

PHYSICOCHEMICAL INVESTIGATION OF GROUND WATER RECEIVING LEACHATES FROM ASH POND OF THERMAL POWER PLANT WITH SPECIAL REFERENCE TO MOUDA, NAGPUR**Prakash A. Fandi ¹, Dr. Pushpendra Sharma ², Dr. Prakash R. Dhote ³**¹ Research Scholar, Department of Chemistry, Sri Satya Sai University of Technology & Medical Sciences, Sehore, M.P.² Research Guide, Department of Chemistry, Sri Satya Sai University of Technology & Medical Sciences, Sehore, M.P.³ Prof. & Head, Department of Chemistry, MIET, Gondia**ABSTRACT:**

Fly ash is a by-product of the coal combustion process in thermal power plants. The non-combustible mineral matter in coal that undergoes thermal modification during combustion is known as fly ash. Fly ash has recently been used extensively in a number of industries, including construction, building engineering, road construction, backfilling, and agriculture. Despite having several favourable geotechnical qualities, it has a lot of heavy metals in it. These metal ions are easily discharged in an aqueous environment, potentially posing harm to the ecosystem in the future. It is extremely concerning that soil, surface water, and ground water could potentially be contaminated by the leaching of coal fly ash during the plant's disposal process. In this article, physicochemical investigation of ground water receiving leachates from ash pond of thermal power plant with special reference to Mouda, Nagpur has been evaluated.

Keywords: Leachates, Ash, Pond, Power, Plant**INTRODUCTION:**

Uncontrolled fly ash disposal could have serious negative effects on the environment and ecology. Fly ash disposal raises concerns about potential contamination, particularly for aquatic environments where ash comes into direct contact with water. The ash pond was not built with an ash pond liner, creating the potential for heavy metals to leach. To lessen the negative effects of fly ash on the surrounding environment, increasing use of fly ash in construction operations, suitable disposal procedures, and better management must be used. [1-5] The objectives of the research are:

- To analyze physicochemical investigation of ground water receiving leachates from ash pond of thermal power plant in Mouda, Nagpur.
- To measure ground water quality of bore wells, wells, lakes, river affected by leachates of ash pond.
- To know about the heavy metal contamination in ground water used for drinking and agriculture purpose due to percolation of leachates.
- To evaluate the ash pond of power plant in on bank of Sand River which is source of drinking water for nearby number of villages.
- To isolate the pollution and contamination which is serious threat to human health hazards perspectives.

- To exploration of the fly ash sampling from selected coal based thermal power plants and ground & surface water sampling including nearby villages of these thermal power plants.
- To ensure about the laboratory batch leaching tests on fly ash samples with periodic analysis of leachate to determine the maximum amount of contaminants that can be leached from fly ash.
- To estimation of solutes in the supernatant of a wet disposal system and measurement of the concentration versus time profile for solute extracted from fly ash.
- To study for the concentration of trace elements in ground and surface water samples in surrounding area of these thermal power plants and to examine the impact of fly ash on surface and ground water.
- To assess compliance with regulatory criteria for the safe disposal of fly ash from thermal power plants.

MATERIALS AND METHODS:

Mouda (or Mauda) is a town and a Tehsil in the Ramtek subdivision of the Nagpur district in the Nagpur Revenue Division. The study has been carried out the plant namely Mauda Super Thermal Power (MSTP) Station of NTPC.

Primarily, the fly ashes are disposed off using either dry or wet disposal scheme. In dry disposal, the fly ash is transported by truck, chute or conveyor at the site and disposed off by constructing a dry embankment (dyke). In the wet disposal system, the fly ash is transported as slurry through pipe and disposed off in impoundment called as "ash pond".

The constructional methods for an ash dyke can be grouped into three broad categories:

- Upstream method,
- Downstream method and
- Centerline method

The construction procedure of an ash dyke includes surface treatment of lagoon ash, spreading and compaction, benching and soil cover.

An important aspect of design of ash dykes is the internal drainage system. The seepage discharge from internal surfaces must be controlled with filters that permit water to escape freely and also to hold particles in place and the piezometric surface on the downstream of the dyke. As per the MoEF prescribed guidelines the ash pond lining must be protected by 500 micron thick HDPE (High density polyethylene) liner as per the Indian standard IS: 2508 over 50 mm thick sand cushion. Top of the HDPE liner must be protected with 300 mm earth cover.

For this study ASTM Method D-3987, Standard Test Methods for Shake Extraction of solid waste with water (ASTM, 1995) were taken into consideration. This method is a procedure for rapidly generating leachate from solid waste that can be used to estimate the mobility of inorganic constituents from the waste under the specified test conditions. The final pH of the leachate is to reflect the interaction of the leaching fluid with the buffering capacity of the waste. In the method, it is stated that the procedure is not intended to produce a leachate representative of leachate generated in the field, and the method does not simulate site-specific leaching conditions (ASTM 1995). ASTM Method D-3987 is an agitated extraction method that uses reagent water as the leaching fluid. The procedure involves different contact time between a solid waste and reagent water with rotary agitation. The method calls for testing a representative sample of the waste, and as a result, it does not require particle size

reduction. The method has been tested to determine its applicability to inorganic constituents, but it has not been tested for application to organic constituents.

Sampling:

10 kg of fresh fly ash samples was collected from thermal power plant. Ground water sampling from the nearby area of the ash pond was carried out. Ground water samples from the nearby area of Thermal Power Station were also collected.

Laboratory Leaching Test:

During the research work, laboratory leaching tests were conducted on ash samples retrieved from hopper bottom of the ESPs of concerned power plant. Batch equilibrium and kinetic tests were conducted on fly ash samples to obtain technical information on kinetics of leaching for a number of chemical constituents contained in fly ash. These tests were termed as time dependent release tests. Batch extractions/leaching tests were conducted in the laboratory on fly ash samples from these power plants using different leaching medium. Three leaching medium has been used for the leaching study namely, Extraction Fluid (pH 4.93 ± 0.05), Aqueous Solution (pH ~ 7) and Buffer Solution (pH ~ 10-11).

The extraction fluid (pH 4.93 ± 0.05) is prepared by mixing 5.70ml glacial acetic acid ($\text{CH}_3\text{CH}_2\text{OOH}$) with 500ml double distilled water. 64.3ml of 1N Sodium Hydroxide (NaOH) solution is added with the solution and volume is diluted to 1000ml.

Double distilled water is taken as aqueous solution (pH ~ 7). The buffer solution (pH ~ 10-11) is prepared by mixing 0.1N Sodium Hydroxide (NaOH) solution drop wise in double distilled water until the pH of the solution is around 10-11.

Three different leaching medium of different pH value were taken for study to see the characteristics of leaching of selected trace elements at different pH value.

Sample preparation:

The collected fresh fly ash sample from the hopper of ESP from thermal power plant was kept in a closed container prior to the extraction in order to prevent sample contamination or constituent loss. For sample preparation, the approximate sample size of 25.00 gm was taken on the centre of a glazed paper. The samples were flattening out gently with a suitable straight-edge until it is spread uniformly to a depth at least twice the maximum particle size. Samples were remixed by lifting a corner of the sheet and drawing it across, low down, to the opposite corner in a manner that the material is made to roll over and over and does not merely slide along. This was continued with each corner, proceeding in a clockwise direction. This operation was operated ten times. All four corners of sheet were lifted towards the centre, holding all four corners together and the entire sheet were raised in air to form a pocket for the sample. Again, the samples were flattened out gently with a suitable straight-edge until it is spread uniformly to a depth at least twice the maximum particle size. With straightedge at least as the flattened mound of the sample, the samples were divided into quarters. An effort was made to avoid using pressure on the straightedge sufficient to cause damage to the particles. The alternate quarters of the samples were discarded. Now the samples were mixed well and sample size of 12.50 gm was selected and weighed for the extraction.

Shake Test:

The shake tests were performed using a specially fabricated extraction apparatus that rotates about a central axis at a rate of 100 rpm. A round, wide mouth bottle was used as a sample

container, with an L/S ratio of 20:1, using 12.50 gm of dried fly ash in 250 ml of extraction solution over varying periods of leaching.

Time-Dependent Release:

Aqueous batch extractions of the fresh ash sample collected during this period were performed to evaluate the release of selected elements from the ash at extended equilibration times.

Extraction Procedure:

The leaching study was performed with all the three extraction solutions. For each extraction, the dried (16 to 20 hours at $104\pm 2^{\circ}\text{C}$) fly ash samples (12.50 gm) and extraction solutions (250mL) were mixed in 500 mL polyethylene bottle in triplicate. Bottles were rotated end-over-end for specified time increments ranging from 1 week to 4 weeks in extraction apparatus. The rotation of the extraction apparatus is controlled by rpm controlling knob. The pH of the solution was measured at regular time interval i.e. after 1 week, 2 weeks, 3 weeks and 4 weeks.

Collection of extracted sample:

After specific time of extraction, the bottles were left for 5 minutes for settling, then the bulk of aqueous phase were separated from the solid phase by filtration through 0.45 μm fiber filters. The pH of the leachate was measured immediately, and was acidified with two drops of concentrated (70%) trace metal grade HNO_3 . The samples were stored in acid-washed 300-mL glass bottles with caps for the analysis of selected trace elements.

Analysis of selected elements:

The concentration of selected trace elements i.e. Iron, Copper, Chromium, Cadmium, Nickel and Lead were analyzed in the leachates using Atomic Absorption Spectrophotometer (Perkin Elmers, Model- AAnalyst 700).

Collection of ground water samples:

Ground water sampling was done as per the CPCB guidelines. For this polyethylene bottles of 1000ml capacity were taken. The sampling bottles were rinsed three times with the representative sample before it was filled. A small air space in the bottle is provided to allow mixing of sample at the time of analysis. The sample container was labeled properly, preferably by attaching an appropriately inscribed tag or label. The sample code and the sampling date were clearly marked on the sample container/ tag. The samples of ground water were collected from the tube wells fitted with a hand pump or a power- driven pump for domestic water supply or irrigation. Samples from the tube wells were collected after running the well for about 5 minutes. Samples were then acidified to pH below 2 with concentrated nitric acid. After preservation, the samples were placed in an insulated ice box for transportation to laboratory for the analysis of respective trace elements. The ground water samples from nearby area of Power House were collected.

Collection of surface water samples:

Surface water sampling was done as per the CPCB guidelines. Polyethylene bottles of 1000ml capacity were taken for sampling. The bottle was rinsed three times with the representative sample before it was filled. Samples were collected from well-mixed section of the river sand (main stream) 30 cm below the water surface using a weighted bottle from different locations. Samples were then acidified to pH below 2 with concentrated nitric acid. After preservation, the samples were placed in an insulated ice box for transportation to

laboratory for the analysis of respective trace elements. The surface water samples from the river Sand were collected.

Detection limit

The detection limit for the various elements are given in table below:

Elements	Minimum Detection Limit (mg/L)
Copper	0.0015
Nickel	0.0060
Lead	0.0150
Cadmium	0.0008
Iron	0.0050
Chromium	0.0030

EXPERIMENTAL STUDIES:**Characterization of Fly Ash:**

The fly ash samples were collected from the ESPs of thermal power plant. The fly ash samples were composed of very fine particles. The colour of the fly ash samples was dark grey. The physical and chemical analysis performed on the fly ash samples are presented in the subsequent sections. One of the objectives of this research work was to perform laboratory leaching tests on the fly ash samples collected from the thermal power plants.

Physico-Chemical Analysis:

The physical characteristics and chemical compositions of the fly ash samples were taken from the material safety data sheet (MSDS) provided by the fly ash producers. A comparison of the chemical parameters of the fly ash samples also presented. Thermal power plant is using Bituminous coal, hence the fly ash generated from the thermal power plants belong to class 'F'. The "Class F" fly ash samples were analyzed for heavy metal concentrations using Atomic Absorption Spectrophotometer. The concentrations of the metals present in the "Class F" sample. The extraction was performed in acidic, aqueous and buffer solution. The initial pH of leaching solution and the pH of the leachate was measured after each extraction. It was seen that the pH of each leaching medium was changing with leaching period.

Batch Leaching Tests:

The laboratory batch leaching tests were performed for several different test conditions.

Extraction of fly ash:

Extraction of fly ash was done by weighing 12.5gm of dry fly ash in a polyethylene bottle of 500 ml capacity. Then 250ml of extraction solution (extraction fluid, aqueous solution and buffer solution) was added in each fly ash samples. The bottles were capped and kept in the box provided with extraction apparatus. The extraction apparatus has provision for six such type of box. At a time six samples were kept for extraction. All the samples were extracted in triplicate. The extractor is rotated end to end by a motor attached to it.

Extraction Solutions:

One of the primary objectives of the research work is to examine the leaching potential of trace metals in fly ash in different condition like acidic, aqueous and buffer medium. The fly ash is disposed off in slurry form mixed with water from the receiving body, that will be acidic, aqueous or buffer. In nature, carbon dioxide from the atmosphere is dissolved in rainwater to form carbonic acid. Therefore, it was decided that an extraction fluid with a pH of around 5.0 be used for the extraction of fly ash in this work along with aqueous and buffer solution to simulate the slight acidic conditions found due to rainwater.

Leachate Collection System:

After extraction for pre-determined period the polyethylene bottles were removed from the extraction apparatus and allowed to settle for five minutes. The supernatants were collected, filtered through 0.45 µm fibre filters. The pH of the leachate was measured and was acidified with concentrated (70%) trace metal grade HNO₃. They were stored in acid-washed 300-mL glass bottles with caps.

Test Procedure:

All the fly ash samples collected from coal-based power plants were extracted and tested simultaneously in triplicate with all three-leaching medium. The following subsections describe the detailed steps taken before and during the test procedures.

Development of the Test Setup:

Equal amounts of fly ash were used from each individual fly ash samples taken for experiment. Each of the fly ash samples were dried in hot air oven for 16 to 20 hours at 104±2°C. The extraction apparatus consists of a wooden box having six small boxes fitted in it. The wooden box is attached with a shaft rod. The shaft rod is attached to motor with facility of rpm controller knob. Polyethylene bottles were taken for sample extraction. Fly ash samples and extraction solutions were mixed and kept in the polyethylene bottles. The sealed airtight bottles are placed in the box provided with extraction apparatus. The samples were agitated end to end for varying period of one week, two-week, three week and four-week duration.

Test Conditions:

The leaching potential of metals is influenced by the pH of the leaching fluid (McClean and Bledose, 1992). To determine how the leaching rates of metal from fly ash are affected with different influx pH, the pH of leachate was measured at the end of each extraction with all three leaching mediums.

Sample Collection:

The leachate samples were collected at pre-determined time intervals. The volume of sample collected each time was used for pH measurement and then acidified and preserved for metal detection. The collected samples were filtered using a 0.45 µm glass fiber filter and the pH was measured using a bench top pH meter immediately after the collection of leachate sample. After measuring the pH, the leachate was analysed for metal concentration using an Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION:

The results from laboratory analysis of leachate samples obtained from the batch leaching

tests performed on the fly ash from thermal power plant. The sets of representative samples of the fly ash were analysed under different test conditions; the leachates generated were sampled and analysed to determine trace metal concentrations using Atomic Absorption Spectrometer (AAS). The fly ash sample were extracted with different leaching medium for different period of time. Four samples were prepared for each leaching medium, for one week, two-week, three week and four weeks and extracted separately for the determined period. The results of metal concentration in the leachate samples were studied.

Presentation of Leaching Test Data:

In addition to the major elements like Calcium, Potassium and Sodium, the fly ash contains a number of heavy metals in small quantities. In the present work six metal ions were selected for their leaching behavior. The choice of these metal ions was based on their effect on humans and plants. These metals are Iron (Fe), Nickel (Ni), Copper (Cu), Chromium (Cr), Lead (Pb) and Cadmium (Cd).

The background concentrations of metals in the reagent water/leaching solution were determined using the AAS so that the true amount of metals leaching from the fly ash under different test conditions may be accurately determined. In each batch leaching test, the pH of the leachants were monitored at regular interval of the experiment using pH meter. The effluent pH was measured before storing the samples for metal concentration analysis.

Results of Leaching Tests and ground water samples of Mauda Thermal Power Station:

The fresh fly ash samples were extracted in three different mediums for different leaching period. The initial pH value of each leaching solutions i.e., aqueous, extraction and buffer solutions were measured before the extraction performed. After the extraction for pre-determined period the pH of leachate was again measured, to see the variations in pH during the extraction. The trace metal concentrations in the leachate samples of Mauda Thermal Power Station with time are presented.

The trace metal concentrations in ground water samples from the nearby area of ash pond of Mauda Thermal Power Station are presented.

The following parameters also evaluated:

- Concentration of selected elements in leachate of aqueous solution
- Concentration of selected elements in leachate of buffer solution
- Concentration of selected elements in leachant of extraction solution
- Test results of surface water sample of river Sand at different locations
- Discussion of Batch Leaching Test Results
- Leaching of Iron, Copper, Lead, Cadmium, Chromium, Nickel with observations
- Estimation of Amount of Mobile Metals

CONCLUSION AND RECOMMENDATIONS:

Due to the presence of hazardous elements in large amount of coal fly ash, disposal of fly ash has drawn great attention regarding public health and environment. As conventional approaches for fly ash disposal, either in landfill or on-site impoundment storage, cannot circumvent the interactions between fly ash and the aqueous phase, metal or toxic elements leaching is inevitable throughout the time of storage. Therefore, contamination of surface and ground water, soil and sediment resulting from the released toxic constituents has become a major environmental concern.

Davison et al. (1974) reported that fine particle fraction of fly ash could be enriched in trace

elements compared with the fraction of trace elements in the parent coal. This is due to the volatilization of some elements in the boiler and their subsequent condensation in the cooler sections of the flue gas stream. In many of the most toxic elements, significant enrichment is observed in the fine particle of coal fly ash (Nelson et al. 2010). Karayigit et al (2005) indicated that some volatile elements, notably As, Cd, and Zn, had increasing concentrations from coarse to finer particle size fly ash. Similar observations with As, Cd, Pb and Zn have also been reported by Hower et al. (2001).

When the heavy metal-containing solid matrix is exposed to aqueous solution, mobile fly ash constituents enter the pore water due to desorption of metals or/and dissolution of metal compounds. The desorption process for metals or dissolution of metal compounds in the pore water is called "solubilization". The difference in chemical potential between the pore fluid and the fluid surrounding the porous matrix induces diffusion of metals through pore fluid and causes leaching. As the aqueous solution or water passes through the porous matrix, contaminant transports due to advection along with dispersion (which includes molecular diffusion) of contaminants through pore water (Fleming et. al., 1996). The solubility of heavy metals in water depends on hydrolysis, and the presence of other organic and inorganic ligands, their coordinate chemistry, and the pH of the solution. The desorption of metals depends on the properties of the solid (particle size, nature inorganic oxide coating, organic carbon content, and zero point charge of the solid) as well as the properties of the liquid, include pH and total dissolved metal concentrations. The effect of pH on desorption is generally dominant, because pH has a major influence on solubility of most chemical species (Sauve et. al., 2000).

Fly ash leaching test has been extensively conducted over the past fifty years to study the mobility of heavy metals in fly ash in particular. Coal ash leachate is generated by the contact of water with the ash. The water soluble oxides on the surface of the ash particles are dissolved into solution, creating a potentially high salinity leachate. The chemistry of the leachate varies quite considerably, with pH ranging from acidic to alkaline. The majority of fly ash leachate is prone to be alkaline due to the presence of lime while fly ash with high Fe can lead to an acidic leachate through oxidation and the release of hydrogen ions.

The primary objective of the research was to determine the long-term leaching potential from fly ash material based on short-term laboratory tests. The research approach used to meet the research objectives consisted of an experimental program. The specific tasks that were accomplished during the period of study are as follows.

A series of batch leaching tests were performed on "Class F" fly ash. The concentrations of six specific metals Fe, Cu, Ni, Cr, Pb and Cd in the leachate were determined using Atomic Absorption Spectrometer. The metal concentrations were plotted against time to observe the leaching trends in short-term laboratory tests.

A number of combinations of influent pH values were used so that the effect of pH on leaching potential of metals from fly ash could be examined. However, when the results of laboratory leaching tests were done, it was observed that the amount of metals leaching from the system showed irregular trend of leaching at different pH. Additionally, it was observed that the effluent pH values were higher than the influent pH values and there they showed very little variation. Therefore, it can be seen that the pH of the fly ash and the pH of leaching medium controls the leaching of metals. From the laboratory test results, it was evident that

out of the six metals examined, Lead and Cadmium, did not show definite leaching trends. Most likely the reason for such behavior is that these metals are present in fly ash only in trace amounts. The remaining four metals showed definite leaching trends.

The results of batch shake tests with fresh fly ash indicate the release of trace elements into extraction medium continuously over a period of time. The pH value of leachates obtained during leaching process appears to be related to the alkalinity of the original ashes. The pH of extraction fluid and aqueous solution increases with agitation period. The release of heavy metals from the ash into all extraction medium strongly depends on the pH of leaching medium and its development during interaction with the fly ash. The leaching of these metals shows their presence in the fly ash sample.

Presently, ash pond lining is not being followed. Therefore, fly ash is disposed of in ash ponds with high environmental risk and the possibility of leaching of heavy metals increases. Since the soil beneath the impoundments is always saturated and under considerable hydraulic head, the improper lined ponds provide a great opening for groundwater contamination. The surface water contamination may also take place due to surface run off from ash ponds. The nature of extract/ leachant, the liquid to solid ratio, pH of leachant and extraction time determine the leachability of elements associated with coal fly ash. A combination of suitable disposal techniques and increase in utilization of fly ash seems necessary steps to combat the environmental problems associated with fly ash generation and its safe disposal.

Toxic Elements from coal fly ash can leach out of disposal facilities and expose humans to serious health risks. A report released by the EPA in 2009 documented that many of those toxicants leach at concentrations high enough to seriously endanger human health. It has long been known that lead in drinking water is highly toxic, and recent developments have increased the level of concern. Contamination of drinking water with significant levels of lead is much more widespread than previously believed, and levels that were once considered safe are now considered to be health threats. Exposure to lead is cumulative over time. High concentrations of lead in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys. This damage commonly results in behavior and learning problems (such as hyperactivity), memory and attentiveness problems, high blood pressure, hearing problems, headaches, slowed growth, reproductive problems in men and women, digestive problems, muscle and joint pain. While chromium (III) is an essential nutrient in the body, the other common form of chromium, chromium (VI), is highly toxic and is frequently found in coal fly ash. When ingested via contaminated water, chromium (VI) can cause stomach and small intestine ulcers. Frequent ingestion can cause anemia and stomach cancer. Contact with the skin by some compounds of chromium (VI) can result in skin ulcers. When inhaled in large amounts, chromium (VI) can cause lung cancer, breathing problems such as asthma and wheezing. Oral exposure to cadmium is possible from shellfish and plants grown on cadmium-contaminated soils. Fortunately, oral ingestion of cadmium results in low levels of absorption. The lungs, however, readily absorb cadmium, so inhalation exposure results in much higher levels of absorption. This makes cadmium a potential hazard from coal ash dust, which may be released into the environment when dry coal fly ash is stored, loaded, transported, or kept in uncovered landfills. Chronic exposure can result in kidney disease and obstructive lung diseases such as emphysema. Cadmium may

also be related to increase blood pressure (hypertension) and is a possible lung carcinogen. Cadmium affects calcium metabolism and can result in bone mineral loss and associated bone pain, osteoporosis and bone fractures.

The technology for coal ash disposal should control the migration of leachate from ash to ground water. Technology includes many methods like liner system in the leachate collection system, waste cover, etc. Fly ash landfill can be designed with multiple liner system, a double composite liner. Another alternative is to cover the coal ash with a low permeable membrane, which removes the infiltrated water laterally, prevents not only groundwater pollution but also the formation of percolates. Migration of these elements in the ground water from the ash-filled mine to a long distance has not been observed. The abandoned open cast mine, which are located in barren area and where there are no nearby habitats, can be used for disposal of coal ash.

India needs to strictly implement clean coal technologies like Flue-gas-desulphurization (FGD) and Fluidized bed combustion (FBC) to minimize the fly ash production during the coal combustion process.

Because of its array of severe effects on human health and the environment, coal - across all of its life cycle, including coal fly ash, must be addressed in a public health context. Corporations that burn coal and generate coal fly ash must not be free of responsibility for the consequences they unleash on human and environmental health. Rather, coal's contaminants must be handled in ways that minimize their impacts on human health. The responsibility of handling fly ash must fall on those who produce, utilize, dispose, and reuse coal and its waste products. Since coal ash contains such high levels of toxics, its disposal and reuse call for high levels of prudence and care. From a health and medical perspective, the situation calls for application of the "precautionary principle." The precautionary principle states that where an action risk causing harm to the public or to the environment, the burden of proof that it is not harmful falls on those who would take the action. In other words, rather than waiting until harm has occurred, we should require those who want to use coal fly ash to demonstrate that the proposed use is safe. It is the same principle applied by the Food and Drug Administration to keep our food supply safe, and it is wise one to apply when dealing with leaking, leaching, toxic substances. In contrast to a classical risk assessment approach, which asks, "How much harm can we tolerate?" the precautionary principle asks, "What actions can we take to prevent harm?" When we release toxic elements into the environment, we expose ourselves and our children to compounds that rob us all of our potential for full development, while also harming the much broader biotic community. Yet our duty as health professionals and environmental stewards includes the responsibility to protect people from such harm, especially those who cannot protect themselves. The precautionary principle supports an approach to policy-making that emphasizes our responsibility to actively promote human and environmental health, for ourselves as well as for generations to come. We have the knowledge and resources to make appropriate decisions to protect public health and the environment, and therefore, the responsibility to do so.

Prudent, precautionary options available that should guide the handling of coal fly ash include:

➤ Incorporating the best available elements of preventative hazard design in storage and disposal facilities. These include engineered composite liner systems, leachate collection

systems, long term ground water monitoring, and corrective action (clean-up standards), if these systems fail.

- Pursuing further independent research and assessment of coal fly ash recycling. Reuse of coal ash should only be permitted when research indicates that the toxic chemicals in coal fly ash will not migrate from the ash in quantities that pose a threat to human health or the environment during the entire lifecycle of the reuse application.
- Research is needed to determine the possible health effects from coal combustion waste on workers who are exposed to ash and sludge at disposal facilities, construction projects and manufacturing plants.
- In view of the immense amount of coal fly ash generated in India and its disposal and reuse in nearly every state and territory of the nation, it is essential that the Ministry of Environment and Forest enact enforceable safeguards that protect the health and environment of every citizen equally and effectively.

REFERENCES:

1. Tiwari, V., Shukla, A., Bose, A. (2004). Acoustic properties of cenosphere reinforced cement and asphalt concrete. *Applied Acoustics*; 65, pp. 263-275.
2. Baba, A., Kaya, A. (2004). Leaching characteristics of solid wastes from thermal power plants of western Turkey and comparison of toxicity methodologies. *Journal of Environmental Management* ;73(3), pp. 199-207.
3. Ram, Lal C., Shrivastava, Nishant K., Tripathy, Ramesh C., Thakur, Sanjay K., Sinha, Awadhesh K., Jha, Sangeet K., Maste, Reginald E., Mitra, Swapna (2007): Leaching behavior of lignite fly ash with shake and column test. *Environmental Geology*; 51, pp. 1119-1132.
4. Tripathi, R. D. and Grill, E. (2002). Role of phytochelatins in phytoremediation of toxic metal ions from the polluted environment (abstract). 2nd International Conference on Plant and Environmental Pollution, 4-9 February. NBRI, Lucknow, India.
5. Sarkar, H. S. (2003). Fly ash: A Global player in utilization games of multifarious areas. In: Proc 3rd Int. Conf. fly Ash Utilization and Disposal, vol. 1 (Central Board of Irrigation and Power, fly ash Mission, TIFAC, DST, New Delhi and National Thermal power Corporation Ltd., New Delhi), 1-39.