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Assessment of Groundwater and Surface Water Quality Indices for Heavy Metals nearby Area of Parli Thermal Power Plant

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Abstract:
The increasing heaps of fly ash generated from coal based thermal power plants become a concerning environmental issue. The fly ash is burned residue of coal which has alarming dimensions, open dumping of fly ash can creates environmental problems such as contamination of surface and groundwater resources by leaching process. During present the investigation the underground and surface water samples were collected from the surrounding areas of fly ash dumping site near Parli Thermal Power Station (PTPS). The heavy metal pollution index (HPI) of the underground and surface water samples shows that, concentration of certain heavy metals is above permissible limit. The heavy metals like As, Hg and Zn shows highest concentration, while metals such as Cu, Cd and Pb shows low concentration. The HPI of ground water were found comparatively low as compare with critical pollution limit of 100. The HPI of surface water near fly ash dumping site were ranged 5.56. The heavy metal pollution index indicates that leaching of fly ash contaminates the groundwater as well as surface water.

Keywords: Fly ash, Heavy Metal Pollution Index, ground water, surface water, Parli Thermal Power Station

1.0 Introduction:
The solid waste disposal has become severe problem in our country. Fly ash (FA) is generated from coal fired thermal power stations. About 70% of India's annual coal production is used in about 72 power generating plants and produce more than 90 million tons of coal ash per year. It is likely that it may cross over 100 million tons during 2001–2010 AD (Muraka *et al.,* 1987). Variety of trace elements, some of them potentially toxic and is transferred to the surrounding environment through different pathways (Goodarzi et al. 2008). The disposal of such huge quantity of fly ash is major problem, probably the leaching of pollutants into surface and ground water. The impact of coal ash leachates on receiving waters, apart from increased elemental concentrations cause changes in water pH with implications for trace element mobility (Carlson and Adriano, 1993).

Fly ash from Parli Thermal Power Station of the Maharashtra State Power Generation Co. Ltd. has been dumped in check dam constructed by PTPS. This is main source of leaching of different heavy metals in the surrounding area and it contaminates ground water and surface water resources. The different parameters of ground water and surface water has been analyzed from different water samples obtained from surrounding areas (1/2 km from fly ash dumping ground) of fly ash dumping ground or site. In the present paper the impact of fly ash leachate from parli thermal power station dumping site has been reported. The trace elements like As, Cu, Pb, Ni, Zn, Co, V, Sc, Be, Cs, and Zr have relatively high amount in Kolaghat ashes and these elements was significantly enrich the pond ash (Mandal and Sengupta, 2005).

2.0 Materials and Methods:
The water samples were collected form both surface and groundwater (from wells and bore well) resources in surrounding areas of Parli Thermal Power Plant (latitude 18°52'05.25" North and longitude 76°31'31.80" East) fly ash dumping sites by using plastic cans. All the samples are labeled properly for the indication of source of that sample. The groundwater and surface water samples were collected after the monsoon season, because most of pollutants are leached out in to water bodies

along with rain water. All the surface and groundwater sampling sites are situated at 300 to 500 meter away from the fly ash dumping ground. The fig. 1 shows satellite image of new Parli Thermal Power Plant and surrounding area. The collected samples were analyzed for different heavy metal content like As, Cu, Pb, Cd, Hg and Zn by using Atomic absorption spectrophotometer (Elico SL – 163). The digestion and concentration of different metals were carried out by using concentrated acids in 1:3 proportions H_2SO_4 and HNO_3 (Zeng Yei Hseu *et al.,* 2002).

The water quality indices are useful and relatively easy way to assess the composite influence of overall pollution. Quality indices make use of a reproducible series of judgments to compile the effects of all of the pollution parameters. For the heavy metal pollution index the method developed by Mohan *et al.,* (1996) was used. The average means concentration of the six heavy metal viz., As, Cu, Cd, Pb, Hg and Zn was used for the calculation of heavy metal pollution index. The critical pollution index considered unacceptable is 100. The Occurance of As, Cu, Cd, Pb, Hg and Zn in fly ash sample collected from thermal power plant was shown in table 1.

2.1 Heavy Metal Pollution Index:

For the calculation of HPI, the different parameters (metals) have great importance and they might extend the pollution index. The other parameters are also important as various parameters are depending on the intended use of the water. The metal such as Arsenic, Copper, Cadmium, Lead, Mercury and Zinc was used for the calculation of HPI.

The HPI is calculated form the following equation

$$\mathrm{HPI} = \frac{\sum_{n=1}^{n} WiQi}{\sum_{n=1}^{n} Wi}$$

Where *Wi* = Unite Weightage of ith parameters, *Qi* = Sub index of the ith parameter, *n* = is the number of parameters considered. Weighted arithmetic index method has been used for calculation of HPI. The unit weight (*Wi*) has been found out by using formula

$$Wi = \frac{K}{Si}$$

Where *K* = proportionality constant, *Si* = standard permissible value of ith parameter. The sub-index of *(Qi)* of the parameter is calculated by

$$Qi = \sum_{n=1}^{n} \frac{|Mi - Ii|}{Si - Ii}$$

Where Mi = is the monitored value of heavy metal of ith parameter, *Ii* = is the ideal value of ith parameter which is taken from the Indian drinking water specification (Indian Standard, 1991, IS 10500), *Si* = is the standard value of the ith parameter, in ppb. After completion of the result, the concentration of each pollutants of each pollutant was converted into HPI. The higher HPI value causes the greater the damage to the health. Generally, the critical heavy metal pollution index value is 100.

3.0 Results and Discussion:

The fly ash is one of the probable sources of heavy metal ingredients in soil, surface water and ground water resources. Therefore to get an idea about the intensity of heavy metal pollution the heavy metal pollution index of the selected study area was calculated. Surface water and ground water samples were taken for study to calculate the heavy metal pollution index. Rainy season was selected for the present study of determination of heavy metal pollution index at Parli thermal power station. The four sampling sites of surface water resources near the dumping sites were selected for the determination of selected heavy metal ingredients. The data monitored have been used to compute Heavy metal pollution index (HPI) using weighted arithmetic mean method and the proposed Pollution Index (HPI) seems to be applicable in the assessment of overall water quality with respect to heavy metal pollution (Mohan *et al,* 1996).

Table 1: Occurrence of As, Cu, Cd, Pb, Hg and Zn in fly ash sample collected from thermal power plant.

Metals	Occurrence of metal content in fly ash (mg/100gm)		
	Min	Max	Average with SD
Arsenic (As)	18.86	21.01	19.93 ± 0.71
Copper (Cu)	23.0	25.2	24.1 ± 0.43
Cadmium (Cd)	1.34	2.12	1.73 ± 0.26
Lead (Pb)	17.0	22.0	19.5 ± 1.35
Mercury (Hg)	1.06	1.94	1.50 ± 0.29
Zinc (Zn)	22.75	28.26	25.50 ± 2.59

Table 2: Concentration of As, Cu, Cd, Pb, Hg and Zn in ground water samples collected from surround of TPS.

Samples	Heavy Metals (ppm)											
	Arsenic		Copper		Cadmium		Lead		Mercury		Zinc	
	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
GW 1	5.14	1.26	0.13	0.02	0.18	0.05	0.05	0.01	6.23	0.04	4.35	0.2
GW 2	8.55	0.67	0.04	0.005	0.25	0.03	0.05	0.02	1.42	0.21	3.78	0.3
GW 3	6.53	0.49	0.07	0.005	0.19	0.02	0.07	0.02	1.96	0.04	4.36	0.4
GW 4	5.08	0.26	0.05	0.005	0.16	0.02	0.05	0.015	2.78	0.15	4.07	0.4

GW – Groundwater, Avg – Average Value of Heavy Metals, SD – Standard Deviation,

Table 3: Concentration of As, Cu, Cd, Pb, Hg and Zn in surface water samples collected from surround of TPS.

Samples	Heavy Metals (ppm)											
	Arsenic		Copper		Cadmium		Lead		Mercury		Zinc	
	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
SW 1	2.50	0.82	0.12	0.009	0.74	0.016	0.12	0.012	1.95	0.64	4.66	1.70
SW 2	1.81	0.90	0.11	0.009	0.22	0.014	0.04	0.009	1.27	0.54	2.51	0.64
SW 3	1.75	0.71	0.16	0.012	0.30	0.029	0.17	0.012	1.05	0.42	1.75	0.41
SW 4	7.88	0.26	0.21	0.008	0.52	0.010	0.10	0.029	2.75	0.93	3.59	0.85

SW – Surface water, Avg – Average Value of Heavy Metals, SD – Standard Deviation

Table 4: Heavy metal pollution index calculations for ground water sample number 1, based on Indian drinking water standards (IS: 1992, 10500)

Metal samples	Mean Conc. ppm (Mi)	Highest permitted value for drinking water (Si)	desirable maximum value (Ii)	Unit weightage (Wi)	Sub-index (Qi)	Wi x Qi
Arsenic	5.14	0.05	0.05	20	5.09	101.8
Copper	0.13	1.5	0.05	0.666	-0.9448	-0.6299
Cadmium	0.18	0.01	0.01	100	0.17	17
Lead	0.05	0.05	0.05	20	0	0
Mercury	6.23	0.001	0.001	1000	6.229	6229
Zinc	4.35	15	5	0.066	2.85	0.19

Σ *Wi* = 1140.73, Σ *WiQi = 6347.82*, HPI = 5.564694

Table 5: Heavy metal pollution index calculations for surface water sample number 3, (IS: 1992, 10500)

Metal samples	Mean Conc. ppm (Mi)	Highest permitted value for drinking water (Si)	desirable maximum value (Ii)	Unit weightage (Wi)	Sub-index (Qi)	Wi x Qi
Arsenic	1.75	0.05	0.05	20	11.7	234
Copper	0.16	1.5	0.05	20	0.075	1.517
Cadmium	0.30	0.01	0.01	100	0.29	29
Lead	0.17	0.05	0.05	20	0.12	2.4
Mercury	1.05	0.001	0.001	1000	10.49	10499
Zinc	1.75	15	5	0.2	0.575	0.115

Σ *Wi* = 1140.73, Σ *WiQi = 6347.82*, HPI = 5.564691

Fig. 1 The Satellite image shows New Parli Thermal Power Plant and surrounding area.

The four underground water samples were selected for the study of heavy metal content. The underground water sampling stations were selected from the adjoining area of the fly ash disposal sites. After the determination of heavy metal ingredients, the heavy metal pollution index was calculated. Heavy metal content such as arsenic, copper, cadmium, lead, mercury and zinc were detected from all water samples. The metallic ingredients were analyzed from the collected water samples and the results were summarized in Table number 2 and 3. The metal contents were analyzed during the rainy season and were used for the determination of heavy metal pollution index value. The concentrations of arsenic in the selected four ground water samples were ranges from 5.08 ppm to 8.55 ppm. The copper content present in ground water ranges from 0.04 ppm to 0.13 ppm in the selected samples. The cadmium content present in the ground water in vicinity of dumping sites was ranged from 0.16 ppm to 0.25 ppm. The lead content in the ground water samples were in the range of 0.05 ppm to 0.07 ppm. The mercury and zinc content in the ground water samples were ranges from 1.42 ppm to 6.23 ppm and 3.78 ppm to 4.36 ppm respectively.

The concentration of arsenic in the selected four surface water resources near the fly ash dumping sites was ranged from 1.75 ppm to 7.8 ppm. The copper content present in surface water ware ranges from 0.11 ppm to 0.21 ppm. The cadmium content present in 4 water samples was ranged from 0.22 ppm to 0.74 ppm. The lead contents were ranged from 0.04 ppm to 0.17 ppm. The mercury content was ranged from 1.05 ppm to 2.75 ppm. The zinc content was ranged from 1.75 ppm to 4.66 ppm selected four water resources adjoining to the fly ash dumping site near Parli thermal power plant. Baba and Gurdal (2006) reported that several toxic trace elements such as arsenic (As), cadmium (Cd), copper

(Cu), lead (Pb), zinc (Zn), selenium (Se) and mercury (Hg) were determined in Can fly ash. The concentrations of As, Cd, Cu, Pb, Zn, Se and Hg are 71.6 x 10^{-6}, 0.3 x 10^{-6}, 71.2 x 10^{-6}, 38.8 x 10^{-6}, 117.6 x 10^{-6}, 3.8 x 10^{-6} and 0.22 x 10^{-6}, respectively.

After the determination of selected heavy metal content in ground and surface water resources, the collected data was used for the calculation of heavy metal pollution index by using permissible limits of heavy metal for drinking water and permissible limit for occurrence in natural water resources. By using the statistical formulas and methodology heavy metal pollution index for ground water and surface water resources for the selected sampling sites were determined. The calculations of heavy metal pollution index for the representative samples of ground and surface water were summarized in table no. 4 and table 5. In the present observation near the Parli thermal power station the heavy metal pollution index of ground water and surface water resources near fly ash dumping sites were more or less constant and present up to 5.5 index value. The HPI of ground water and surface water samples collected from surrounding fly ash dumping ground are shown in Table 3 and 4, it was totally based on mean concentration of all selected metals for all sampling points. The HPI for the samples collected in the month of October and November was 5.56 approximately, which is low as compare with critical pollution index value of 100? Very less work has been done on HPI related to fly ash dumping site but, Prasad and Jaiprakash (1999) studied the mining area filled with fly ash and found to be 11.25 while Prasad and Sangita (2008) reported 36.67 which is below critical index.

4.0 Conclusion:

Heavy metal pollution index is useful tool in evaluating overall pollution of ground as well as surface water pollution. The results indicated that leachate from the fly ash dumping site has apparently contaminated the ground water and surface water bodies. The HPI of ground water and surface water samples collected from surrounding fly ash dumping ground is low as compare with critical pollution index value of 100. It has been observed that, the higher the heavy metal pollution index value, greater the threat to the living organism consuming contaminated water generally, the critical heavy metal pollution index value.

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References:

1) Alper Baba and Gulbin Gurdal (2006): Concentrations of heavy metals in fly ash from CAN coal combustion thermal power plant (Canakkale-Turkey)-II. *Chinese Journal Geochemistry,* 25: Supplement 1: 53.
2) Bably Prasad and Kumari Sangita (2008): Heavy Metal Pollution Index of Ground Water of an Abandoned Open Cast Mine Filled with Fly Ash: a Case Study. *Mine Water Environ.,* 27: 265–267.
3) Carlson, C. L., & Adriano, D. C. (1993): Environmental impacts of coal combustion residues. *Journal of Environmental Quality,* 22: 227–247.
4) Goodarzi F, Huggins FE, Sanei H (2008) Assessment of elements, speciation of As, Cr, Ni and emitted Hg for a Canadian power plant burning bituminous coal. *Int J Coal Geol* 74:1–12.
5) Indian Standard (1991): Bureau of Indian Standards drinking water specifications IS 10500: 1991, New Delhi, India.
6) Mandal A, Sengupta D (2002) Characterisation of coal and fly ash from coalfired thermal power plant at Kolaghat—possible environmental hazards. *Indian J Environ Prot* 22(8):885–891.
7) Mohan, S. V., Nithila, P. and Reddy S. J. (1996): Estimation of heavy metal in drinking water and development of heavy metal pollution index. *J Environ Sci Health,* A 31(2): 283–289.
8) Muraka, I. P., Boyd, R. H. and Harbert, H. P. (1987): Solid waste disposal and reuse in the United States (ed.) I P Muraka (Boca Raton F L: CRC Press Inc.), 95.
9) Prasad, B., and Jaiprakas, K. C. (1999): Evaluation of heavy metals in ground water near mining area and development of heavy metal pollution index. *J Environ Sci Health* A 34(1): 91–102.
10) Trivedy, R. K., Goel, P. K. and Trishal, C. L. (1987): Practical Methods in Ecology and Environmental Science. Enviro Media, post box 60, Karad - 415110, India.
11) Zeng-Yei Hseu, Zueng-Sang Chen, Chen-Chi Tsai, Chun-Chih Tsui, Shuang-Fu Cheng, Chyan-Lan Liu And Haw-Tarn Lin. (2002). Digestion methods For Total Heavy Metals In Sediments And Soils. *Water, Air, And Soil Pollution,* 141: 189–205.