

A review on effluents of Thermal Power Plants & its impacts on natural ecosystem with reference to coal and fly ash radiation

¹Sanjay Dey & ²Ashis Kumar Panigrahi

¹Research Scholar, Ecotoxicology, Fisheries and Aquaculture Extension Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal 741235 (India)

²Professor, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal 741235 (India)

ARTICLE DETAILS

Article History

Published Online: 25 May 2019

Keywords

Eutrophication, Bioaccumulation, Biodiversity, Food chain, Genotoxicity, Methylation, Mutation, DNA, Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated biphenyls (PCB).

ABSTRACT

Thermal power plants are being used as energy source. But this thermal power plant emits several poisonous gases like, sulphur dioxide, carbon dioxide, nitrogen dioxide, etc. Contamination of air, water due to thermal power plants affecting local people. This thermal power plant has negative impact on environment. Discharge of thermal power plants is cause alteration in physicochemical parameters of water. Water temperature is significantly changing due to thermal plants effluents. Coal ashes properties dependent on the coal's combustion conditions. Untreated coal power plant affects flora and fauna. Variation of water pH occurs due to effluents of thermal plants. Dust arises from fly ash seriously affects ground water contamination. Fly ash from thermal power plants pollutes soil. Volatiles organic compounds, nitrogen oxides, carbon mono oxide cause several diseases. This paper contains effluents of thermal power plants with coal and fly ash radiation and its impact on local ecosystem.

1. Introduction

Thermal electric power plants use steam-water energy cycle. In aquatic environment heated water is directly discharge and cause changes of physicochemical parameters of water, such as density, viscosity, solubility of gases & steam pressure. Influence of heating on aquatic ecosystems is ambiguous, & at different levels of heating it may be both positive & negative. Thermal loads can cause negative impact on local areas aquatic environment, such as highly presence of blue-green algae, water quality deterioration, changes in composition of plankton & dynamics of its numbers, disruptions of structure of fish communities, & microclimatic changes. It is combination of thermal releases & chemical contamination leads to local disturbances of ecological equilibrium, such as accelerated eutrophication, changes in species structure of aquatic ecosystem. As rule, nuclear & gas power plants prove to be cleaner than coal & fuel-oil TPPs in extent to which they create chemical contamination of aquatic ecosystems. Among important factors of impact on aquatic biota are affected to aquatic organisms in water intake facilities & condensers of power plant cooling systems, resulting in mass death of phytoplankton and zooplankton & young fish. Power generating units requires various resources like, fossil fuels & water, thus create everlasting impacts on environment & generate tremendous stress in local eco-system. Due to continuous & long lasting emission of SO₂ & NO₂, which are principal pollutants coal based plants, surrounding structures, buildings, monuments of historic importance & metallic structures too are affected very badly due to corrosive (Acid rain) reactions. An example of this victimized is Tajmahal. It is noted that high amount of carbon dioxide (CO₂) emission from thermal power plants contribute to global warming and ultimately leading to climate change. Water requirement for coal-based power plant is about 0.005-0.18 m³/ kwh. Water requirement can marginally reduce about 0.18 m³/ kWh to 0.15

m³/ kwh after installation of treatment facility for ash pond decant. Still water requirement of 0.15 m³/ kwh per unit of electricity is very high compared to domestic requirement of water of big city. Ash pond contains harmful heavy metals like B, As, Hg. These heavy metals had tendency to leach out over period. Due to this, ground water gets polluted & becomes unsuitable for domestic use. Thermal power plants impacts on socio-economic environment is based on several parameters, like, Resettlement & Rehabilitation (R & R), effect on local civic amenities & work related hazards to employees of power plants. Civic amenities development is directly proportional to size of project. Same had been observed for coal based plants followed by natural gas based plant. Due to hazardous working conditions coal based thermal power plant cause highest number of accidents.

Depending upon nature & intensity of utilization of fresh water & thermal effluents, ecosystem may either re-establish previous equilibrium or establish new one, or it may remain in prolonged disequilibrium. Periodic observations are very important as it is used to estimate changing salinity, suspended load & temperature, enabling retaining better quality of river water & associated fish habitat. Periodic observations are also necessary to estimate exact response of biotic community.

Coal fired power plants use coal, air & water inputs to generate electric power. In thermal power plants large amount of water is used for generation of steam, cooling & disposal of ash to ash settling ponds. During this process solid, liquid & gaseous effluents are generated. Three categories of liquid effluents are generated within the power plants, they are, high turbidity effluents, high dissolved solid effluents & oily effluents. Oily effluents are treated in treatment plant. Liquid effluent is mainly composed of waste water from cooling tower & service water from different source which is reused for dust

suppression & boiler blow down quenching. Power stations generate more or less 2700 MT / day of ash, some part is disposed to ash ponds as ash slurry & some part is used in cement industry also in brick manufacturing. Deposition of ash occurs at the bottom of pond whereas clear water stays on top of it. Then the water is collected and it is pumped to tube settler where coagulant based chemical treatment used to remove suspended solids. Then water is reused for preparation of ash slurry. To find out efficient way of using this water, study was done to characterize ash water & their utilization potential mainly for plantation purposes.

2. Review of Literature:

(Moore & Witherspoon, n.d.) Studied "*Radiological Impact on Airborne Effluents of Coal Fired & Nuclear Power Plants*" & found that effluents of coal fired, power plants as well as radioactivity are releases from nuclear power plants. Radiological impact had been evaluated by Federal Radiation Council, International Commission on Radiological Protection, & Part 20 of Title 10 of the Code of Federal Regulations. Studies revealed that radioactive materials from coal fired plants and also in nuclear plants were well within limits.

(Kathiravale, Teknologi, & Sekitar, 2010) Studied "*Radiological Impact from Airborne Routine Discharges of Coal-Fired Power Plant*" & observed that Radioactivity exists everywhere in nature. We are exposed to intense & continuous natural radiation coming from sun, cosmic radiation, telluric radiation & even to internal radiation of our own body. Fly ash emitted from burning coal by power plant carries into 100 times more radiation of surrounding environment than nuclear power plant. This paper presents information of studies on radiological impact from airborne routine discharge of coal-fired power plants.

(Das & Paul, n.d.) Studied "*Impact of Coal Ash Surrounding Thermal Power*" & found that Electricity is most refined & convenient form of energy. It is an indispensable part of modern daily life & also prime component of every economic activity like industrialisation, etc. to build up nation. With rapid urbanization & advent of Green Revolution, utilization of power had occupied significant role of all utilities in society. It may be mentioned here that most prominent power producing countries like China & USA had also appreciated its recognition.

Plants, T. P. (2017) Studied "*Environmental, Health, & Safety Guidelines for Thermal Power Plants*" & observed that Environmental, Health, & Safety (EHS) Guidelines are technical reference documents with general & industry-specific examples of Good International Industry Practice (GIIP). EHS guidelines are used together with general EHS Guideline's document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary.

(Shen, Zhang, Cheng, & Chen, n.d.) Studied "*Radioactivity of Five Typical General Industrial Solid Wastes*" & found solid waste discharged in various industrial production processes, like waste of electric power industry, coal chemical industry,

metallurgy, & so forth. This includes fly ash (FA), red mud (RM), phosphogypsum (PG), phosphorus slag (PS), & electrolytic manganese residue (EMR). At present, most industrial solid wastes are mainly used as raw materials for construction, such as cement & concrete, as well as environmental functional materials & source of valuable elements.

Group, E. W. (2016) Studied "*Water Energy Nexus: Coal Based Power Generation & Conversion – Saving Water*" and found that Modern day energy & water systems are intrinsically intertwined. Use of water is ever present in energy production – extraction, refining, transport of fossil fuels, power generation, & in growing of feedstock for biomass generation. On other hand, use of energy is indispensable in modern water treatment & distribution systems. Rapid urbanization & economic growth had mounted pressures on both energy & water resources. For coming decades, it is forecasted that these trends will continue. Also, anthropogenic climate change will lead to changes in local weather patterns & in turn affect availability of water in region.

(Baxter, 1993) Studied "*Environmental radioactivity: perspective on industrial contributions*" & found that Awareness of exposure to natural radioactivity — & its technological enhancement — in both industrial & environmental domains is growing. Ambient radioactivity with nuclear industry and indeed assumption that radioactivity is in some way unnatural. Combination of nuclear reactions & radioactivity creates all matter. It was nuclear stability which determined which elements are abundant & which are rare in our universe. Of more than 5000 known kinds of atom (nuclides), about 95% are radioactive.

(Hvistendahl, 2007) Studied "*Coal Ash Is More Radioactive than Nuclear Waste*". Coal, creates several problems like, mining accidents, acid rain & greenhouse gas emissions.

(Moore & Witherspoon, n.d.) Studied "*Radiological Impact of Airborne Airborne of Coal-Fired & Nuclear Power Plants*" & found that radiological impact of naturally occurring radionuclides in airborne effluents release to atmosphere of 1 percent of ash. In coal burned & compared with radioactive materials impact in airborne effluents of model light-water reactors [1000 Mw (e)]. For nuclear plants inversion in effluents of airborne is also significant factor in dose commitment.

(Flues, Camargo, Silva, & Mazzilli, 2006) Studied "*Radioactivity of coal & ashes from Figueira coal power plant in Brazil*" & found that Figueira coal-fired power plant (CFPP) presents higher uranium concentration. Spectrometry of gamma -ray was used to determine ²³⁸U, ²²⁶Ra, ²¹⁰Pb, ²³²Th & ⁴⁰K contents in pulverized coal, furnace bottom ash & fly ash samples. Fly ash fraction gave concentrations ranging from 1442 to 14641 Bq/kg, for uranium series.

(Gabbard, 1993) Studied "*Coal Combustion nuclear resources or danger*" & found that over past few decades, American public had become increasingly wary about normal plant operations, plant accidents, & nuclear waste. Except for

Chernobyl & other nuclear accidents, releases had been found to be almost undetectable in comparison with natural background radiation. Another concern had been cost of producing electricity at nuclear plants.

(Kant, 2003) Studied "*Environmental Impact of Utilization of coal In Thermal Power Plant*" & found that Radon, which is topic of public health concern, had been found to be ubiquitous air pollutant to which all persons are exposed. ^{222}Rn , progeny of ^{238}U formed from radioactive decay of radium emits alpha radiation & decays with half-life of 3.824 days. Radon is present in soil, ground water and it is present in trace amount.

(Lu, Jia and Wang, 2006) Studied "*Natural radioactivity of coal & its by-products in Baoji coal-fired power plant, China*" & found that there had been a highly demand for electricity generation throughout world. Coal is important source of electric power worldwide. China depends largely on coal reserves for energy needs, which contribute more than 70% of total power generated at present in China. Coal, burned as fuel material in power plants, produces energy & large amount of solid waste. Solid waste resulting from coal combustion are mainly fly ash & bottom ash. Bottom ash is coarse-grained material that is collected at bottom of boiler & fly ash is entrained in gas stream & carried up stack following combustion.

3. Fly Ash & Its Impacts:

Ranging of fly ash size varying from 0.01 to 100 μm and it is released into stream during combustion of coal from power stations. Mineralogical, physical & chemical characteristics of fly ash depend on type of coal, combustion conditions, emission control devices & handling methods. Chemically it is mixture of oxides, hydroxides, carbonates, silicates & sulphates of calcium, iron, aluminium & other metals in trace amount. It is grey to black in colour, abrasive, alkaline & refractory in nature. Fly ash is considered to be a pollutant due to its adverse effect on ecosystem, although it had alternate, safe & viable utilities

Formation of fly ash: Coal is sedimentary rock and contains several minerals like alumina-silicate clays, silica, carbonates of calcium, magnesium or iron & sulphides among other traces. During combustion, several elements of coal excluding carbon, hydrogen, nitrogen & sulphur form ash. Vaporous pollutants & heavy metals accumulate over ash particles. Coarse ash particles sometimes known as slag or bottom ash. These slag or bottom ashes fall to bottom of combustion chamber, at that time lighter fine ash particles remain suspended in flue gas. 10-30% is removed as coarse-grained bottom ash in case of pulverized fuel firing systems. Enrichment of components is found to be higher in fly ash when compared to bottom ash.

Constituents of fly ash: Apart from high percentage of silica (SiO_2), alumina (Al_2O_3) & magnetite (Fe_2O_3), fly ash also contains oxides, hydroxides, carbonates, silicates & sulphates of different elements like phosphorous, potassium, calcium, magnesium, iron, manganese etc. Based on nature of coal & combustion conditions, fly ash may contain various levels of heavy metals such as antimony, arsenic, barium,

boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, & zinc

Heavy metals in fly ash: Indian coal had very high ash content in range of 35-40%. Study of 3 coal thermal plants based in & around Delhi reveals amount of heavy metals in fly ash generated. Concentrations of toxic heavy metals such as arsenic, mercury, lead were present according to analysis of 5 thermal power plants fly ash in India. Groundwater heavy metals analysis near an ash disposal site in Orissa, India showed high concentrations of iron, barium, copper, manganese, sulphur, lead, vanadium & zinc. According to study, zone of attenuation for barium, iron, copper, manganese, sulphur & zinc in groundwater was about 600 – 900 m from ash pond, while lead did not show any significant attenuation.

Impact of heavy metals on natural ecosystem: Heavy metals like arsenic, lead, nickel, cobalt, chromium, boron & antimony found in fly ash are hazardous for living organisms. These elements can potentially be released to soil, surface water, & groundwater by leaching processes also affecting vegetation. Due to diurnal & seasonal variations in temperature, moisture, leaching potential of ash ponds is higher. Studies indicate that leach ability of cationic metals such as cadmium, lead, mercury, & silver increases with decreasing pH or acidic conditions. Due to bio-accumulation of heavy metals, amount of heavy metals in plants also increased and in this way this heavy metals entering into food chain. Ames Salmonella mutagen city assay conducted on two-tester strains & genotoxicity assay on fly ash leach are carried in vitro on human blood cells & in vivo on Nicotine plants indicates that leach directly affect certain DNA damage. In human, heavy metals affect DNA by methylation, mutation of DNA and deletion of certain base pairs. It also affect in whole blood cells, lymphocytes. Waste water from thermal power plants containing heavy metals making fish weak and cause several disease.

Other pollutants in fly ash: Several organic constituents arises during combustion and forming organic pollutants such as Polycyclic Aromatic Hydrocarbons (PAH) & Polychlorinated biphenyls (PCB) which are adsorbed to fly ash. Impact of organic pollutants adsorbed to fly ash also reflects on water, soil & vegetation. Based on generation of fly ash from 5 thermal power plants in India, concentration of Benzo[a]pyrene varies ranging from 0.82- 18.14 ng/g. Studies on fly ash also reveal increased threat of radioactivity & its impact on ecosystem including humans. According to study based on 30 power plants in India, natural radionuclide's like Ra-226, Th-228 & K-40 gets enriched by 2-5 times in resulting fly ash compared to parent coal.

Utilization of fly ash: Fly ash generated from thermal power plants mainly stored in ash ponds which affect biodiversity. However, fly ash utilization for alternative purposes had following benefits:

1. Minimizing environmental impact of direct disposal,
2. Minimizing disposal costs,
3. Enabling other uses of land since fly ash disposal requires less area.

4. Procuring financial returns from sale of by-product
5. Replacing expensive natural resources. In India, one of major areas for fly ash utilization is in construction (cement production, brick manufacturing & road embankments). Typical highway engineering applications include fly ash for encapsulated purposes & unencapsulated purposes.

4. Conclusion:

Fly ash is major solid waste product & also particulate pollutant derived from combustion of pulverized coal in thermal power plants. Pollutants when released into environment, affects vegetation directly or indirectly. With recent introduction of super thermal power plants, production & disposal of fly ash will continue to be one of major national problems. However,

research & development units are active and are trying to innovate methods to reduce fly ash pollution with sophisticated techniques like ammonia prevention technology (not described yet in their reports). Lot of emphasis is being laid on biological & non-biological utilization of fly ash. As physicochemical properties of fly ash depend on type & nature of coal burnt, its special effect with respect to particular affected areas, especially on vegetation, is matter of concern for environment research explorers.

Acknowledgement:

The first author is grateful to Council of Scientific & Industrial Research (CSIR), Govt of India for providing assistance to conduct this research work.

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