was only 40 MT. Although the rate of CCRs generation is not uniform in all the years from 1992–2004, as an average of 7.4% of annual increase in CCRs could be seen. It is obvious that the CCRs generation increased when the power generating capacity increased from the last five decades from 1350 MW in 1947 to ∼100,000 MW in 2004 to cater the need of the Nation. In the year 1994, 1999 and 2000 there was not much increase in power generation while comparing the previous years due to the failure in the boilers in some of the power plants. Out of the present installed capacity, about 75,000 MW of electricity is from the coal-based thermal power stations, ∼20% is from hydro-electric plant and the rest is from nuclear and non-conventional energy sources (Kumar and Mathur, 2004; Mishra, 2004; Roongta, 2000). India has about 211 billion tons of coal reserves, which is known to be the largest resource of energy and presently ∼240 MT of coal is being used annually to meet the Nation's electricity demand. In terms of energy, India stands at world sixth position accounting ∼3.5% of the world commercial energy demand in 2001, but the electricity generation yet not completely fulfilled the present requirement. Though nuclear power programme envisaged for generation of 20,000 MW of nuclear energy by the year 2020, India do not have option in the foreseeable future, except the fossil fuel mainly based on coal sources. The rate of annual increase in power generation in India is ∼5%. And at this rate the annual power generation by the year 2020 is expected to be 180,000 MW, which may release about 190 MT of CCRs per annum. However, to achieve sustainable development the Nation may have to generate at least 260,000 MW of power (i.e. 10% increase in rate of annual electricity generation) by the year 2020 and as consequence ∼273 MT of CCRs is expected to be released. Keeping in view of the formidable future problems due to these huge quantity of CCRs to achieve Environmental