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Trace metals and Environmental Impact of Fly ash on Marine sediment in Tuticorin Coastal area, Tuticorin, Tamil Nadu, India

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Abstract

Major non-degradable pollutants of thermal power plants are heavy metals present in ash. Arsenic, barium, copper, molybdenum and zinc are normally present in fly ash, besides these lots of other metals are also present in traces. Therefore, the problems related with their safe management and disposal has become a major challenge. Heavy metals cannot be degraded biologically like other organic waste. A study was conducted to investigate the impact of fly ash pollution from Tuticorin thermal power plant in Tuticorin coast area. Sediment samples were collected from three different stations in and around 5 km of ash slurry discharge point of power plant. Trace elements of Cu, Fe, Pb were found high in station 1 due to ash slurry discharge. The results of the present study suggested the need for a regular monitoring program of the help to improve the sea water quality.

Keywords: Fly ash, tuticorin coast, sediment, traces elements, sea water quality.

Introduction

Heavy metals are considered a major anthropogenic contaminant in coastal and marine environments worldwide[1]. Thermal power plant generates large amounts of fly ashes which contain toxic metals and environmental risks. In India, about 75% of the electricity is generated by coal-based thermal power plants. Thermal power plant is one of the industries that produce 6.5×10^7 tons per year of fly ash as a by-product[2]. The Tuticorin Thermal Power station (TTPS) utilized 18,000 tons/day of coal and contributed an important pollutant of fly ash[3].

The distribution of heavy metals in the soil is probably controlled by both geogenic and anthropogenic factors[4,5] Heavy metals in the sediment are essential to assess the extent of metal pollution. Today contamination of water by toxic heavy metals resulting from the discharge of industrial wastewater is a worldwide environmental problem[6].

The distribution of heavy metals in solution has widely been recognized as a major factor in the geochemical behavior, transport and biological effects of these elements in natural waters[7-11]. Moreover, sediment has aptly been called as 'Trace element traps[12] because they eventually receive almost all the heavy metals, which enter the aquatic environment[9]. Sediment samples have also been widely used to monitor heavy metal pollution in coastal areas[11,13]. The present study deals with the impact of trace elements of fly ash in marine sediments of Tuticorin coastal area.

Collection of samples: A collection of soil samples from three stations of Tuticorin sea water in and around the Thermal power plant of 5 km. The grab sediment samples were collected during the period from July 2014 to December 2014 by standard procedure and collected in polythene bags. Analysis of sediments was carried out for the trace elements by the standard procedure.

Study area: Tuticorin Thermal power plant is located along the Tuticorin coast. Three stations were fixed in the outlet water of slurry ash coming from the power plant into the coastal water.

Station 1 - Ash slurry discharge point (08° 46' 379"N & 078° 10' 660"E).

Station 2 - 2 km away from the ash slurry discharge point. (08° 47' 164"N & 078° 10' 579"E).

Station 3 - 3 km away from station 2 (08° 47' 833"N & 078° 10' 260"E).

Material and Methods

Sediment samples were collected from three stations using grab and samples were transferred to prewashed glass wares and kept in an oven at 80°C±1°C till complete dryness. Dried samples were then ground with mortar and pestle into fine powder. Then sieved through a 102 µ mesh size sieve, weighed out 1 g and sieved samples in triplicate[14] put into 100 ml digestion flask. Samples were digested with 9 ml concentrated HNO_3 and 1 ml of perchloric acid over a hot plate, heated the samples until the solution become clear. Then it was cooled, filtered through Whatmann No.1 filter paper and made up to 25 ml in a volumetric flask. The made up samples were stored in prewashed polythene bottles and analyzed for various metals on an Atomic absorption Spectroscopy (AAS; Elico-SD 164 India). Blank was also prepared by addition of same quantity of reagents without sediment.

Results and Discussion

Table-1 showing the amount of trace elements present in the sediment samples. The trace metals content in the polluted sediment samples were taken and compared with the results from unpolluted sediment samples.

Figure-1
Sample Collection from the study area

Table-1
Mean and Statistical analysis of trace metals μg g^{-1} in sediment

Elements μg g^{-1}	Month	S1	S2	S3	Statistical analysis	
					Mean	SD
Cu	July	19.9	22.34	19.31	20.516	1.3115
	Aug	25.2	23.2	20.5	22.966	1.9258
	Sep	27.5	25.7	26.4	26.533	0.7408
	Oct	20.9	29.4	14.5	21.6	6.1030
	Nov	32.4	27.5	26.4	28.766	2.6081
	Dec	34.5	24.7	28.5	29.233	4.0342
Fe	July	2637.75	2244	2060	2313.91	240.99
	Aug	2712.25	2090	1992	2264.75	318.949
	Sep	3600	2925.2	2545	3023.4	436.263
	Oct	2890	2545	2240.2	2558.4	265.448
	Nov	3990.5	2100.2	2215.4	2768.7	865.22
	Dec	3150.4	2547.5	2145.5	2614.46	412.97
Pb	July	25.4	21.48	13.7	20.193	4.8623
	Aug	23.7	21.4	13.2	19.433	4.5065
	Sep	22.8	00	21.5	22.15	0.65
	Oct	27.5	22.5	14.5	21.5	5.3541
	Nov	39.6	23.6	20.5	27.9	8.3693
	Dec	22.4	27.5	22.6	24.166	2.3584
Cd	July	0.17	0.24	0.15	0.1866	0.0385
	Aug	0.14	BDL	0.19	0.165	0.025
	Sep	00	0.123	0.115	0.119	0.004
	Oct	00	0.132	0.19	0.161	0.029
	Nov	0.163	0.12	0.192	0.1583	0.0295
	Dec	0.15	0.35	0.30	0.2666	0.0849

S1= Station 1, S2 =Station 2, S3 =Station 3, SD= Standard Deviation

Trace metals: Copper: Copper content ranged from 19.31 µg g^{-1} to 34.5µg g^{-1} shown in figure- 2. Maximum level was recorded at station 1 slurry ash discharge point in December 14' and minimum level was encountered in June 14'at station 3, which was located 5 km away from the ash slurry discharge point are shown in table-1. Sediments having higher concentration of Cu than 60µg g^{-1} are classified by the EPA as contaminated sediments[15]. The concentration of the copper in three study areas were less than 34.5µg g^{-1} are shown in table-1, these sediments can be considered uncontaminated with the elements.

Iron: Iron content was ranged from 1992 to 3995µg g^{-1} shown in figure-3. Station 1, which is the slurry ash discharge point showed the maximum level of iron in November 14' and station 3 showed the minimum level in August 14'. The fly ash composition contains high amount of iron which changed the iron content in the discharge site, so maximum value was recorded in station 1. Baskaran et al.[16] also observed high concentration of Fe, Cu and Zn in the sediment at fly ash dumping dyke at Tuticorin Thermal Power Plant.

Lead: Concentration of Lead varied from BDL to 39.6µg g^{-1} shown in figure-4. The minimum value of lead in September 14' at station 2, which is 2 km away from the discharge point and maximum in July 14 at station 3 were recorded. Around 50-60 % Pb is estimated to be in surface association in fly ash[17], although the findings that the majority of Pb is probably associated with the internal galaxy matrix of fly ash, and is therefore not leached even under extended acidic weathering. In the months of October 14' and November 14' (monsoon) the maximum value of lead was recorded and in August 14' and September 14' (pre-monsoon) the minimum value was recorded. Lead is a dangerous element; it is harmful even in small amount.

Cadmium: Cadmium content was ranged from BDL to 0.35µg g^{-1} shown in figure-5. The higher level of cadmium content was recorded in December 14 at station-2.The slurry ash discharge point of station-1 showed only lower value, cadmium may leached from the sediment and showed the lower value. Leaching of Cd from Israeli fly ash was shown also in laboratory experiments with sea water[18], at the dump site[19] and even from stabilized coal fly ash/cement blocks after 33 months deployment at sea[20].

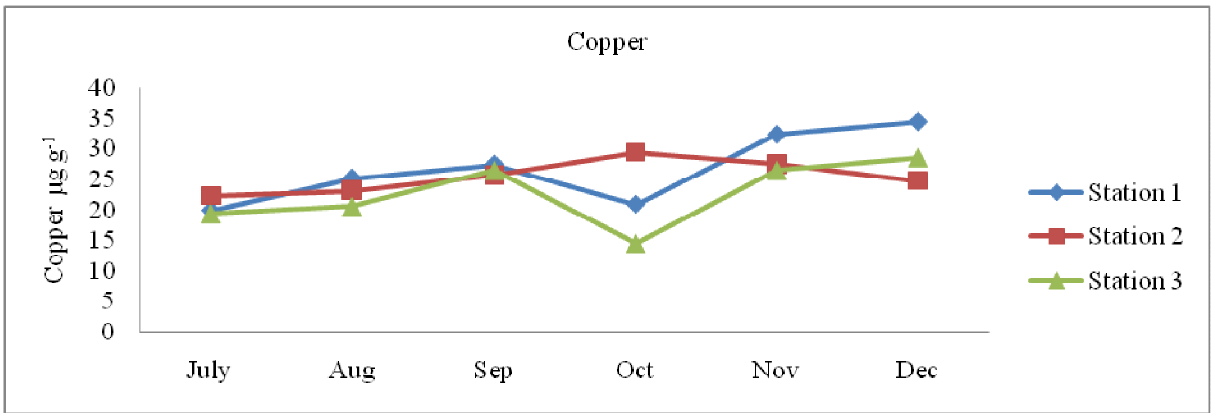

Figure-2
Monthly variation of Copper in sediment

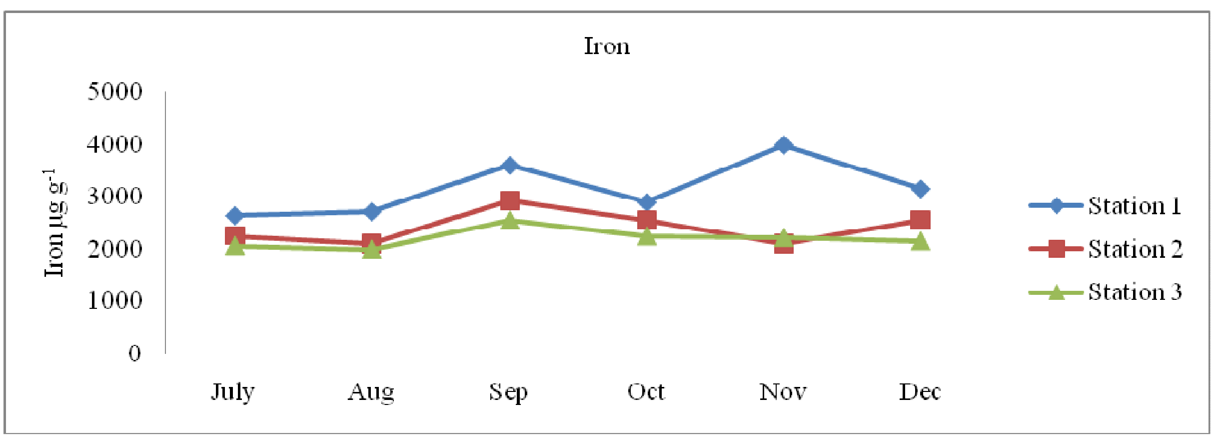

Figure-3
Monthly variation of Iron in sediment

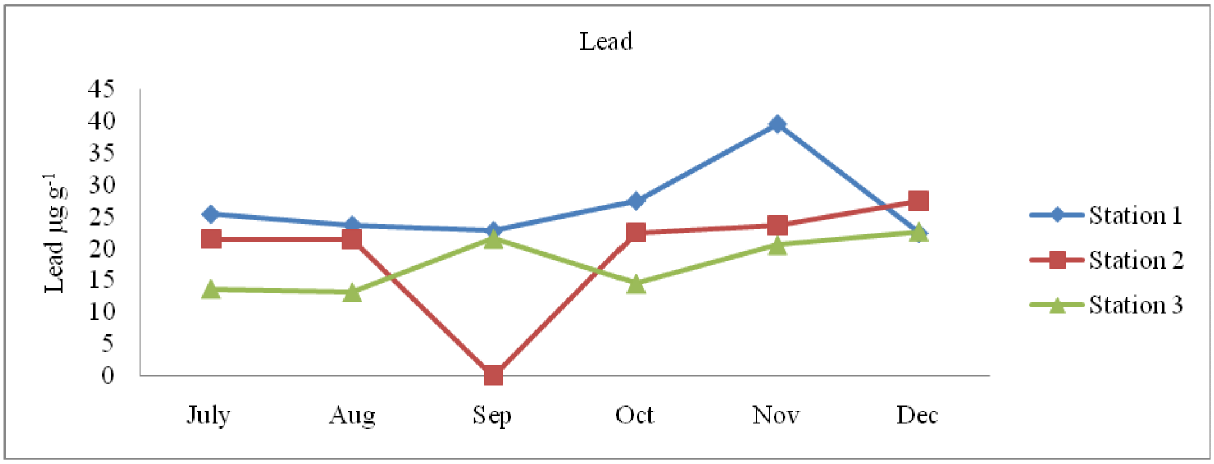

Figure-4
Monthly variation of Lead in sediment

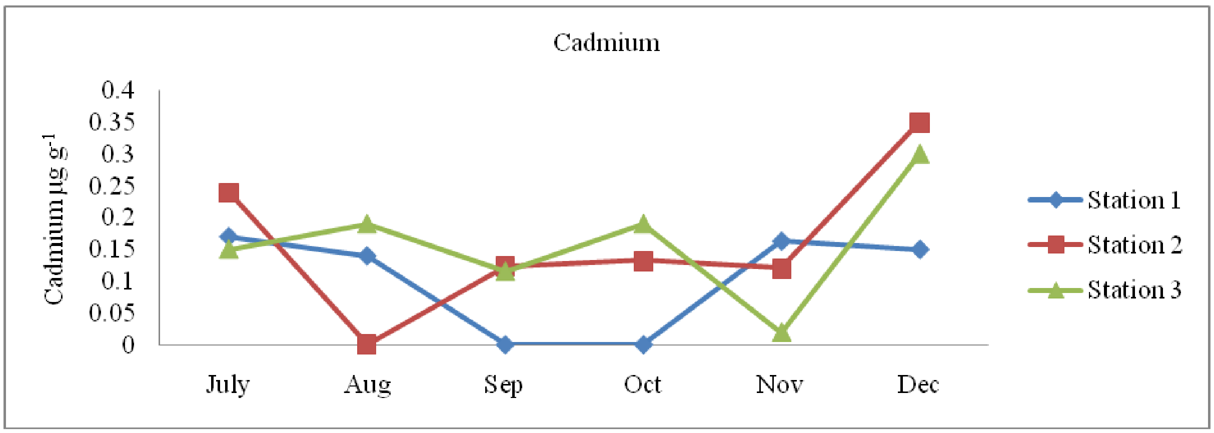

Figure-5
Monthly variation of Cadmium in sediment

Conclusion

In this study we tried to find out the impact of trace elements of fly ash on marine environment. Some trace element levels were high in station 1. Trace element values were compared with the results of other coast which showed the result of our present study within the values given by the other studies. Impacts of fly ash on water and sediment may be balanced by minimizing its accumulation either stabilization process. Heavy metals in fly ash however can be immobilized by chelating agents. The impact of fly ash is mainly dependent on site conditions.

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