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LEVEL OF MINERAL ELEMENTS IN SOIL AND PLANT ROOTS OF THE ADJACENT AREA OF BARAPUKURIA COAL MINE

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ABSTRACT

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This study was carried out to estimate the level of mineral elements in the soil and plant roots of the nearby area of Barapukuria coal mine project area. For this purpose, soil samples were collected from storage ditch (ST), coal water contaminated (CWC) field and non-contaminated (NC) field. Root samples were also collected from CWC and NC fields. Soil and plant samples were analyzed to determine the level of pH, organic carbon (OC), P, K, S, Ca, Mg, Fe, Zn, and Mn contents. The pH of the soil samples ranged from 5.57-7.8. The highest OC content was found in ST soil (12.37%) followed by CWC soil (5.39%) and NC soil (1.88%). The concentrations of P, K, Ca, Mg, Fe, Zn, and Mn were found to be highest in CWC soil. The contents of these elements were also found to be highest in plant roots grown in CWC fields in comparison to NC field soils showing a tendency of transformation of these elements from contaminated soil to plants.

Key words: coal Mining, CWC soil, macro-elements, micro-elements, NC soil

INTRODUCTION

Coal is a black or brownish-black rock that of plants that lived and died about 100 to 400 million years ago. It is a heterogeneous mixture of several components e.g. sulfur, elemental carbon, arsenic, ash and heavy metals etc. (Ashton 1999). Bangladesh is one of the coal producing countries in the world. Barapukuria coal field are believed to be hold the highest coal reserve among the other coal field in Bangladesh. Barapukuria coal field was discovered in 1985 by Geological survey of Bangladesh in Dinajpur district. Coal layers were encountered at a shallow depth of about 118 to 500 meter in this field. An underground coal mine is being completed at Barapukuria by early 2005 under Chinese technical and financial assistance to meet energy requirements (Imam 2005).

Mining has an adverse impact on the environment. The habitat and plant communities in the nature get disturbed and impoverished due to mining, presenting adverse conditions for plant growth. Coal mining poses a serious threat to the environment, erosion of soil in a greater scale, pollution of air, water and land and threat to biodiversity. The severity of the impacts varies depending on whether the mine is working or abandoned, the mining methods used, and the geological conditions (Bell *et al.* 2001). The disposal of waste rock also creates problems to the landscape around mining areas (Goretti 1998). Damage to plants, animals and humans occurs from the destruction and removal of habitat and environmental contamination. Surface mining completely removes land from its normal uses (Keating 2001). As mining brings subsurface rocks and minerals to the surface, it was thought pertinent to observe the concentration of some macro and microelements in surface soil and plant roots.

MATERIALS AND METHODS

Soil and plant samples were collected from an adjacent area of Barapukuria coal mine which is located in the north-western corner of Bangladesh at about 45 km east of the Dinajpur district headquarters. Soil samples of approximately 1 kg were collected from three spots at rooting depth (~15 cm). First, soil samples were collected from a ditch where coal treated water is stored (hereinafter called as ST). Soil samples were also collected from a non-contaminated farmer's field (hereinafter called as NC) which is about 500 m far from the mine and another from a coal water contaminated land (hereinafter called as CWC) where mine drainage water was used for irrigation. NC field was selected after discussing with the farmers whether they use contaminated or non-contaminated water. Soil and plant samples from NC area were collected to observe whether any differences in mineral concentration have with soil and plant samples collected from the CWC area. The sampling was done randomly in replicates from each site. Roots of rice were also collected which were left in the field after harvest from both contaminated and non-contaminated fields in a random away.

After bringing the samples in the laboratory, the soil samples were first dried in air at room temperature for 2 days by spreading the samples in a thin piece of paper. Visible roots and plant fragments were removed. Large aggregates were broken with wooden hammer and sieved through 2 mm stainless steel sieve for chemical analysis. Root samples were washed with water very well and then dried in air at room temperature by spreading the samples in a piece of paper. After air drying, the samples were oven dried at 70°C for 48 hours. After oven dry the roots were grind and sieved through 0.5mm stainless steel sieve for chemical analysis.

Soil pH and EC were determined by pH meter and EC meter after preparing the soil: water suspension at a ratio of 1:2.5 and 1:5 respectively for pH and EC. Organic carbon was determined using Walkley and Black's method

by oxidation of organic matter with potassium dichromate ($K_2Cr_2O_7$) (Gosh *et al.* 1983). Exchangeable potassium (K) was determined by flame photometer after extracting the samples with 1N ammonium. Exchangeable Calcium (Ca) and magnesium (Mg) contents were measured by atomic absorption spectrometer (NOV AA-300) after extracting the sample according to Peterson (Peterson 2002). Available phosphorus (P) was determined by colorimetric method. Available sulphur (S) was determined by extracting the soil samples by calcium chloride solution (0.15%). The amount of sulphur content in the extract was estimated turbidimetrically by spectrophotometer at 420 nm wavelength (Page *et al.* 1982). Copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) were determined by using atomic absorption spectrometer after extracting with DTPA as outlined by Peterson (Peterson 2002). For the determination of P, K, Ca, Mg, Fe, Zn and Cu, the root samples were digested with conc. nitric acid. Determination of Ca, Mg, Fe, Zn and Cu and was performed by atomic absorption spectrophotometer. Potassium and P were determined by flame photometer and spectrophotometer respectively as outlined by Page *et al.* (1982). For the determination of S, the roots samples were digested with a mixture of nitric and perchloric acid.

RESULT AND DISCUSSION

The pH of ST soil was found to be higher than NC field's soil. The pH of CWC soil was found intermediate between ST soil and NC field's soil. The pH of ST soil, coal water contaminated soil (CWC) and non-contaminated field soil (NC) are given in Table 1. Alam *et al.* (2011) found the pH of surface waters surrounding Barapukuria slightly alkaline. Like pH, the highest organic carbon content was found in ST soil, whereas CWC soil contained intermediate and NC field soil contained lowest organic carbon content (Table 1). The maximum carbon content in ST soil and CWC field soil (CWC) may be due to the release of carbon from coal. Since the major element of coal is carbon, the organic carbon content was found higher in ST soil than CWC and NC soils.

Maximum amount of available P was found in CWC soil followed by ST soil and NC soil. Mean values of available P content of ST soil, CWC soil and NC soil are given in Table 1. Phosphorus content of CWC soil was higher than NC agricultural soil due to continuous addition from applied coal water. Ghose (2004) stated that the concentration of P is relatively low in the non-contaminated soil than the concentration of P in any contaminated soil and most of the P present in the soil is not readily available for the plants. Mean values of exchangeable K content in ST soil, CWC soil and NC soil are presented in Table 1. CWC soil contained higher K content followed by NC soil and ST soil. CWC soil contained almost two times K content of the NC soil and three times of ST soil. The highest concentration of K in CWC soil may result from deposition of K from coal water. This leads to continuous addition of K with coal water in CWC soil. Due to mining primary minerals i.e. feldspar, pyrite and other compounds are weathered into the soil (Sadhu *et al.* 2012). Over time, these compounds release different kinds of cations (e.g., K, Na etc.) which results in higher concentration of K in the CWC soil than ST or NC soil. Table 1 shows mean values of available S contents of ST soil, CWC soil and NC field soil. The highest level of S was found in NC field soil. The second highest content was found in CWC soil followed by ST soil. The level of S content in NC field soil was 1.45 times higher than those of CWC soil. Coal contains a significant amount of ferrous sulphate in the form of pyrites and the exposure of pyrite to atmospheric O_2 through the mining operations releases S into the soil (Sarma 2005).

The highest level of exchangeable Ca was observed in CWC soil and lowest level was in ST soil (Table 1). This increment in Ca content in CWC soil is possibly due to gradual deposition of Ca from water as well as the sediment carried by discharged water from coal mining operation. Calcium concentration in CWC soil was 1.62 times higher over the NC field soil possibly due to addition from coal water. Farmers use contaminated water for irrigation purpose which may results in increased Ca content in CWC field soil over the ST soil as well as the initial soil content. Due to mining compounds e.g., feldspar, pyrite etc. are added to the soil which results in continuous release of Ca into the soil from the breaking down of these compounds (Sadhu *et al.* 2012). The concentration of exchangeable Mg was found to be lower than Ca in all three types of soil. Like Ca, the maximum content of Mg was found in CWC field soil, while NC field soil contained intermediate content of Mg and ST soil contained lowest level of Mg (Table 1). The highest Mg content in CWC field soil over NC field soil is due to application of coal water to the normal agricultural field. Magnesium content of CWC field soil was almost 1.24 times higher than Mg content of the NC field soil. Possibly, the highest content of Mg in CWC soil is the result of continuous release of Mg from feldspar, pyrite etc.

Table 1 shows the concentrations of micro-elements like Zn, Fe, Cu and Mn. The concentrations of these elements were found to be highest in CWC field soil and lowest were found in ST soil except Zn and Mn. A little difference was found in the concentration of Zn between ST soil and NC field soil. The Zn content of CWC field soil was almost 3.07 times higher than NC field soil. In case of Mn, the second highest content was found in ST soil which was almost 1.5 times of the Mn content found in NC field soil. CWC field soil has extremely high content of Mn which was almost 7.7 times higher compared to NC field soil. The maximum content of these elements in CWC field soil in comparison to NC field soil is due to presence of these metals in coal treated water. This coal treated water when applied to agricultural field results in the deposition of metals in

soil. Sarma (2005) stated that mining causes the addition of metals such as Zn, Fe, Cu and Mn that affects the soil quality.

Table 1. Physico-chemical properties of soil

Parameters	Unit (s)	ST soil	NC field's soil	CWC soil
pH	-	7.80±0.16	5.57±0.18	6.18±0.30
Organic Carbon	%	12.37±0.76	1.88±0.31	5.39±0.64
P	mg/kg	8.55±0.65	4.23±0.44	15.11±0.79
K	mg/kg	24±2.44	45±1.49	81±2.61
S	mg/kg	59.97±2.17	94.59±2.14	82.59±1.11
Ca	mg/kg	783.4±11.32	963.4±13.19	1559.6±10.96
Mg	mg/kg	109.74±7.38	175.81±2.73	218.88±6.18
Zn	mg/kg	3.97±0.26	3.87±0.09	11.87±0.84
Fe	mg/kg	6.27±0.43	15.28±0.56	58.79±1.55
Cu	mg/kg	1.534±0.06	2.35±0.16	5.538±0.56
Mn	mg/kg	50.23±3.13	20.77±1.89	160.1±3.06

Mean values of total P, K, S, Ca, Mg, Fe, Mn, Cu and Zn contents (oven dry basis) in plant roots are shown in Table 2. It is clear that a greater amount of these elements accumulated in roots when plants were grown in CWC field. The concentration of these elements in both CWC field plants and NC field plants showed a good relation between soil and plant concentration. During irrigation the application of coal treated contaminated water provided water-soluble P, K, S, Ca, Mg, Fe, Cu, Zn which may have supplemented the inherent availability of these elements in the soil to plant roots, allowing these elements to be transferred from soil to roots in CWC field.

Table 2. Concentration of macro and micro- elements in plant roots

Parameters	Unit (s)	Root (CWC field)	Root (NC field)
P	%	0.30±0.07	0.22±0.05
K	%	2.26±0.08	2.05±0.12
S	%	0.182±0.04	0.136±0.01
Ca	%	0.067±0.01	0.039±0.01
Mg	%	0.096±0.02	0.085±0.01
Fe	%	0.06±0.00	0.012±0.00
Mn	%	2.98±0.30	1.12±0.11
Cu	mg/kg	46.01±1.31	6.0±0.90
Zn	mg/kg	0.011±0.00	0.007±0.00

All the elements were higher in plants grown in CWC field soils than the plant samples grown in NC field. In the area, farmers apply various inorganic fertilizers as a usual practice of rice production. The concentration of elements in CWC field plants may also be higher due to readily availability of essential elements in fertilizer rather than coal treated contaminated water. It is noticeable that all the macro-elements viz. P, K, Ca, Mg and S were found to be higher in concentration than the micro-elements viz. Fe, Cu and Zn in both contaminated and non-contaminated condition.

CONCLUSION

The present study analyses the nutrient content of soil and plant roots as affected by mine. From the study it was found that mining activities increases the concentration of chemical elements in soil and subsequently in plant roots. However, the presence of heavy metals like lead, cadmium, chromium, etc. that may affect the soil quality of the surrounding areas of Barapukuria coal mining is important to ascertain. To reduce or minimize the adverse impacts of coal mining on surrounding environment mine drainage water must be run out after proper treatment of the water. Awareness must be increased among local to minimize the negative impacts of mining activities on soil and water quality for agricultural purposes.

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