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Seasonal variations of selected heavy metals in the soil of Barjora coal mine

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Abstract

We analyzed the seasonal variations of Zn, Cu , Pb, Cr, Co, and As in the surface of Barjora coal mine, located in the Bankura district of the maritime state of West Bengal during 2015. The selected metals accumulated as per the order Cr > Zn > Cu > Co > Pb > As with highest values during monsoon, followed postmonsoon and premonsoon. Sensitization of local community is essential to bring mass awareness to this issue as these metals can bio-accumulate within the vegetables and crops, and may pose threat to human health.

Keywords: Barjora Coalmine, Heavy Metals, Surface soil, Seasonal Variations.

Introduction

Coal is the indispensable part and parcel for energy production, which acts as the wheel of modern civilization. Open cast mines are the sources of pollution in the ambient media. The heavy metals in the soil are released through mine drainage. During the process of coal production, acid drainage from mines, coal washing, tailings, dumps and abandoned mine pits are the sources of heavy metals. It has been documented that due to influence of acid, coal mine waste water, heavy metal and chloride contents exceed the limits as seen in case of Kaili coal mining region, Guozhou province, China (Edeltrauda, 1996). Several researches have been conducted to evaluate the problems caused by coal mining in context to geological hazards, environmental pollution and land resource destruction (Shi 2002; Bell 2000; and Sidle, 2000). However, very few researches have been conducted on the seasonal variation of heavy metal level in the soil around the coal mine and the causes behind it. For Barjora coal mine situated in the maritime of West Bengal, (India), there is practically no data on the seasonal oscillation of heavy metals in and around the coal mine region. The present study is therefore the baseline documentation of selected heavy metals like Zn, Cu, Pb, Cr, Co and as in the soil around Borjora coal mine.

Materials and Methods

Study site

Barjora coal mine is situated in the Bankura District of West Bengal. It is in close proximity to the Durgapur-Asansol industrial region, just separated by the Damodor River flowing from east to west. This zone lies between 23˚23' and 23˚31' North latitude and between 87˚05' and 87˚20' East longitude.

Sample collection

1-5 years old mine spoil from the surface (5 cm from the top) was collected from Barjora coal field during three seasons in 2015.Clean plastic scalpels were used to collect the soil samples to avoid any metallic contamination.

Analysis

Inductively coupled plasma – mass spectrometry (ICP-MS) is now - a - day accepted as a fast, reliable means of multi-elemental analysis for a wide variety of sample types (Date and Gray, 1988). A Perkin-Elmer Sciex ELAN 5000 ICP mass spectrometer was used for the present analysis. A standard torch for this instrument was used with an outer argon gas flow rate of 15 L/min and an intermediate gas flow of 0.9 L/min. The applied power was 1.0 kW. The ion settings were standard settings recommended, when a conventional nebulizer/spray is used with a liquid sample uptake rate of 1.0 mL/min. A Moulinex Super Crousty microwave oven of 2450 MHz frequency magnetron and 1100 W maximum power Polytetrafluoroethylene (PTFE) reactor of 115 ml volume, 1 cm wall thickness with hermetic screw caps, were used for the digestion of the soil samples of Barjora coal mine. All reagents used were of high purity available and of analytical reagent grade. High purity water was obtained with a Barnstead Nanopure II water-purification system. All glass wares were soaked in 10% (v/v) nitric acid for 24 h and washed with deionised water prior to use.

The analyses were carried out on composite samples of 20 specimens of each species having uniform size. This is a part of quality assurance to the data. 20 mg composite soil samples from 5 sites (of 100 m distance from each other) were weighed and successively treated with 4 ml aqua regia, 1.5 mL HF and 3 ml H_2O_2 in a hermetically sealed PIFE reactor, inside a microwave oven, at power levels between 330-550 W, for 12 min to obtain a clear solution. After digestion, 4 ml H_2BO_3 was added and kept in a hot water bath for 10 min, diluted with distilled water to make up the volume to 50 ml. Taking distilled water in place of muscle samples and following all the treatment steps described above the blank process was prepared. The final volume was made up to 50 ml. Finally, the samples and process blank solutions were analysed by ICP-MS. All analyses were done in triplicate and the results were expressed with standard deviation.

The accuracy and precision of our results were checked by analyzing standard reference material (SRM, Dorm-2). The results indicated good agreement between the certified and the analytical values.

Table 1: Concentrations of metals found in Standard Reference Material DORM-2 (dogfish muscle) from the National Research Council, Canada (all data as means ± standard errors, in ppm dry wt)

Value	Zn	Cu	Pb
Certified	26.8	2.34	0.065
SE	2.41	0.18	0.009
Observed*	23.9	2.29	0.060
SE	1.99	0.17	0.006
Recovery (%)	89.2	97.8	92.3

Results

We observed significant seasonal variations of soil pH and selected heavy metals. The pH was lowest in monsoon followed by postmonsoon and premonsoon (7.28). In case of heavy metals the order is Cr > Zn > Cu > Co > Pb > As. The selected heavy metals also exhibited sharp seasonal variation with highest gap in monsoon followed by postmonsoon and premonsoon (table 2).

Table 2: Seasonal variation of heavy metals in soil samples

Season	Zn (in ppm) dry wt	Cu (in ppm) dry wt	Pb (in ppm)	Cr (in ppm)	Co (in ppm)	As (in ppm)
Premonsoon	176.98	5.88	0.99	567.90	1.08	0.28
Monsoon	298.56	9.54	2.35	665.90	1.66	0.89
Postmonsoon	184.55	6.31	1.05	456.22	1.19	0.37

Discussion

Coal is the primary source of energy to run industries and urban sectors in the under developed and developing nations of the world. About 70 % of coal mining is presently done by open cast methods. It is undoubtedly a destructive method that poses an adverse impact on the surrounding environment. The release of heavy metals through different operations related to open cast mining is a matter of great concern as these heavy metals get accumulated in the soil and water from where they are deposited in the vegetables, crops and fishes through the process of bioaccumulation. It is therefore important to know the seasonal status of heavy metals in the surrounding environment of the open cast open mine from the human heath safety point of view. In this study we observed the monsoon period to be highly alarming in context to heavy metal levels compared to other two seasons. The lowering of pH due to monsoonal precipitation may be the primary factor of dissolution of heavy metals from the overburden due to which the levels of heavy metals become maximum during monsoon. It is therefore the purpose of human consumption. In this context, it is extremely important to sensitize the local community regarding the consumption of crops, vegetables, and fishes during monsoon. Some special adaptive approaches as listed here need to be introduced.

1. Create awareness and provide education at the community school and user level on a continuous basis.
2. Facilitate the forming of eco-restoration group with common interest located in an around the coal mine zone in order to create forums to discuss common concerns.
3. Strengthen user group organizations to serve as the basis for implementing environmental health related stewardship project.

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