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Studies on Assessment of Heavy Metals in Samples Collected from Surrounding Area of Fly Ash Dumping Ground

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Abstract:

Coal burning can organize trace elements by presenting them to the surrounding environment. When these elements leached out may cause the contamination of soil, surface water and groundwater. Disposal or any function of coal ash is becoming a major topic because of its potential to pollute surface and groundwater with heavy metals. Potential heavy metal problems with power plant wastes are greatly shortened by the pronounced liming effects of the wastelands. In the present study relative abundance of total heavy metals in fly ash was found in the order As, Cu, Cd, Pb, Hg and Zn. The concentration and availability of metals depends on the character and nature of the coal used in thermal power plant. In the acid digested solution all metals were found above detectable limits. Arsenic, Mercury and Zinc found in greatest extent in soil samples i.e. Hg – 20.51 to21.74 ppm, As – 3.32 to 4.47 ppm Zn – 7.39 to 9.00 ppm. The assessment of the great metal shows that the fly ash dumping ground and surrounding area contains bioavailability of different heavy metals which can well recover, reuse and recycling potential of fly ash.

Keywords: Heavy Metals, bioavailability, leaching, contamination, fly ash.

1.0 Introduction:

Electricity production form coal based power plant is the cheapest and technologically suitable method. The coal based power plants are decentralized systems of power production and hence convenient to setup the different parts of country. Almost all coal, nuclear, geothermal, solar thermal, electric and waste incineration plants as well as natural gas power plants are thermal power plants burning coal, oil or natural gas are often referred to collectively as fossil fuel power plants. In present investigation study is concentrated on coal based thermal power plant (Mandal and Sengupta, 2002, Rajmane, 2003, Batra and Vaidy, 2006). The use of coal in these power plant results in to production of fly ash. The extent of production of fly ash depends upon type and quality of coal used like lignite, anthracite bituminous and sub bituminous coal (Praharaj *et al.,* 2002). Indian coal is of mostly sub-bituminous rank, followed by bituminous and lignite (brown coal). The ash content in Indian coal ranges from 35% to 50% (Padam Raj, 2010). The fly ash spreads around thermal power plant largely. The fly ash also dispersed off in different from like hues loose solids, sludge and greet ash.

These ash particles contaminate the soil and water largely in and around the power plant. The soil composition deteriorates. The soil becomes infertile and many times barren (Mandal and Sengupta, 2006). The constituents of fly ash mix with surrounding and pollute the water. The agricultural land gets converted into barren land secondly the severity of pollution remains uncured for years to come (Shukla and Pandey, 2012). It is necessary to find the proper solution to treat the hues quantity of waste as resource as row material in various process or uses. About 73% of India's total installed electricity generation is from a thermal power plant, out of which 90% is based on coal combustion and produces around 90 – 100 million piles of fly ash annually (Anon, 2000). Fly ash is the finest coal combustion product generated during the combustion of pulverized coal for power generation. Consisting of little molecules of inorganic minerals, with some carbon, it is characterized by high flow ability due to its near-spherical particle shape. About 25 to 30% of the entire quantity of residue generated during combustion of coal in thermal power plants constitutes large amount of fly ash, which is potentially hazardous for living organisms for various causes. Approximately for generation 1 MW electricity, 1 ton of coal is needed but it produces 35 to 45% fly ash as a byproduct (CPCB, 2006).

Fly ash can carry high levels of potentially toxic components like a V, Se, As, B, Al, Cd, Pb, Hg and Cr (Gupta et al., 2005). The bearing of these metals and metalloids in the fly ash leads to, alteration of enzymatic activities, degradation of membranes, proteins, nucleic acids and chlorophyll and increased peroxidation of lipids due to multiplication of free radicals (Dietz et al., 1999). These parameters are plant growth limiting factors (Wong and Wong, 1989). These components are also exacerbating the adverse result of fly ash on microbial populations in land and decrease their respiration and enzymatic activities which leads to loss of soil fertility (Meeta Gupta et al., 2002). Furthermore fly ash disposal sites are major source of debris which has potential impact on the ambient visibility, health hazard, and gives to the deterioration of surface and ground water quality. The problem is severe, huge quantity of fly ash is generated in thermal power plant. Thither is a demand to build up novel technologies for suitable disposal or the handling of ash and its effective recovery, reuse and recycling potential of fly ash.

2.0 Materials and Methods:

Fly ash leachate (FAL), soil, groundwater sampling and plant species (dominant vegetation was studied) were collected from the ash dumping sites and surrounding areas of Nashik Thermal Power Plant (NTPP) Nashik, India. The tasting was carried out in the month of October and November (post monsoon season).The polyethylene bags were used for the accumulation of plant stuff (leaves & petiole) and soil samples, whereas the groundwater and leachate were collected in plastic bottles. Total 17 no. of samples were collected in and round the thermal power plant for the assessment of heavy metals. The experiment was carried out for 5 soil samples, 4 groundwater samples, 5 plant species and 3 fly ash leachate samples. To examine the bioavailability of heavy metals, the plant species viz. *Cynodon dactylon* Pers., *Parthenium hysterophorus* Linn. *Cassia auriculata*. Linn. *Lantana camara* Linn., *Catharanthus roseus* Linn., were collected from the ash dumping ground. The leaves and petiole were separate and grid with the help of mortar and pestle after drying. All the samples were subjected to the heavy metal analysis in the lab. The plant material was washed with tap water thoroughly and sun dried for 2 to 3 days and soil samples were oven dried at 80oC for overnight. The dried samples were ground with mortar and pestle. The digestion was carried out for all samples by using 10 ml con. HNO3 andH2SO4 in 3:1 preparation and analysis of As, Cu, Cd, Pb, Hg and Zn were carried away by using AAS (Model: Elico SL – 168).

Image 1: Showing the Eklahare Thermal Power Plant and Fly ash Dumping Ground

3.0 Results and Discussion:

3.1 Characteristics of Fly Ash:

The characteristics of fly ash material are shown in table no. 1. The SiO2 ranges between 54.9 to 64.03% with an average of 59.465 ± 3.0%, Fe2SO3 ranges between 6.50 to 9.30% with an average 7.9 ± 0.9%. The Al2O2, CaO, MgO are ranging between 19.6 to 26.4%, 1.2 to 2.9% and 0.2 to 0.6% respectively, and average ranges between 23 ± 2.2%, 2.05 ± 0.1% and 0.4 ± 0.5% respectively. The average 3.33 ± 0.6% was done after ignition and 1.06 ± 0.6% remained as insoluble residue. In India, due to sulfur rich coal the pH was observed alkaline and the high salt content can increase the electrical conductivity (µs/cm). The water holding capability of Indian fly ash is 35.6 to 48.6 percent and the organic carbon content is between 1.2 to 1.9 percentages.

Table 1: Composition of fly ash used in this study

Sr. No.	Constituents	Fly ash (%)		Average (S.D)
1	SiO_2	54.9	64.03	59.465 ± 3.0
2	$Fe2O_3$	6.50	9.30	7.9 ± 0.9
3	Al_2O_3	19.6	26.4	23 ± 2.2
4	CaO	1.2	2.9	2.05 ± 0.1
5	MgO	0.2	0.6	0.4 ± 0.5
6	Loss on ignition	2.31	4.35	3.33 ± 0.6
7	Insoluble residue	0.12	2.00	1.06 ± 0.6
8	pH	0.84	9.6	5.22 ± 2.9
9	Electrical Conductivity	36.4	84.3	60.35 ± 16.0
10	Water Holding Capacity	35.6	48.6	42.1 ± 4.3
11	Organic Carbon	1.2	1.9	1.55 ± 0.2

Table 2: Availability of heavy metals in fly ash

Sr. No.	Metals	Bioavailability metal conc. In fly ash (ppm)		
		Min	Max	Average with SD
1	Arsenic (As)	18.86	21.01	19.93 ± 0.71
2	Copper (Cu)	0.23	1.54	0.88 ± 0.43
3	Cadmium (Cd)	1.34	2.12	1.73 ± 0.26
4	Lead (Pb)	0.17	1.24	0.70 ± 0.35
5	Mercury (Hg)	9.06	9.94	9.50 ± 0.29
6.	Zinc (Zn)	22.75	24.26	23.50 ± 0.59

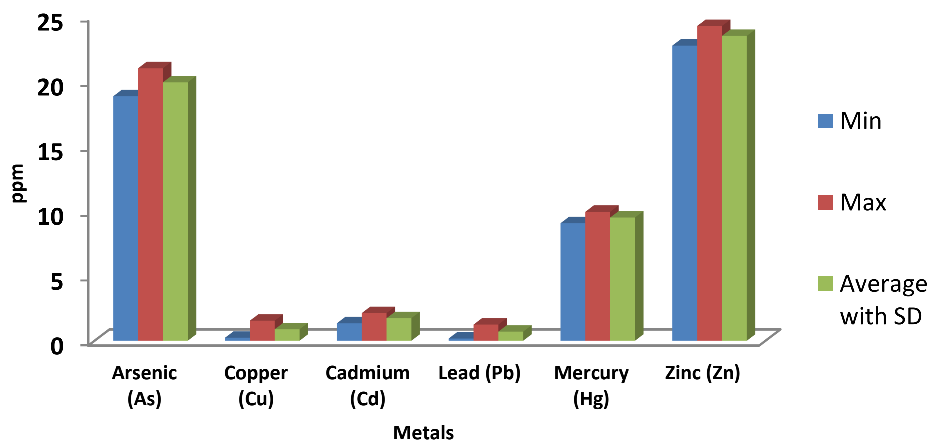

Fig 1 Occurrence of As, Cu, Cd, Pb, Hg and Zn in fly ash sample.

3.2 Heavy Metals in Fly Ash:

The high absorption of toxic elements presents in fly ash in the kind of hard metals. Cd, Cr, Ni, Pb and Zn are the metals enriched in fly ash, others have intermediate enrichment like Al, Fe, Mn, Mg, Si and V and Ca, Co, Cu, K, have equal amount in the fly ash (Annon, 2002). In the present study relative abundance of total heavy metals in fly ash was planted in order of As, Cu, Cd, Pb, Hg and Zn after complete acid digestion is summarized in table no. 2. The medium reach of these metals is 19.93 ± 0.71 ppm. 24.1 ± 0.43 ppm., 1.73 ± 0.26 ppm., 19.5 ± 1.35 ppm., 1.50 ± 0.29 ppm. and 23.50 ± 0.59 prospectively.

3.3 ***Bioavailability of Heavy Metals in Soil:***

The soil samples collected from nearby area of thermal power stations and the fields near to the fly ash disposal sites and subjected to the analysis of selected heavy metals contents such as As, Cu, Cd, Pb, Hg and Zn and were expressed in mg/100gmsoil samples. The total 5 sampling sites were taken for the assemblage of samples. The soil 1 to 5 was collected from the agricultural fields adjoining to the fly ash disposal sites come on the Nashik thermal power station. The collected samples were examined for the selected heavy metal ingredients and the outcomes were summarized in table no. 3 and 4 and Fig No. 2. In the soil samples one the arsenic, copper, cadmium, lead, mercury and zinc content were 3.32, 0.39, 1.24, 0.34, 20.51 and 7.39 mg/100gm found respectively. In soil simple to the average As, Cu, Cd, Pb, Hg and Zn content were found 4.16, 0.29, 1.30, 0.25, 15.64 and 8.50 mg/100gm soil respectively. It was observed that As, Cu, Cd, Pb, Hg, and Zn content found in soil sample three were 3.91, 0.24, 1.39, 0.23, 14.67 and 6.87 mg/100gm of soil respectively. In the soil sample four, the As, Cu, Cd, Pb, Hg and Zn metals found were 4.47, 0.32,1.57, 0.17, 21.74 and 9.00 mg/100gm soil respectively. While in soil sample five, the As, Cu, Cd, Pb, Hg, and Zn content were 3.97, 0.44, 1.27, 0.21, 19.71 and 7.65mg/100gm of soil respectively. It was noted that in the soil sample arsenic and zinc content were found comparable in higher quantity.

3.4 Bioavailability of Heavy Metals in Groundwater:

Details of results for ground water samples, which are obtained after the AAS detection was shown in table no. 5 and 6 and Fig No. 3. Mercury, zinc and arsenic content of different samples shows more bioavailability than cadmium, copper and lead. The values of Hg, Zn and As were found in the range of 1.96 ppm to 6.23 ppm, 3.78 ppm ato 4.36 ppm. and 5.14 ppm.to 10.04 ppm. respectively. While the concentration of Cd, Cu and Pb found in the range of 0.16 ppm to 0.25 ppm. and 0.06 ppm. to 0.09 ppm. Prakash and Sangita (2008) described the heavy metal pollution index of ground water of an open cast mine filled with fly which shows the availability of metals in groundwater after leaching. Prasad and Jaiprakash (1999) reported that the heavy metal pollution index of soil water from very near to mining area filled with fly ash was found to be 11.25. It argued that although the ground water at the study site was likely affected by leaching of heavy metals from the fly ash, it was not critically contaminated with respect to heavy metals. The different ground water samples collected from Parli Thermal power plant was contaminated with different pollutants, but the critical pollution index value of all the samples was low as compare to the standard values (Nalawade *et al., 2012)*

3.5 Assessment of Heavy Metals in Fly Ash Leachates:

The fly ash slurry disposal site has been selected for the study of occurrence of selected heavy metals viz. As, Cu, Cd, Pb, Hg and Zn in the leachate. The water accumulated in the shallow reason (fly ash pond) was selected for the study of selected heavy metals present in the leachate. The fly ash disposed pond near the Nashik thermal power station was selected and the leachate sample was gathered for analysis in the rainy time of year. The three samples were compiled for the metallic ingredient analysis. The outcomes were summed up in Table No. 7 and 8 and Fig. 4. The three leachate samples were compiled from the vicinity of fly ash disposal pond and analyzed for the different heavy metal substance. The arsenic contents were found 2.28, 2.98 and 2.80 mg/litre in three different samples. In the leachate sample number one to three the copper content were found 0.62, 0.51 and 0.59 mg/litre respectively. The cadmium content found in leachate sample one, two and three were found 1.62, 2.17 and 1.99 mg/l respectively. The lead, mercury and zinc content found in a leachate sample number one were observed 0.36, 1.49, 9.46 mg/l respectively.

The leachate sample number two was analyzed for lead, mercury and zinc metals and it was discovered that the mercury content were found 0.45, 1.75 and 8.97 mg/l respectively. The locate sample number three were subjected to analyze for the heavy metal content such as lead, mercury and zinc and the content found were 0.40, 1.30

and 8.57 mg/l respectively. In the present study of heavy metal contents present in the leachate sample collected from fly ash disposed ground, it was observed that As, Cu, Cd, Pb, Hg and Zn were found comparatively high in leachate samples. Singh *et al.,* (2012) study the leaching characteristics of different trace element from coal fly ash and ash disposal system of thermal power plants. He found that the leachability of elements increased with the leaching time. He also observed that the leaching of trace element is strongly depends on the pH of the fly ash. Sarode *et al.,* (2010) worked on extraction and leaching of heavy metals from thermal power plant fly ash and its admixtures. The different metals studied during the study were found below permissible limit and they may be safe for environmental disposal.

3.6 ***Assessment of Heavy Metals in Plants Samples:***

To study the accumulation and absorption of heavy metal ingredients in the plants, some plants growing on the disposed fly ash were selected. The fly ash disposal site near the Nashik thermal power station was attended for the occurrence of plants on dispose fly ash. From the observed plants, 5 species were selected for the metal content study in the dry weight of plant tissue. The five species of plants viz. *Cynodon dactylon* Pers., *Parthenium hysterophorus* Linn. *Cassia auriculata*. Linn. *Lantana camara* Linn., *Catharanthus roseus* Linn was selected for the study. The plants were gathered up, dried and unit weight was subjected for the acid digestion and then submitted to the analysis of selected heavy metals. The measures of heavy metals were extracted in the unit mg/GM dry weight of plant samples. The selected heavy metals such as arsenic, copper, cadmium, lead, mercury and zinc were the analysis of the dried plant tissue and the outcomes were summarized in the Table No. 9 and 10 and Fig 5.

The plant samples 1 was analyzed for the selected heavy metals such as arsenic, copper, cadmium, mercury and zinc and found 0.95, 0.27, 0.61, 1.06 and 2.88 mg/gm. of the dry weight of plant tissue respectively. The lead content was found below detectable limit in plant sample number 1. In the plant sample 2 the average heavy metal such as Cu, Cd, Pb, Hg and Zn content were 0.49, 0.70, 0.06, 4.31 and 1.97 mg/gm. of dry weight of plant tissue respectively. The arsenic content was found below detectable limit in plant sample number2. The Cu, Cd, Pb, Hg and Zn content found in the dried plant tissue sample number three were observed in 0.40, 0.91, 0.12, 1.22 and 2.59 mg/gm. respectively. The arsenic content was absent or found below detectable limit in sample number 3. It was observed that the As, Cu, Cd, Pb, Hg and Zn content in a plant sample number 4were found in 0.52, 0.37, 0.93, 0.10, 2.71 and 2.28 mg/gm. of dry weight of plant sample tissue. The As, Cu, Cd, Pb, Hg and Zn content found in the plant sample number 5were observed in 0.82, 0.22, 0.80, 0.14, 5.70 and 2.39 mg/gm. of dry weight of plant tissue. In the present study of arsenic, mercury and zinc content present in the different plant tissue collected from fly ash disposal pond were found comparatively high.

The Ni accumulation in tree *Cassia some* growing on fly ash was reported between 60 and 120 mg kg−1 (Tripathi *et al.,* 2004). Begonia et al., (1998) constitute the degree of metal ion accumulation depends on both sorts of metal and on the plant species. In the sake of plant species the concentration of several metals in the shoots can be different from those3 in the stems. The elements Fe, Zn, Cu and Mn accumulated in larger amounts in plants grown in 100% fly-ash was reported by Meetu Gupta et al., (2000). Pandey *et al.,* 2012 also studied the Lead accumulation in the plants and vegetables cultivated around coal mines and power plant of Singrauli District. He found that the Pb negatively affects the growth and productivity of the plants and vegitables.

Table 3. Occurrence of As, Cu and Cd in soil samples collected from surrounding of fly ash disposal site (mg/100 g)

Samples	Arsenic (As)				Copper (Cu)				Cadmium (Cd)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
Soil 1	3.21	3.42	3.32	0.10	0.37	0.41	0.39	0.02	1.04	1.45	1.24	0.20
Soil 2	4.01	4.32	4.16	0.15	0.27	0.31	0.29	0.02	1.26	1.35	1.30	0.04
Soil 3	3.74	4.12	3.91	0.19	0.23	0.25	0.24	0.01	1.39	1.40	1.39	0.005
Soil 4	4.29	4.65	4.47	0.18	0.32	0.33	0.32	0.005	1.56	1.59	1.57	0.015
Soil 5	3.74	4.21	3.97	0.23	0.41	0.48	0.44	0.035	1.21	1.33	1.27	0.06

Table 4. Occurrence of Pb, Hg and Zn in soil samples collected from surrounding of fly ash disposal site (mg/100 g)

Samples	Lead (Pb)				Mercury (Hg)				Zinc (Zn)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
Soil 1	0.30	0.38	0.34	0.04	20.01	21.01	20.51	0.5	7.31	7.40	7.39	0.04
Soil 2	0.24	0.26	0.25	0.01	15.60	15.69	15.64	0.04	8.45	8.42	8.50	0.04
Soil 3	0.17	0.29	0.23	0.06	14.31	15.04	14.67	0.36	6.85	6.97	6.87	0.06
Soil 4	0.15	0.19	0.17	0.02	21.49	21.99	21.74	0.25	8.93	9.08	9.00	0.07
Soil 5	0.19	0.24	0.21	0.02	19.27	20.15	19.71	0.44	7.61	7.95	7.65	0.18

Table 5. Occurrence of As, Cu and Cd in ground water samples collected from surrounding of fly ash disposal site (mg/litre)

Samples	Arsenic (As)				Copper (Cu)				Cadmium (Cd)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
G. Water 1	3.88	6.4	5.14	1.26	0.11	0.15	0.13	0.02	0.13	0.24	0.18	0.055
G. Water 2	7.88	9.22	8.55	0.67	0.04	0.05	0.04	0.005	0.22	00.28	0.25	0.03
G. Water 3	6.04	7.02	6.53	0.49	0.07	0.08	0.07	0.005	0.17	0.21	0.19	0.02
G. Water 4	9.78	10.3	10.04	0.26	0.05	0.06	0.05	0.005	0.14	0.18	0.16	0.02

Table 6. Occurrence of Pb, Hg and Zn in ground water samples collected from surrounding of fly ash disposal site (mg/litre)

Samples	Lead (Pb)				Mercury (Hg)				Zinc (Zn)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
G. Water 1	0.04	0.06	0.05	0.01	6.19	6.27	6.23	0.04	4.33	4.38	4.35	0.02
G. Water 2	0.03	0.07	0.05	0.02	1.21	1.64	1.42	0.21	3.75	3.82	3.78	0.03
G. Water 3	0.05	0.09	0.07	0.02	1.92	2.01	1.96	0.04	4.31	4.41	4.36	0.05
G. Water 4	0.04	0.07	0.05	0.015	2.63	2.94	2.78	0.15	4.03	4.12	4.07	0.04

Table 7 Occurrence of As, Cu and Cd in leachate samples collected from surrounding of fly ash disposal site (mg/litre)

Samples	Arsenic (As)				Copper (Cu)				Cadmium (Cd)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
Leachate 1	2.25	2.31	2.28	0.03	0.62	0.63	0.62	0.005	1.57	1.67	1.62	0.05
Leachate 2	2.96	3.00	2.98	0.02	0.49	0.54	0.51	0.025	2.10	2.25	2.17	0.075
Leachate 3	2.23	2.89	2.80	0.35	0.58	0.61	0.59	0.015	1.98	2.01	1.99	0.015

Table 8. Occurrence of Pb, Hg and Zn in leachate samples collected from surrounding of fly ash disposal site (mg/litre)

Samples	Lead (Pb)				Mercury (Hg)				Zinc (Zn)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
Leachate 1	0.34	0.39	0.36	0.02	1.48	1.50	1.49	0.01	9.43	9.48	9.46	0.02
Leachate 2	0.40	0.51	0.45	0.05	1.72	1.79	1.75	0.03	8.92	9.02	8.97	0.05
Leachate 3	0.39	0.42	0.40	0.01	1.29	1.32	1.30	0.01	8.52	8.62	8.57	0.05

Table 9. Occurrence of As, Cu and Cd in plant material gathered from surrounding of fly ash disposal site (mg/gm)

Samples	Arsenic (As)				Copper (Cu)				Cadmium (Cd)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
Plant 1	0.88	1.02	0.95	0.07	0.25	0.29	0.27	0.02	0.61	0.62	0.61	0.005
Plant 2	Bdl	Bdl	Bdl	Bdl	0.48	0.51	0.49	0.01	0.69	0.72	0.70	0.015
Plant 3	Bdl	Bdl	Bdl	Bdl	0.37	0.43	0.40	0.03	0.82	1.01	0.91	0.095
Plant 4	0.36	0.69	0.52	0.16	0.35	0.39	0.37	0.02	0.91	0.96	0.93	0.025
Plant 5	0.67	0.97	0.82	0.15	0.19	0.25	0.22	0.03	0.74	0.86	0.80	0.06

Table 10. Occurrence of Pb, Hg and Zn in plant material gathered from surrounding of fly ash disposal site (mg/gm)

Samples	Lead (Pb)				Mercury (Hg)				Zinc (Zn)			
	Min	Max	Ave.	SD	Min	Max	Ave.	SD	Min	Max	Ave.	SD
Plant 1	Bdl	Bdl	Bdl	Bdl	1.05	1.08	1.06	0.01	2.86	2.90	2.88	0.02
Plant 2	0.04	0.09	0.06	0.025	4.05	4.58	4.31	0.26	1.97	1.98	1.97	0.007
Plant 3	0.10	0.14	0.12	0.02	1.19	1.25	1.22	0.03	2.57	2.61	2.59	0.02
Plant 4	0.09	0.12	0.10	0.015	2.63	2.80	2.71	0.08	2.27	2.30	2.28	0.015
Plant 5	0.10	0.19	0.14	0.045	5.47	5.94	5.70	0.23	2.37	2.42	2.39	0.025

Bdl – Below detectable limit

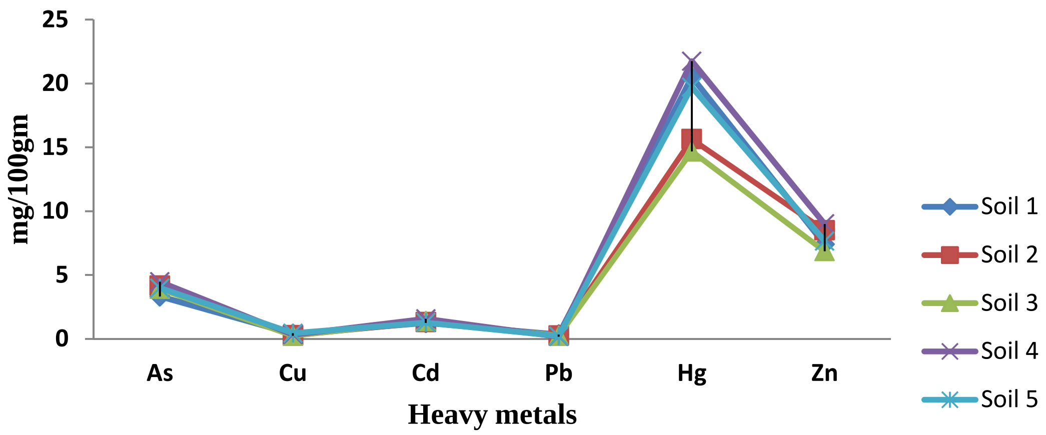

Fig 2 Occurance of As, Cu, Cd, Pb, Hg and Zn in soil samples collected form surrounding of fly ash disposal site

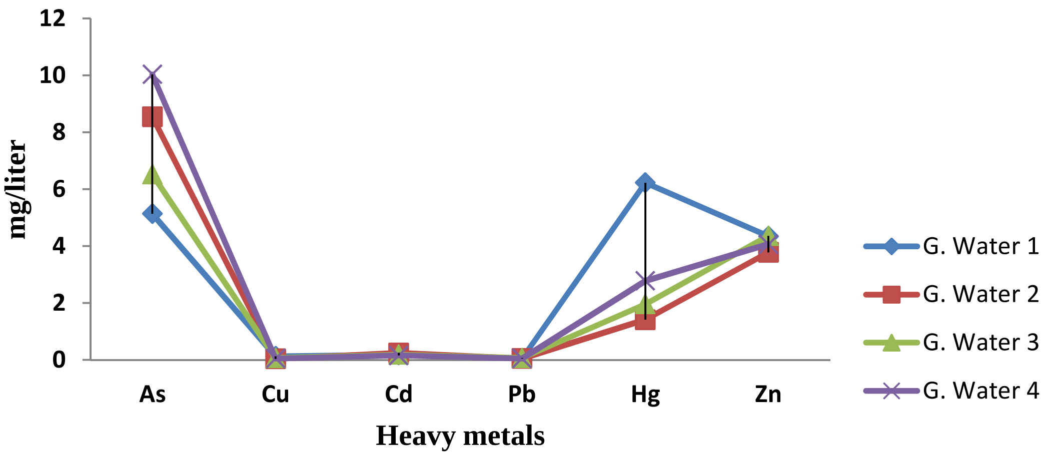

Fig 3 Occurance of As, Cu, Cd, Pb, Hg and Zn in ground water samples collected form surrounding of fly ash disposal site

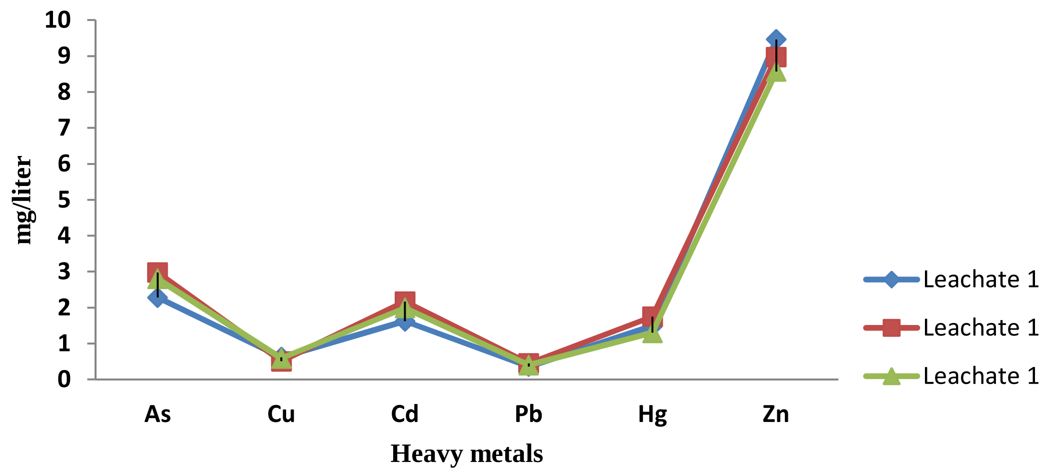

Fig 4 Occurance of As, Cu, Cd, Pb, Hg and Zn in leachate samples collected form surrounding of fly ash disposal site

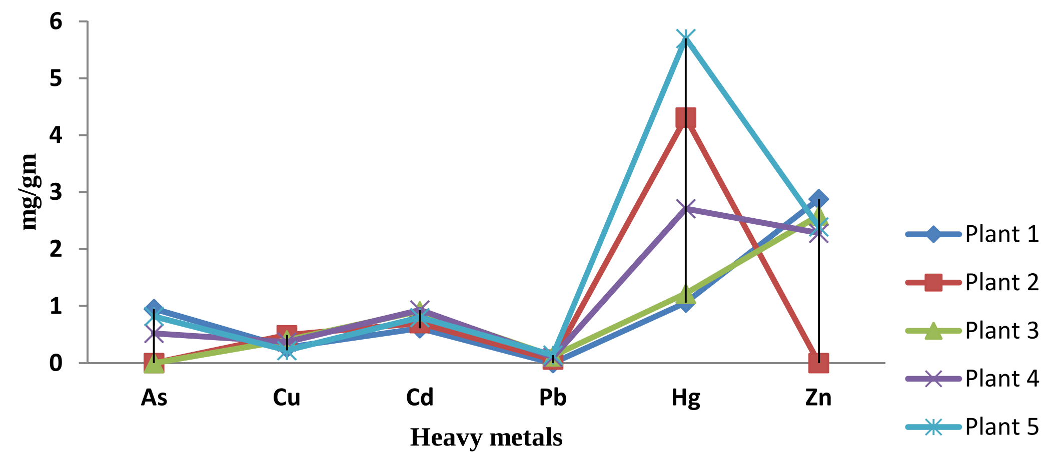

Fig 5 Occurance of As, Cu, Cd, Pb, Hg and Zn in dry weight of plant tissue samples collected form surrounding of fly ash disposal site

4.0 Conclusion:

The assessment of the metal shows that the fly ash dumping ground and surrounding area contains availability of different heavy metals which can be well recover, reuse and recycled. The metal availability also suggested heavy metal contamination in the surrounding region of thermal power plant which is harmful to the human life living in that country. There is need to develop some technology for the eco-friendly bioremediation of metal pollutants, because it is one of the latest technique which is useful to remediate such kind of problem.

5.0 Acknowledgement:

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