THERMAL POWER AND ENVIRONMENT

Mr. Muhammed Abdul Hakkeem C

Assistant Professor & Head, Department of Physics, KAHM Unity Women's College, Manjeri, Kerala-676122, India
E-mail: hakeemchatholi@gmail.com

INTRODUCTION

Thermal Power plants (TPPs) are the major source of generation of electricity for any developing country. Around 70% of electricity generation in our country is met by thermal power plants. Fuel is blown into the combustible chamber of the boiler where it is burnt at high temperature where Heat energy converts water into steam. High energy steam is passed through the turbine and the steam creates force on the turbine causing the shaft to rotate at high speed. A generator is coupled at one end of the turbine shaft which generates power. The thermal power plant has serious impacts on land, soil, air and various social impacts. The thermal power plant are also said to emit large amount of mercury and generate large quantity of fly ash which destroys the surrounding environment. These plants also consume a large amount of water. Due to these problems they require a proper Environmental impact assessment.

Possible fuel sources include Fossil fuels such as coal, petroleum products and natural gas, Residual and waste materials such as domestic and industrial refuse and fuel made from recovered oil. Anthracite coal is the largest source of fuel for electricity generation followed by brown coal, natural gas and petroleum oils. Non-fossil sources of fuel such as landfill gas and biogases are also used. In some cases, these non-fossil fuels are co-fired with coal. The major components of TPP include the power system (i.e., power source, turbine and generator and associated facilities, which may include the cooling system, stack gas cleaning equipment, fuel storage handling areas, fuel delivery systems, solid waste storage areas, worker colonies, electrical substations and transmission lines, etc. The type of facility and size of thermoelectric projects, as well as technological configuration of generation system and also other associated facilities besides, environmental and social concerns of plant location, will determine the nature and intensity of environmental impacts of proposed TPP facility.

COAL AS A FUEL

Coal is the only natural resource and fossil fuel available in abundance in India. Consequently, it is used widely as a thermal energy source and also as fuel for thermal power plants producing electricity. Power generation in India has increased manifold in the recent decades to meet the demand of the increasing population, of which more than 65% is produced by coal- based thermal power plants. The only fossil fuel available in abundance is coal, and hence its usage will keep growing for another 2–3 decades at least till nuclear power makes a significant contribution. The coal available in India is of poor quality, with very high ash content and low calorific value, and most of the coal mines are located in the eastern part of the country. The coal supplied to power plants is of the worst quality.. Combustion process converts coal into useful heat energy, but it is also a part of the process that produce greatest environmental and health concerns. Combustion of coal at thermal power plants emits mainly carbon dioxide, sulphur oxides, nitrogen oxides, and air borne

 ISBN 978-93-5396-526-6

inorganic particulates, such as fly ash and suspended particulate matter (SPM). High ash content in Indian coal and inefficient combustion technologies contribute to Indi's emission of air particulate matter and other trace gases, including gases that are responsible for the greenhouse effect. And mercury which is a dangerous metal released by this coal combustion.

But the projected rapid growth in electricity generation in the country over the next couple of decades is expected to be met by using coal as the primary fuel for electricity generation, because of its abundance and deficiency of other fossil fuels.

ENVIRONMENTAL IMPACTS OF THERMAL POWER PLANTS

The impacts of TPPs on the environment are influenced by processes used and the location characteristics in different ways. Coal-based power plants significantly impact the local environment. Direct impacts resulting from construction and ongoing operations include:

i) Ambient Air Pollution – particulates, sulphur oxides, nitrous oxides, and other hazardous chemicals and toxic metals like Hg, As, etc.

ii) Water Pollution – occurs in local water streams, rivers and ground water from effluent discharges and percolation of hazardous materials from the stored fly ash

iii) Land Degradation – occurs due to alterations of land used for storing fly ash

The indirect impacts result mainly from coal mining, which includes degradation and destruction of land, water, forests, habitats, and societies. In addition to the impact of the coal-power plants, there is also a larger issue of the environmental and social impact of coal mining. In a typical TPP, environmental impacts are likely to comprise the following principal components:

- transportation of raw material
- preparing and storing raw material
- burning fuel and generating steam
- generating electricity and available heat
- treating exhaust gases and solid and liquid residues
- cooling infrastructures
- safe handling and disposal of wastes

Exhaust Gases

Initially, perceptions of objectionable effects of air pollutants were limited to those easily detected like odour, soiling of surfaces and smoke stacks. Later, it was the concern over long-term/chronic effects that led to the identification of six criteria pollutants. These six criteria pollutants are sulphur di-oxide (SO_2), Carbon Mono-oxide (CO), Nitrogen oxide (NO_2), Ozone (O_3), suspended particulates and non-methane hydrocarbons (NMHC) now referred to as volatile organic compounds (VOC). There is substantial evidence linking them to health effects at high concentrations. Three of them namely O_3, SO_2 and NO_2 are also known phytotoxicants (toxic to vegetation). In the later part Mercury (Hg) has been added to that list.

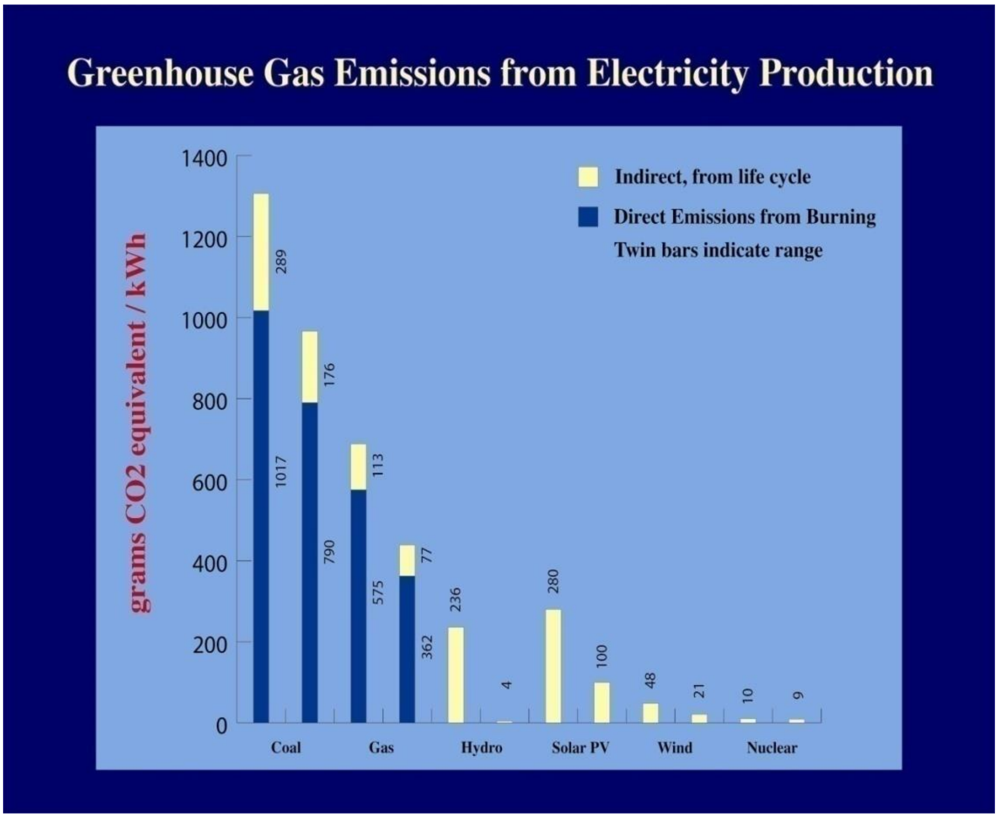
Sulphur Oxide: The combustion of sulphur containing fossil fuels, especially coal is the primary source of SOx. About 97 to 99% of SOx emitted from combustion sources is in the

ISBN 978-93-5396-526-6

form of SO_2, which is a criteria pollutant, the remainder is mostly SO_3, which is in the presence of atmospheric water is transformed into Sulphuric Acid at higher concentrations, produce deleterious effects on the respiratory system. In addition, SO_2 is phytotoxicant.

Particulate matter: The terms particulate matter, particulate, particles are used interchangeably and all refer to finely divided solids and liquids dispersed in the air.

Carbon Oxide: Increasing CO_2 levels have significant implications such as changes in monsoon precipitation patterns as well as rise in extreme rainfall events, coastal storms, droughts and global warming. Such changes in the climate could have enormous human, ecological, and economic impacts.



The particulate and noxious gas emissions from TPPs primarily and directly pollute the air. Eventually, the particulate emissions and, for the most part, the noxious gases and any atmospheric transformation products that may have formed (e.g., NO2 and nitrate from NO) fall to earth either by a way of precipitation or by dry deposition, thereby imposing a burden on the water and/or soil, with resultant potential damage to flora and fauna.

Emissions from thermoelectric projects can act as precursors of acid precipitation, particularly when coal with its high sulphur content is the fuel. Acid precipitation accelerates the deterioration of buildings and monuments, radically alters aquatic ecosystems of certain lakes, and damages vegetation in forest ecosystems.

Land Degradation

The thermal power stations are generally located on the non-forest land and do not involve much resettlement and rehabilitation problems. However its effects due to stack emission etc, on flora and fauna, wild life sanctuaries and human life etc., have to be studied for any adverse effects. One of the serious effects of thermal power stations is land requirement for ash disposal and hazardous elements percolation to ground water through ash

ISBN 978-93-5396-526-6

disposal in ash ponds. According to the studies carried out by International consultants thousands of sq. km of land should be required for ash disposal only.

Cooling Water Sources And Issues

Aquatic organisms drawn into cooling water intake structures are either impinged on components of the cooling water intake structure or entrained in the cooling water system itself. In case of either impingement or entrainment, aquatic organisms may be killed or subjected to significant harm. In some cases (e.g., sea turtles), organisms are entrapped in the intake canals.

Hot Water Ejection

The effect on biological environment can be divided into two parts, viz. the effect on flora and the effect on fauna. Effect on flora is due to two main reasons, land acquisition and due to flue gas emissions. Land acquisition leads to loss of habitat of many species. The cooling water being at higher temperature (by 4 - 5^{o}C) when discharged can harm the local aquatic biota. The primary effects of thermal pollution are direct thermal shocks, changes in dissolved oxygen, and the redistribution of organisms in the local community. Because water can absorb thermal energy with only small changes in temperature, most aquatic organisms have developed enzyme systems that operate in only narrow ranges of temperature. These stenothermic organisms can be killed by sudden temperature changes that are beyond the tolerance limits of their metabolic systems.

Waste Water

The wastewater streams in a TPP include cooling tower blow down; ash handling wastewater; material storage runoff; metal cleaning wastewater; and low-volume wastewater, such as air heater and precipitator wash water, boiler blow down, boiler chemical cleaning waste, floor and yard drains and sumps, laboratory wastes, and back flush from ion exchange boiler water purification units . Such wastewater is usually generated in power plants which burn coal or biomass. The characteristics of the wastewaters generated depend on the ways in which the water is used.

The discharge of waste water causes water quality problems and has a high impact on the aquatic environment, which vary widely, depending on the type of fuel used, the abatement technique applied, the cooling technique and consequently the amount of water used, and the chemical and biological treatment reagents added for cleaning and maintenance purposes. These substances can impart significant toxicity to the receiving water. For instance, water from slag flush and ash transport has an alkaline character due to the composition of the ash, whereas water from boiler washing is acidic. Wastewater from the wet desulphurisation plant contains salts such as chlorides and sulphates. Salt derived from the sea is found in most coastal waters. However, discharges from industrial activities such as energy generating facilities provide a further source of salt. This effect is even more significant if the water is discharged to a river or lake.

The withdrawal of such large quantities of water and discharge with elevated temperature along with various pollutants, chemical contaminants picked up during process such as biocides or other additives may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life. In Oil or Gas-based TPP, the same wastewater sources are usually present in plants except some of these streams (e.g., ash handling wastewater) may not be present at all. Apart from their cooling-water consumption, power plants have very modest water requirements.

ISBN 978-93-5396-526-6

Noise

Noise is another air pollution and the principal source of noise in a TPP includes the turbine generators and auxiliaries; boilers and auxiliaries, such as coal pulverisers; reciprocating engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers. TPPs used for base load operation may operate continually while smaller plants may operate less frequently but still pose a significant source of noise if located in urban areas.

Fly Ash and Bottom Ash

Coal or biomass-fired Thermal power plants generate the greatest amount of solid wastes due to the relatively high percentage of fly ash in the fuel. The other solid waste from large-volume coal combustion wastes includes bottom ash, boiler slag. Fly ash removed from exhaust gases makes up more than 60–85% of the coal ash residue in pulverised-coal boilers. Bottom ash includes slag and particles that are coarser and heavier than fly ash.

Thermal power stations in India, where poor quality of coal is used, add to environmental degradation problems through gaseous emissions, particulate matter, fly ash and bottom ash. Growth of manufacturing industries, in public as well as private sectors has further aggravated the situation by deteriorating the ambient air quality. Abundance of ash content in Indian coal results in increase of fly ash and bottom ash content for disposal. The fly ash generated in thermal power station causes many hazardous diseases like asthma, tuberculosis, etc.

The particles of Fly ash are generally spherical in shape and range from 0.5 to 100 micron in size. The fine particles of fly ash reach the pulmonary region of the lungs and remain there for long periods of time; they behave like cumulative poisons. The submicron particles enter deeper into the lungs and are deposited on the alveolar walls where the metals could be transferred to the blood plasma across the cell membrane fly ash can be disposed off in a dry or wet state. Studies show that wet disposal of this waste does not protect the environment from migration of metal into the soil. Heavy metals cannot be degraded biologically into harmless products like other organic waste.

COLLECTION OF FLY ASH

After the combustion of the coal in the boiler, 20% of the ash is collected at the bottom of the boiler called bottom ash and 80% is carried along with flue gases called fly ash. Bottom ash is mixed with water and made into sludge form and sent through pumps into the ash ponds. The Electro Static Precipitator is used to collect the ash particles in the flue gases. The era after the introduction of the Electro Static Precipitator has partly protected the environment from harmful gases and hazardous chemicals. Generally dust is collected from the waste in two processes that is mechanically and electrically.

Mechanically is by using filters and electrically is by using Electro Static Precipitators. The ESP is efficient in precipitation of particles from sub microns to large sizes of particles and hence they are preferred to mechanical precipitators. The efficiency of modern ESP"s is of the order 99.9%.The Electro Static Precipitators have high collecting efficiency, low sensitivity to high temperatures, low pressure drop, limited process controls and an easy and reduced maintenance make the electro static precipitators one of the most reliable and appreciated units available at the moment in the market. Electrostatic precipitators can be used for collecting virtually all kinds of dust coming from coal and oil fired power stations, blast furnaces and industrial furnaces, iron and steel processes, cement

ISBN 978-93-5396-526-6

factories, municipal solid wastes incinerators , paper mills, wood factories, textile industries, food and pharmaceuticals industries.

Principle of Electro Static Precipitator: The electro static precipitator utilizes electrostatic forces to separate dust particles from the gas to be cleaned. The flue gas is ionized in the electro static field and large quantities of positive and negative ions are formed. The positive ions are immediately attracted towards the negative wires by the strength of the field. The negative ions however attracts towards the positive plates.

UTILIZATION OF FLY ASH

Fly ash bricks: The Central Fuel Research Institute, Dhanbad has developed a technology for the utilization of fly ash for the manufacture of building bricks. Fly ash bricks have a number of advantages over the conventional burnt clay bricks. Unglazed tiles for use on footpaths can also be made from it

Fly ash in manufacture of cement: In the presence of moisture, fly ash reacts chemically with calcium hydroxide and CO_2 present in the environment attack the free lime causing deterioration of the concrete. A cement technologist observed that the reactive elements present in fly ash convert the problematic free lime into durable concrete. Fly ash can substitute up to 66% of cement in the construction of dams. Fly ash in R.C.C. is used not only for saving cement cost but also for enhancing strength and durability. Fly ash can also be used in Portland cement concrete to enhance the performance of the concrete. Portland cement is manufactured with Calcium oxide, some of which is released in a free state during hydration. Utilization of fly ash in cement concrete minimizes the carbon dioxide emission problem to the extent of its proportion in cement.

Fly ash-based ceramics: Ceramic products with up to 50 wt% of mullite and 16 wt% of feldspars were obtained from binary mixtures of fly ash from the Teruel power station(N-E Spain) and plastic clays from the Teruel coal mining district. The firing behaviour of fly ash and the ceramic mixtures was investigated by determining their changes in mineralogy and basic ceramic properties such as colour, bulk density, water absorption and firing shrinkage. To determine the changes on heating suffered by both the fly ash and the ceramic bodies, firing tests were carried out at temperatures between 900 and 1200°C in short firing cycles. The resulting ceramic bodies exhibit features that suggest possibilities for use in paving stoneware manufacture, for tiling and for conventional brick making. The National Metallurgical Laboratory; Jamshedpur has developed a process to produce ceramics from fly ash having superior resistance to abrasion

Fly ash as fertilizer: Fly ash provides the uptake of vital nutrients/minerals (Ca, Mg, Fe, Zn, Mo, S and Se) by crops and vegetation, and can be considered as a potential growth improver. Because it can be a soil modifier and enhance its moisture retaining capacity and fertility the improvement in yield has been recorded with fly ash doses varying from 20 tone / hectare to 100 tone / hectare . On an average 20-30% yield increase has been observed. Out of 150 million hectare of land under cultivation, 10 million hectares of land can safely be taken up for application of fly ash per year. The fly ash treated fields would give additional yield of 5 million tone food grains per year valued at Rs.3000 per year.

Fly ash in road construction: The use of fly ash in large quantities making the road base and surfacing can result in low value–high volume utilization technology demonstration projects at New Delhi, Dadri (U.P.) and Raichur (Karnataka) have been successfully completed for use of fly ash in road / flyover embankments.

ISBN 978-93-5396-526-6

Roads and Embankments: Another area that holds potential for utilization of large volumes of fly ash is road and flyover embankments. Fly ash embankments at Okhla, Hanuman Setu, Second Nizamuddin bridge in Delhi and roads at Raichur, Calcutta, Dadri etc. have established that on an average Rs. 50 to 75 per MT of earth work cost can be saved by using fly ash (in lieu of soil) in such works, primarily due to reduction in excavation & transportation costs.

ENVIRONMENTAL IMPACT OF FLY ASH UTILIZATION

Utilization of fly ash will not only minimize the disposal problem but will also help in utilizing precious land in a better way. Construction of road embankments using fly ash, involves encapsulation of fly ash in earthen-core or with RCC facing panels. Since there is no seepage of rain water into the fly ash core, leaching of heavy metals is also prevented. When fly ash is used in concrete, it chemically reacts with cement and reduces any leaching effect. Even when it is used in stabilization work, a similar chemical reaction takes place which binds fly ash particles. Hence chances of pollution due to use of fly ash in road works are negligible.

CLEAN COAL TECHNOLOGIES

Clean Coal Technologies (CCTs) offer the potential for major improvements in efficiency and significant reduction in the environmental emissions when used for power generation. These technologies may be utilized in new as well as existing plants and are therefore, an effective way of reducing emissions in the coal fired generating units. Several of these systems are not only very effective in reducing emissions of noxious gases, but because of their higher efficiencies they also emit lower amount of CO2 per unit of power produced. CCTs can be used to reduce dependence on foreign oil and to make use of a wide variety of coal available. To meet increasing demand of power with minimal environmental impact for sustainable development, adoption of clean coal technologies with enhanced power plant efficiency, fuel switching, use of washed coal, efficient pollution control systems and proper by product and waste handling & utilization, is necessary.

PRE-COMBUSTION TECHNOLOGIES

Coal Beneficiation: Ash, sulphur and other impurities can be reduced from the coal before it is burnt.

Combustion Technologies: Generation of emissions of SO2, NOx & CO2 can be minimized by adopting improved combustion technologies

Super-critical Technology: By increasing steam temperature and pressure, the efficiency of the steam turbine (and hence, of electricity generation) can be increased. As the steam-pressure and temperature increases to a critical point, the characteristics of steam are altered such that water and steam are no longer distinguishable and it is known as super-critical steam and this technology is more efficient.

POLLUTION CONTROL TECHNOLOGIES

Air pollutants emitted from combustion process from boilers consists mainly of particulates, sulphur oxides, nitrous oxides, heavy metals, and CO_2 – chemicals that cause serious health and environmental damages. There are a range of flue gas treatment technologies for reducing such flue gas emissions of these pollutants; they are now typically a part of specific coal-utilization technology packages. The add-on pollution-reducing technologies are broadly installed at three stages namely: pre-combustion, in-combustion and post-combustion. In pre-combustion stage coal beneficiation/washing is carried out to reduce

ISBN 978-93-5396-526-6

the overall amount of coal ash and also increase energy efficiency. The pollution cleanup technologies to remove particulates and sulphur from the combustion gas are also viewed as pre-combustion mechanisms. During in-combustion stage, low NOx to reduce NOx emissions, dry limestone scrubbing for sulphur removal in fluidized-bed combustion and gasification are incorporated as pollution control measures.

CONCLUSION

Environmental pollution by the coal based thermal power plants all over the world is cited to be one of the major sources of pollution affecti/..ng 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. Fly ash also affects environment because it is a directly in contact with water. Heavy metals can also adversely affect the growth rate in major carps. Coal combustion residues (CCRs) are a collective term referring to the residues produced during the combustion of coal regardless of ultimate utilization or disposal. It includes fly ash, bottom ash, boiler slag, and fluidized bed combustion ash and other solid fine particles. In India, presently coal based thermal power plants are releasing 105MT of CCRs which possess major environmental problems. Presently from all these thermal power plants, dry fly ash has been collected through Electrostatic 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 these affect on environment, economy, and social factor. The disposable management of fly ash from thermal power plant is necessary to protect our environment. It is advisable to explore all possible applications for fly ash utilization. All possible mitigation measures should be employed at each and every thermal power plant in order to reduce its adverse environmental impacts.

REFERENCES

1. Mishra U.C., Environmental impact of coal industry and thermal power plants in India, J Environ Radio act, 72(1-2), 35-40 (2004)
2. Technical EIA guidance manual for thermal power plants, Ministry of Environment and forest, Govt. Of India, August 2010.
3. Sahithi Avirneni, Dharmateja Bandlamudi, Environmental Impact of Thermal Power Plant in India and Its Mitigation Measure, International Journal of Modern Engineering Research (IJMER) Vol.3, Issue.2, March-April. 2013 pp-1026-1031
4. Jamil S., Abhilash P.C., Singh A., Singh N. and BhelHari M., Fly ash trapping and metal accumulation capacity of plant, implication of for green belt around thermal power plant, J. Land Esc. And Urban Plan, 92, 136-147 (2009)
5. Fulekar M.H. and Dave J.M., Release and behavior of Cr, Mn, Ni and Pb in a fly-ash/soil/water environment: column experiment, IntJ. Of Environmental Studies, 4, 281-296 (1991)
6. Sameer Kumar, Dhruv Katoria and Dhruv Sehgal, Environment Impact Assessment of Thermal Power Plant for Sustainable Development, International Journal of Environmental Engineering and Management. ISSN 2231-1319, Volume 4, Number 6 (2013), pp. 567-572

ISBN 978-93-5396-526-6

7. Ashoka D., Saxena M. and Asholekar S.R., Coal Combustion Residue-Environmental Implication and Recycling Potential, Resource Conservation and Recycling, 3, 1342-1355 (2005)
8. Shrivastava Shikha and Dwivedi Sushma, Effect of fly Ash Pollution on Fish Scales, Re. J. of Che. Sci, 1(9), 24-28 (2011)
9. Keefer R.F., Coal ashes-industrial wastes or beneficial by-products. In: Keefer R.F., Sajwan K., editors, Trace Element in Coal and Coal Combustion Residues. Advances in Trace Substances Research, Florida: Lewis Publishers, CRC Press, 3–9 (1993)
10. Kumar Vimal and Mathur Mukesh, Clean environment through fly as utilization Cleaner (2003)
11. Critical Review in Environmental Control, CRC Press, 3, (1989)
12. Pvrecek, Lbendik, Pb210 and Po210 in fossil fuel at the sostanj thermal power plant (Slovenia), Czechoslovak j of phy, 53 a, 51-a (2003)
13. F˙IL˙IZ G ¨ UR and G ¨ UNSEL˙I YAPRAK, Natural radionuclide emission from coal-fired power plants in the southwestern of Turkey and the population exposure to external radiation in their vicinity, J. of Environ. Sci. and Health Part a, 45, 1900–1908 (2010)
14. Kant K., Chakarvarti S.K Environmental impact of coal utilization in thermal power plant, J. of Punjab Acad. of For. Med. &Toxi, 3, 15-18 (2003)
15. [12] Senapati Manas Ranjan, Fly ash from thermal power plants–waste management and overview current science, 100, 1791-1794 (2011)
16. korba.gov.in/kwflyash.htm (2012)
17. www.wealthywaste.com/fly-ash-utilization-in-india (2012)
18. Cement Manufacturing Association, (1999)
19. IgnasiQuerlt,XavierQuerol ,Angel Lopez-Solar ,Felicano Plana ,Use of coal fly ash for ceramics ;a case study for large Spanish power station, fuel,8 , 787-791, (1997)
20. SaikatMaitra, Cremic product from fly ash global prospective. In preceding of the national seminar on fly ash utilization, February 26-27 NLM Jamshedpur India (1999)
21. Kumar Vimal and MathurMukesh, Clean environment through fly as utilization. Cleaner Technology, Impacts/12/2003-2004, MOEF-CPCB, Govt. of India, 235-255, (2003)
22. Fly Ash Mission‟, (TIFAC), Department of Science and Technology, Ministry of Science and Technology, Government of India, Technology (1994)
23. www.crridom.gov.in/techniques-facilities/10.pdf (2012)
24. M.Ahmaruzzaman, A review of utilization of fly ash In Energy and Combustion. Sci.30, 327-363 (2010)
25. Jha C. N. & Prasad J. K. Fly ash: a resource material for innovative building material - Indian perspective substitute and paint from coal ash" 2nd international conference on "fly ash disposal &utilization", New Delhi, India, (2000).

 ISBN 978-93-5396-526-6