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Spatial Assessment of Trace Metals in Groundwater Around Udupi Thermal Plant, India

Dr. H. N. Udayshankar
Professor, Department of Civil Engineering,
MIT, Manipal University,
Manipal - 576104, Karnataka, India
E-mail: udayahn@gmail.com

Vincellin Vincent
M.Tech,
Department of Civil Engineering,
MIT, Manipal University,
Manipal - 576104, Karnataka, India
E-mail: vincellin@gmail.com

Dr. K Balakrishna
Associate Professor
Department of Civil Engineering
MIT, Manipal University,
Manipal - 576104, Karnataka, India
E-mail: kbalak@gmail.com

Nishitha D'Souza
M.Tech
Department of Civil Engineering
MIT, Manipal University,
Manipal - 576104, Karnataka, India
E-mail: udayahn@gmail.com

Y Praveen Kumar Reddy
Senior Research Fellow
Department of Civil Engineering
MIT, Manipal University,
Manipal - 576104, Karnataka, India
E-mail: ypraveen21@gmail.com

Minal Gune
Research Scholar
Department of Civil Engineering,
MIT, Manipal University,
Manipal - 576104, Karnataka, India
Email: minugune@gmail.com

ABSTRACT
Udupi Power Corporation Limited (UPCL) is a coal based thermal power station in Karnataka, India, established in 2008. The fly-ash which is produced in the process of burning coal to produce power contains trace metals which are toxic in nature. A study is carried out to assess the concentration of zinc, cadmium, lead, copper, nickel and cobalt in groundwater around the thermal power plant at a radius of 10km. Groundwater from open well at an interval of 1km is taken along north, east and south regions. The water samples were tested for the pH, conductivity and onsite using Hach HQ40D multi-Parameter and trace metal concentration using Metrohm Voltammetry 797 with anodic striping. The trace elements were found to be higher on the eastern region.

Keywords
Thermal power plant, Trace metals, groundwater pollution

1. INTRODUCTION
The coal used as a raw material in production of electricity in thermal power plants, has impurities that are harmful to human health, animals, vegetation and the surrounding ecosystem [1] [2] [3]. When the coal is burned it undergoes thermal decomposition, fusion, disintegration and agglomeration. A portion of the metals present in the volatile form vaporizes and the major portion forms slag or bottom ash, the rest is given out as fly ash [4].

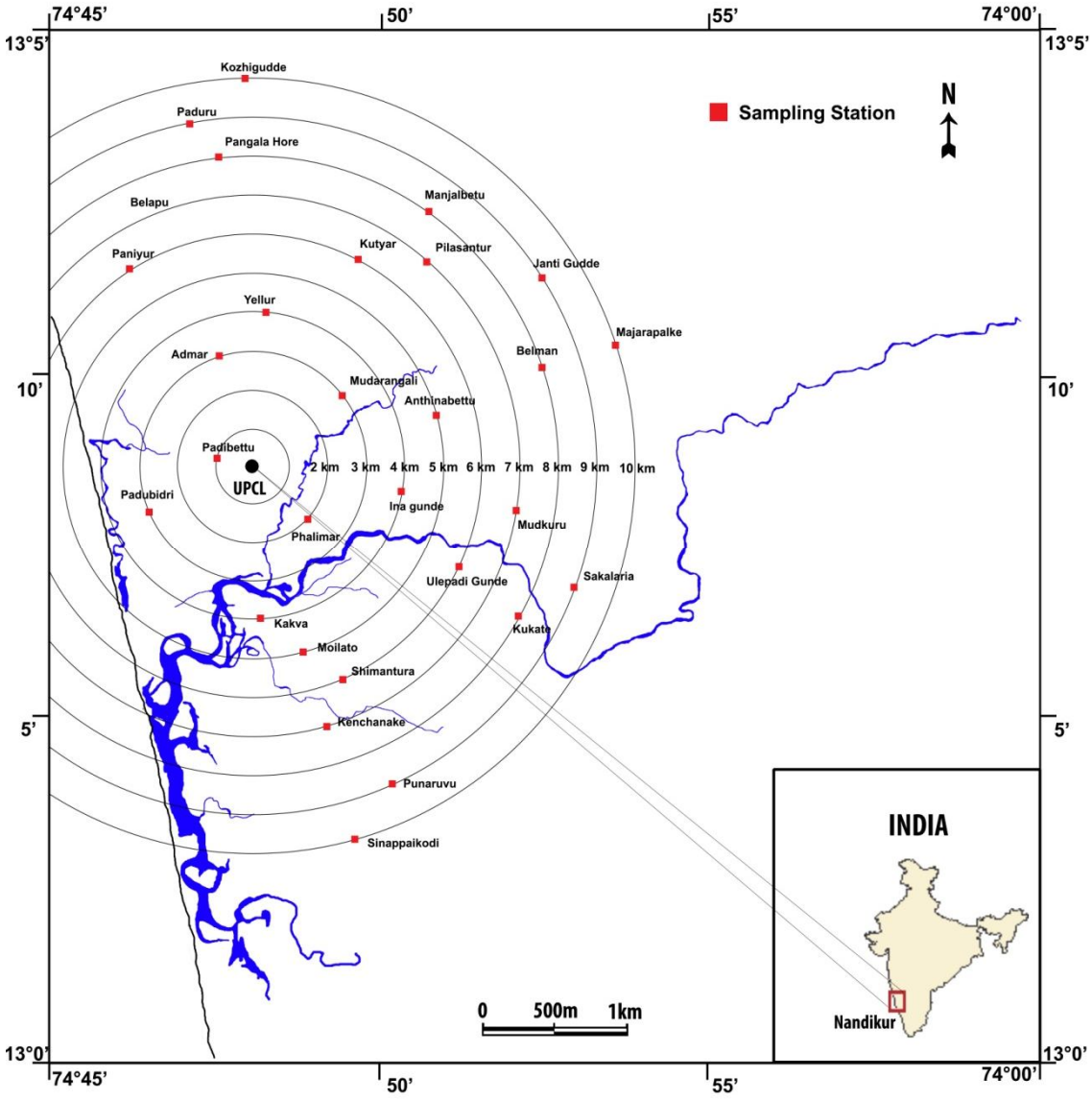
The fly ash possess serious threat to the environment The main constituents of fly ash are silica (SiO_2), alumina (Al_2O_3), ferric oxide (Fe_2O_3), magnetite (Fe_3O_4), Titanium dioxide (TiO_2), quick lime (CaO) and toxic trace elementals such as zinc (Zn), cadmium (Cd), lead (Pb), copper (Cu), nickel (Ni), arsenic (As) and cobalt (Co) which effect the soil, surface water and ground water [5]. Trace metals are essential as nutrition for human metabolism in minute quantities [6]. When the concentration increases it becomes toxic in nature and leads to various health related issues [7]. The trace elements enters the environment via atmospheric emission from the stack and leaching of bottom ash from the ash ponds. The objective of this paper is to assess the trace metal concentration of Zn, Cd, Pb, Cu, Ni and Co in groundwater around Udupi thermal power plant.

2. STUDY AREA
The study area is 10 km radius around UPCL (13°9′35″N, 74°48′0″E), situated north of Mangalore, around 8 km from the coast. It is 20m – 40m above mean sea level. It is a coal based thermal power station in Nandikur, Karnataka, India, established in 2008. It has an installed capacity of 1200 MW (2x600). The plant became fully operational in September 2012. About 2.2 million tons of coal per annum is imported from Indonesia (UPCL website). In August 2014, Lanco Infratech sold this power plant to Adani Power. Its power is distributed to Karnataka (90%) and Punjab (10%).

3. MATERIALS AND METHODS
3.1 Sampling
The study was carried out during monsoon season in the month of October. The sampling station is taken at an interval of 1km radius from UPCL to understand the spatial variation of trace metals in ground water. The groundwater samples were drawn from thirty different open well (Fig. 1). Only water from frequently used open well were taken to prevent sampling of stagnant water. The sampling stations are taken along the north, south and east direction. The west side is avoided as it is closer to the costal side and chance of contamination from the harbor region is more prevalent.

3.2 Sampling Preparation
The water samples were collected in a 1 litre polypropylene (PP) bottles which were acid washed with nictric acid (10 percent) and Mili-Q water (Millipore make), and dried in a laminar flow chamber to avoid contamination. While collecting water from the open well plastic buckets were used. The bucket was immersed thrice to get a well-represented water sample. Then the bottles were covered with a polythene bag and later carried to laboratory for further processing.

Figure 1. Study area map showing the sampling station around UPCL



3.3 Methodology

The pH, total dissolved solids (TDS) and conductivity is measured onsite using Hach HQ40D multi-Parameter. Then the samples were filtered in the lab using a Nalgene vacuum filtration system with a Sartorius acetate cellulose filter paper (47mm diameter and 0.45µm pore size). 50ml of the water was acidified and used for trace metal analysis which is carried out using anodic striping voltammetry, Metrohm 707. The remaining water sample is acidified below 2 pH with ultrapure nitric acid and stored in the acid rinsed PP bottle to arrest bacterial growth. The water sample were then refrigerated at 4°C to preserve for future reference.

Table 1. Water Sample Analysis

S.No.	KM	Zone	Name	pH	TDS (ppm)	Conductivity (µs/cm)	Zinc (ppb)	Cadmium (ppb)	Lead (ppb)	Copper (ppb)	Nickel (ppb)	Cobalt (ppb)
1	2	NE	Padibettu	5.39	15.85	36.00	257.28	0.93	6.75	23.44	24.70	3.69
2		SE	Phalimar	6.49	47.40	106.60	193.48	0.94	7.10	23.01	15.11	1.81
3	3	NW	Mudrangali	4.85	427.00	192.00	149.93	0.97	7.86	24.97	15.88	1.99
4		NE	Padubidri	5.38	28.80	65.90	148.86	0.96	8.35	28.67	16.73	3.40
5	4	NE	Admar	6.30	49.40	113.30	140.96	1.02	7.65	26.74	21.57	1.30
6		NE	Yellur	5.61	47.10	99.90	109.47	0.91	7.24	27.25	17.09	1.78
7		NW	Inna Gunde	5.92	43.90	101.10	87.95	0.89	6.50	23.33	15.35	1.77
8		SE	Atikaribettu	6.20	101.90	232.00	116.96	1.00	7.42	28.19	15.53	1.80
9	5	NW	Anthinabettu	5.81	58.20	133.50	108.31	0.95	7.29	27.45	31.90	2.15
10		SE	Moilottu	5.48	61.20	140.00	107.00	0.98	7.12	26.01	13.28	1.53
11	6	NE	Paniyar	6.17	48.60	111.40	147.92	0.94	6.93	27.24	21.05	1.73
12		NW	Kutyar	5.79	24.30	56.20	206.12	1.89	8.68	25.60	16.50	1.80
13		SE	Ulepadi Gunde	5.50	24.70	56.90	143.89	1.01	7.18	26.95	15.30	1.71
14		NE	Panjanedka	5.34	22.20	51.10	155.73	1.16	7.79	26.48	17.52	1.90
15	7	NE	Belepu	4.95	44.50	102.40	142.60	0.97	8.63	28.80	15.83	2.69
16		NW	Pilasanthur	5.68	20.70	41.60	65.39	0.50	4.61	13.24	18.25	1.93
17		SE	Mundkuru	6.40	66.10	151.50	133.01	0.93	6.80	24.94	15.38	1.42
18		SE	Shimantura	6.29	61.30	140.30	108.65	0.94	6.85	27.90	17.01	1.72
19	8	NE	Pangala Hore	6.00	51.70	118.60	115.55	0.99	7.30	26.70	15.36	1.71
20		NW	Majalbettu	6.07	13.26	30.70	137.59	1.08	7.46	40.90	21.75	1.94
21		NE	Belmun	5.12	81.60	86.30	285.76	0.92	17.37	20.39	24.27	3.04
22		SE	kukkatte	5.48	15.98	37.10	250.90	0.94	8.57	22.79	15.05	1.63
23		SE	Kenchanakere	5.52	26.60	61.40	194.66	0.92	7.30	21.22	14.21	1.55
24	9	NE	Paduru	5.25	30.70	70.80	223.79	0.94	7.11	20.00	14.43	1.94
25		NW	Janti Gunde	5.03	12.84	29.80	223.05	0.94	7.71	22.79	16.38	1.96
26		SE	Sankalakaria	5.81	57.90	132.80	170.11	1.00	7.20	23.43	46.71	3.43
27		SE	Punaruvu	5.67	32.20	76.40	232.10	0.99	7.73	23.63	17.14	1.60
28	10	NW	Kazhigudde	5.34	75.30	172.30	244.74	1.01	8.06	24.69	34.21	2.46
29		NW	Majarapalke	5.81	43.60	100.50	220.14	0.95	7.59	23.94	14.47	1.13
30		SE	Sinappaiyakodi	5.71	31.30	72.20	197.42	1.00	7.03	40.08	19.25	1.97

Table 2. Descriptive statistic value

Parameter	Stations	Min.	Max.	Mean	Std. Deviation
pH	30	4.85	6.49	5.6787	.43582
TDS	30	12.84	427.00	55.537	73.42232
EC	30	29.8	232.0	97.353	49.8504
Zinc	30	65.39	285.76	167.22	57.66555
Cadmium	30	.504	1.891	.985	.205513
Lead	30	4.612	17.365	7.744	2.044088
Copper	30	13.239	40.896	25.761	5.304148
Nickel	30	13.276	46.706	19.240	7.161938
Cobalt	30	1.127	3.687	2.016	.629981

Table 3. Detailed analytical value

Parameter	Zones	N	Min	Max	Mean	Std. dev.
pH	NE	10	4.95	6.3	5.551	0.4578
	NW	9	4.85	6.07	5.58	0.41
	SE	11	5.48	6.49	5.86	0.39
TDS	NE	10	15.85	81.6	42.045	18.76
	NW	9	12.84	427	79.1	131.87
	SE	11	15.98	101.9	47.87	24.97
EC	NE	10	36	118.6	85.57	28.41
	NW	9	29.8	192	95.3	60.9
	SE	11	37.1	232	109.74	56.57
Zn	NE	10	109.5	285.76	172.79	60.73
	NW	9	65.38	244.72	160.35	65.49
	SE	11	107	250.9	172.55	52.28
Cd	NE	10	0.9	1.15	0.97	0.07
	NW	9	0.504	1.89	1.02	0.36
	SE	11	0.915	1.2	0.971	0.08
Pb	NE	10	6.75	17.36	8.51	3.16
	NW	9	4.61	8.68	25.21	7.12
	SE	11	6.531	8.809	7.39	0.718
Cu	NE	10	19.99	28.8	25.57	3.19
	NW	9	13.23	40.89	25.21	7.12
	SE	11	21.21	58.01	29.45	10.73
Ni	NE	10	14.42	24.7	18.85	2.74
	NW	9	14.47	44.21	20.52	7.43
	SE	11	13.27	46.7	18.54	9.47
Co	NE	10	1.3	3.68	2.31	0.82
	NW	9	1.12	3.45	1.9	0.35
	SE	11	1.42	3.43	1.83	0.54

4. RESULTS AND DISCUSSION

The analysis result of the water sample is tabulated in table 1. The samples analyzed were classified into three zones; north-west (NW), north-east (NW) and south-east (SE) with 9, 10 and 11 samples respectively to make interpretation easier.

According to Indian Standards (IS) 10500:2004 for drinking water, the desirable limit for pH is 6.5-8.5, beyond this will effect the mucous membrane. The maximum and mean level of total dissolved solids is within the drinking standards (500 mg/l). Conductivity is in direct proportion to the total dissolved solids.

The values of zinc, cadmium, lead, nickel, cobalt and copper are well within the desirable limits. The groundwater can't be said safe for drinking although the trace metals are within the permissible limits because there are chances of pathogens present. Table 2 and table 3 give statistical values of the samples.

The north east and south east regions exhibit similar level of pollution (table 1). From table 3, it is evident that eastern sides of the thermal plant is more polluted then the western side. This can be because of the wind direction is towards east
most of the time [9] [10]. This may carry the fly-ash towards the eastern side.

It is also noted that Zinc is present in high concentration. The order of concentration of trace metals is as follows Zn > Cu > Ni > Pb > Co > Cd.

5. CONCLUSION

This shows that the groundwater around the UPCL is not contaminated yet, but there are chances of future contamination as the trace metals don't decompose fast and are bio-accumulative. The study concludes that the effect on ground water is within the permissible limits. The work can be further expanded by studying the effect on soil.

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