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Amount of Selected Heavy Metals (Cu, Mn, Zn, Ni and Cr) on Different Age Series Over Burden Dumps in Sonepur Bazare Coalmine Under Raniganj Coalfield Area, West Bengal.

Abstract

In recent years heavy metal contamination is one of the major environmental problems and it produces many adverse effects on whole ecosystem. In the present work for the analysis of five heavy metals (Cu, Mn, Zn, Ni & Cr) soil/spoil samples were collected from different places of different age series over burden dumps of the present study site and analyzed in the laboratory of West Bengal Pollution Control Board, Durgapur following Atomic Absorption Spectrophotometry (AAS). It was observed that OBD-0 (Fresh mine spoil) contain maximum amount of different heavy metals and went on decreasing with the ages of OBDs. It was also found that foot hill region of individual OBD contain maximum amount of heavy metals and mid top region contain least amount of heavy metals except in freshly dumped OBDs. The decreasing trends of heavy metal concentration on older OBDs are due to leaching down the gravity and plant absorption of these heavy metals. The freshly dumped spoil contain maximum amount of heavy metals and zone wise distribution do not show any specific trends because sufficient time was not available for the leaching and other processes to occur.

Chanchal Kumar Biswas
Assistant Professor,
Deptt.of Botany,
Banwarilal Bhalotia College,
Asansol, West Bengal.

Keywords: Heavy metals, Over Burden Dump, Atomic Absorption Spectrophotometry (AAS), OBDs

Introduction

Open cast coal mining i.e. surface mining methods produce a dramatic change in the landscape in coal mine are due to large scale excavation and removal of overlying vegetation cover along with its topsoil and supportive life- forms (Dash, 2001). In the recent past the open cast coal mining has been creating immense perturbations in the coal belts of West Bengal. The coalmine debris is heaped in the form of dumps around the mining area and is called spoil. These dumps change the normal land topography and affect the drainage system of the mining area (Chaulya *et al*. 2000). The soil of the dumps is acidic in nature, along with higher concentration of heavy metals. Other adverse physico-chemical factors include high stone content, lack of moisture, higher compaction, shortage of fine soil forming materials and organic matter, which tend to inhibit soil forming process and plant growth (Maiti,1994; Maiti and Saxena, 1998). This mixture is hostile to the growth of both plants and microbes (Sethy and Behera, 2009) because of impoverished organic matter content, detrimental pH and draught arising from coarse texture or oxygen deficiency caused by higher compaction (Agarwal, *et al*.1993) and also due to presence of several types of heavy metals.

Heavy metals can be defined as elements with metallic properties and atomic weight more than 20 (Canarache *et al*. 2006). According to another concept, the heavy metals are defined as metals with a density higher than 5g cm^3 (Parker. 1989). Heavy metals contamination in the environment is of global concern, for its threat to the ecosystem. The degree of heavy metal pollution is increasing day by day in all environments. Metals like arsenic, cadmium, lead, mercury, silver etc cause heart diseases, liver damage, cancer, neurological disorders, cardiovascular diseases, central nervous system damage and sensory disorder. The chemical nature and bioavailability of a metal can be changed through oxidation or reduction; however, the elemental nature remains the same because the metals are neither thermally decomposable nor microbially degradable. Consequently metals are difficult to remove from the environment.

The objective of this present study is to estimate of some selected heavy metals (Cu, Mn, Zn, Ni and Cr) in different age series overburden dumps and at different region of same dump in Sonepur bazare coalmine under Raniganj Coalfield area, West Bengal, India.

Review of Literature

Heavy metal pollution in all ecosystems is now a global concern. It is more vigorous near the open cast mining where the spoil is dumped around the mining area throughout the world. The presence of higher concentration of such heavy metals in coalmine spoil has also been reported by many workers previously working in and outside of our country in different coal field areas. Ladwani *et al.* (2012) in Surat District (Gujarat), India found the presence of considerable amount of heavy metals like Mn, Cu, Zn, Ni, Co, Pb and Cd in the lignite coal mine tailings. Meriem *et al* (2015) found that concentrations of seven heavy metals (Co, Cr, Cu, Cd, Ni, Zn and Pb) were significantly higher than those in uncontaminated soils while working on the mining area of Midelt in Upper Moulouya (Morocco). Chen *et al* (2015) showed that the soil has been seriously polluted by Hg, Fe while working on the along a section of the Chongan River channel from Yudong to Jiangkou adjacent to the coal mining region of Kaili, Guizhou Province, China. Khan *et al.* (2017) showed that the amount of some heavy metals (Fe, Zn, Mn, Pb, and Cu) was initially higher but was decreased over time in their study site located in the Dudhichua project of the Northern Coalfield Limited (NCL) situated partly in Uttar Pradesh and partly in Madhya Pradesh, India.

Materials and Methods

For the analysis of heavy metal content in soil, soil samples were collected from the different age series OBDs (OBD-0, OBD-4 OBD-8 OBD-12 OBD-16 to OBD-20 for fresh mine spoil, 4 years old, 8 years old, 12 years old, 16 years old and 20 years old spoil respectively) in the post monsoon season in the year 2014. While collecting sample from each OBD, the OBD were demarcated in to five regions i.e. foot hill, lower slope, upper slope, side top and mid top at equal distance from base to top of the OBD depending on its height. Soil samples were taken from 15 cm depth using soil core from 5 randomly distributed sites in each region of the OBDs and were packed in clean and sterilized polythene bags. The samples were crushed by mortar and pestle in the laboratory and sieved by using 2 mm nylon mesh. The powered samples were kept in plastic container for heavy metal analysis. The completely dried soil and plant samples were taken to West Bengal Pollution Control Board, Durgapur Centre for the estimation of heavy metal concentration.

Available micronutrients cations (viz. manganese, copper, and zinc) and non-essential metals like chromium and nickel were extracted by digesting 0.5 g of sample using mixture of concentrated HNO_3 and HCl (3:1) in a microwave. Metal content associated with the composite materials was then determined by Atomic Absorption Spectrophotometry (AAS).

Results

Concentration of Copper

Table 1 represents the concentration of Copper in different region (Foot Hill, Lower Slope, Upper Slope, Side Top and Mid Top) of the different age series over burden dumps starting from OBD-0 to OBD-20. In OBD-0 the concentration of Copper varied from 211 to 214 ppm with a maximum value on the mid top region of the dumps. In OBD-4 it ranged from 192 (Mid top) to 207 ppm (foot hill). In all other dumps the foot hill region contained maximum concentration of Copper and the mid top portion contains least amount of Copper.

Table 1: Concentration of Copper (ppm) in different portions of age series OBDs.

Age of the OBDs	Foot Hill	Lower Slope	Upper Slope	Side Top	Mid Top	Mean±SD
OBD-0	211	205	213	203	214	209.2±4.9
OBD-4	207	206	202	193	192	200±7.1
OBD-8	203	202	199	193	188	197±6.3
OBD-12	196	195	190	186	183	190±5
OBD-16	188	185	181	176	172	180.4±6.5
OBD-20	175	173	162	159	156	165±8.5

Concentration of Chromium

Table 2 represents the concentration of Chromium in different regions of the over burden dumps (OBD-0 to OBD-20). In OBD-0 the concentration varied from 715 to 731 ppm with a maximum value recorded in the mid top of the dumps. In OBD-4 minimum value was found at mid top (700 ppm) of the dump while maximum value was in foot hill region (718 ppm). In rest of the dumps maximum concentration of Chromium was found in the foot hill region while minimum concentration was found in mid top of each dump.

Table 2 Concentration of Chromium (ppm) in different portions of age series OBDs.

Age of the OBDs	Foot Hill	Lower Slope	Upper Slope	Side Top	Mid Top	Mean±SD
OBD-0	715	725	731	729	715	724.2±6.4
OBD-4	718	717	709	707	700	710.2±7.4
OBD-8	697	694	691	688	687	694±8.2
OBD-12	694	688	683	682	678	685±5.5
OBD-16	632	625	622	616	610	621±8.4
OBD-20	541	536	533	528	521	531.8±7.6

Concentration of Nickel

The concentration of Nickel in different portion of different age series over burden dumps starting from OBD-0 to OBD-20 has been represented in Table 3. The concentration of Nickel in OBD-0 varied from 260 to 281 ppm with a maximum value as recorded in the side top of the dumps while the minimum value was recorded in lower slope region (260ppm). In OBD-4 minimum value was found at mid top (241 ppm) of the dump while maximum value was in foot hill region (253 ppm). In rest of the dumps maximum concentration of Nickel was found in the foot hill region while minimum concentration was found in mid top of each dump.

Table 3 Concentration of Nickel (ppm) in Different Portions of Age Series OBDs.

Age of the OBDs	Foot Hill	Lower Slope	Upper Slope	Side Top	Mid Top	Mean±SD
OBD-0	270	260	275	281	272	271.6±7.7
OBD-4	253	253	250	242	241	247.8±5.8
OBD-8	247	243	240	238	236	240.8±4.3
OBD-12	242	238	230	226	224	232±6.9
OBD-16	211	206	203	193	188	200.2±9.4
OBD-20	178	172	168	162	158	167.6±7.9

Concentration of Manganese

The concentration of Manganese in different portion of different age series over burden dumps has been presented in Table 4. In OBD-0 it was varied from 419 to 430 ppm and maximum value was recorded in the lower slope of the dump, while the minimum value was recorded in the foot hill (419 ppm). In OBD-4 maximum value was recorded in foot hill region (404 ppm) and minimum value was found at mid top (390 ppm) of the dump. In the remaining dumps maximum concentration of Manganese was found to be present in the foot hill region while minimum concentration was found in mid top of each dump.

Table 4 Concentration of Manganese (ppm) in different regions of age series OBDs.

Age of the OBDs	Foot Hill	Lower Slope	Upper Slope	Side Top	Mid Top	Mean±SD
OBD-0	419	430	424	420	425	423.6±4.3
OBD-4	404	401	396	391	390	396.4±6.1
OBD-8	389	387	378	377	374	381±6.5
OBD-12	376	372	370	364	358	368±6.3
OBD-16	315	311	303	297	288	302.8±10.8
OBD-20	261	256	255	252	248	254.4±4.8

Concentration of Zinc

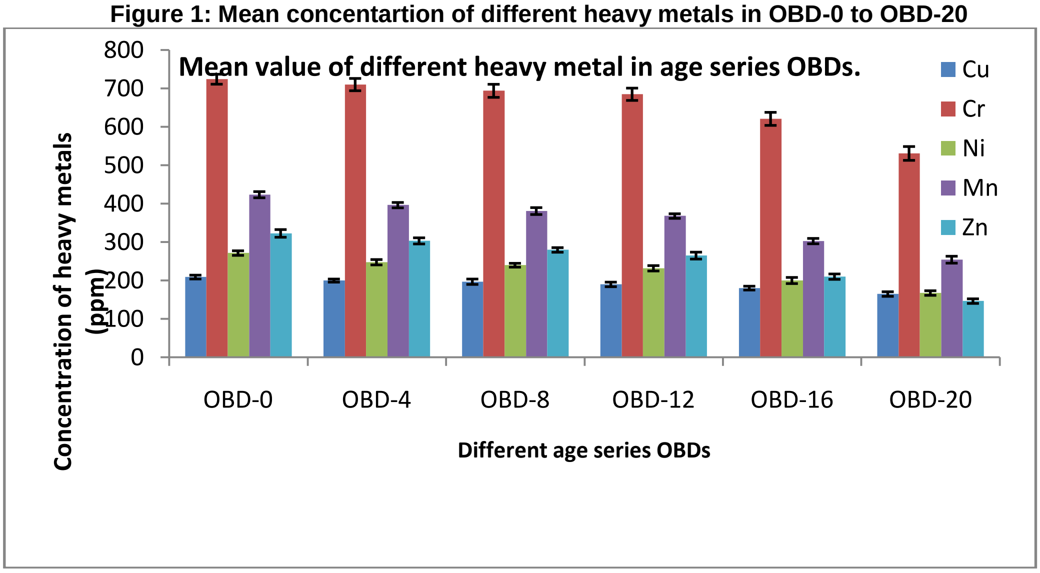
The concentration of Zinc in different portion of different age series over burden (OBD-0 to OBD-20) has been given in Table 5. In OBD-0 the concentration varied from 316 to 331 ppm with a maximum value on the upper slope of the dump. In OBD-4 it ranged from 294 (Mid top) to 312 ppm in foot hill region of the dump. In the remaining dumps the foot hill region contains maximum concentration of Zinc while the mid top portion contains least concentration of Zinc.

Table 5 Concentration of Zinc (ppm) in different regions of age series OBDs.

Age of the OBDs	Foot Hill	Lower Slope	Upper Slope	Side Top	Mid Top	Mean±SD
OBD-0	317	326	331	316	324	322.8±6.3
OBD-4	312	307	303	301	294	303.4±6.7
OBD-8	287	283	277	278	274	279.8±5.1
OBD-12	271	269	266	261	258	265±4.8
OBD-16	221	215	211	204	200	210.2±8.4
OBD-20	164	146	144	141	138	146.6±10.2

The mean concentartion of different heavy metals observed in OBD-0 to OBD-20 (Figure 1) indicated that the heavy metal concentration went on decreasing with the age of OBDs. Concentrations of all heavy metals was found to be higher in OBD-0 and the concentration went on declining in OBD-4, OBD-8, OBD-12, OBD-16 and OBD-20. But the differences was marked not to be very significant in two successive OBDs but it was found to be significant in between OBDs of alternative age series i.e. between OBD-0 and OBD-8, OBD-4 and OBD-12, OBD-8 and OBD16 and OBD-12 and OBD-20.

Figure 1: Mean concentartion of different heavy metals in OBD-0 to OBD-20



The data relating to the concentration of different heavy metals (Copper, Chromium, Nickel, Manganese and Zinc) in different portions of the different age series OBDs was subjected to taken in two way analysis of variance (ANOVA). It was observed that the variance with respect to different dumps and with in the dumps was statistically significant (Table 6).

Table 6

Analysis of variance to show the significance of variation in concentration of different heavy metals with in the dumps and between the dumps.

Type of Metal		$F_{Calculated}$	$F_{Critical}$	
			P<0.05	P<0.001
Copper	Between the Dumps	80.55	2.71	6.46
	Within the Dumps	12.06	2.87	7.09
Chromium	Between the Dumps	1192.64	2.71	6.46
	Within the Dumps	8.67	2.87	7.09
Nickel	Between the Dumps	209.7	2.71	6.46
	Within the Dumps	4.90	2.87	7.09
Manganese	Between the Dumps	1151.42	2.71	6.46
	Within the Dumps	11.46	2.87	7.09
Zinc	Between the Dumps	864.51	2.71	6.46
	Within the Dumps	7.74	2.87	7.09

Discussion

The results indicate that heavy metals (like Cu, Cr, Ni, Mn and Zn) are present in an appreciably high concentration in the spoil of over burden dumps. In the present work it was observed that the heavy metals concentration went on decreasing with the age of the OBDs (OBD-0 to OBD-20) over a period of 20 years. But this decrease in concentration of the heavy metals over a period of time is not overwhelming i.e. the process is very slow. The decrease in concentration is due to leaching down of these heavy metals and due to absorption by plants when vegetation gets established on the OBDs over a period of time (Awokunmi *et al.* 2010). However, it is also possible that some amount of heavy metals becomes available due to biological activities of microorganisms and plants which further balance the removed heavy metals from the deposits (Majid, 2010). These later dissolved metals from the parent rocks present in the OBD deposits further add to the total heavy metal concentration apparently decreasing the gap between fresh and older OBDs. Das and Chakrapani, (2011) have also reported that mineral dissolution from overburden materials is primarily responsible for high heavy metal concentrations in over burden spoils. Some heavy metals although essential for the normal growth of all living organisms, can produce toxic effects at elevated concentration (Adriano, 2001). In the present study it was found that heavy metal concentrations (of Cr, Cu, Ni, Mn and Zn) in study site of Raniganj coalfield lie alarmingly close to the maximum allowable concentration (MAC) limit proposed by European Commission for agricultural soils.

When the concentration of different heavy metals was estimated in different regions (Foot Hill, Lower Slope, Upper Slope, Side Top and Mid Top) of the overburden dumps, it was observed that in all the OBDs except OBD-0 (freshly dumped spoil) the foot hill region contained highest concentration of heavy metals. The concentration of the heavy metals was found to decrease gradually in the lower slope, upper slope, side top and mid top regions. This could be primarily due to the leaching down of these metals towards the foot hill region. More over secondarily these could also be due to absorption by the plant developing on it over a period of time. In case of OBD-0 the distribution of these heavy metals in different regions did not show any specific trends because it was the freshly dumped spoil and hence sufficient time was not available for the leaching process to occur. More over this particular OBD was devoid of any vegetation so metal uptake by biological activity was also absent.

Conclusion

From this study it can be concluded that (i) the overburden spoils contained high concentration of heavy metals, which went on decreasing with increase in age of the OBDs. (ii) The concentrations of each heavy metal were highest in the foot hill region and it goes on decreasing above and above the over burden dump and reaches it minimum value on the mid top portion in aged OBDs.

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