Chapter V

METAL CONCENTRATION IN TEA PLANTS OF THE AFFECTED AREA

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5.1 Introduction

Tea is one of the most popular beverages after water in the world. Use of tea as folk medicine for headache, digestion, dieresis, immune defence, energizer and longevity of life is well known. Thus, the associated chemical components in tea received a notable concern as it is related to human health. Extensive study on potential health implications of heavy metals in tea has been carried out as tea bush is known to accumulate trace metals (Bosque et al., 1990; Jackson and Lee, 1988; Anonymous, 1999; Kalita and Mahanta, 2006; Street et al., 2006; Mehra and Baker, 2007; Han et al., 2007; Karimi et al., 2008; Giilten and Tuysiiz, 2009; Magalhaes et al., 2009;). Tea can be contaminated by heavy metals during growth period and manufacturing processes which might increase the metal contents above the tolerance limit (WHO, 2004) for human consumption. Apart from normal agricultural practices related to increase in productivity unattended industrial activities have also contributed significantly in that direction. Moreover, local dispersion in soil profiles also helps in extensive contamination of toxic metals. Several studies have shown that plants growing on soils with high metal concentrations can absorb a considerable amount of metal in them (Marcos et al., 1998; Han et al., 2007; Karimi et al., 2008; Borah et al., 2009; Abanuz and Tuyuz, 2009; Magalhaes et al., 2009). The tea plants generally grow on acidic soils where metals are easily absorbed by plant roots. Transfer of elements from soil to plants is very important for plant nourishment and for contamination of plants by heavy metal contents. The main sources of heavy metals in plants are their growth media, nutrients, agro inputs and soil (Kabata-Pendias and Pendias, 1984). Other factors may include pesticides and fertilizers. The extent to which plants take up metals (the biological availability) depends on the binding of trace elements to soil constituents. In general, plants readily take up those species that are dissolved in soil solutions in ionic, chelated or complex form. Although adsorption by roots is the main uptake pathway (Ross, 1994), it is also a notable observation that tissues other than roots have taken a role in absorbing nutrients including trace metals. Uptake from it depends not only on the total content of the respective metal, but also on its accessibility to roots and transfer across the soil-root inter-phase. The total amount of metal in a soil is in turn, affected by the inherent natural resources of the area in addition to the agricultural and industrial activities.

Wide variations in metal uptake are observed in different plant species. Some plants are known to have special affinity for accumulating certain metals. Besides the root, metal may enter the plants through aerial parts including the leaf surface. High lead content may be observed in plants growing near busy traffic points. Minute particles (<2μm) of some metals/metalloids, e.g. As, Cd, Cu, Se, and Zn, emanating from combustion sources may get dissolved in rain water and enter the plant through leaf surface. Foliar application of some fertilizers may contribute to the bioavailability of Cu, Fe, Mn, and Zn with variable affinity of absorption.

The land around Lakwa Oilfield is dominantly utilized for cultivation paddy and tea. The land around GGS-I is surrounded by tea gardens and spillage of oil causes a noticeable degradation of soil (Plate 3, Photo A & B) affecting tea production in the area. The tea plants of the affected area might have absorbed some of the toxic metals which may affect the growth, production and quality of produced tea. It is therefore felt that the study of different parts of the tea plants for associated chemical components around GGS-I will help to provide significant input about the possible environmental threat in relation to the oilfield activities in the area.

The objective of the present approach is to investigate the associated heavy metal concentration in different parts of the tea plants growing on contaminated/polluted soil due to oilfield activities around GGS-I of Lakwa oilfield. Possible heavy metal contamination in tea plants in areas of oil field activities have been investigated and tried to explore the possibility to have certain relationship between elements in soil and tea plants. Several studies have shown that plants growing on soils with high metal concentrations absorb these metals and pose a potential health risk. Various studies on heavy metal contamination in plants have demonstrated the relationship between concentration of elements in tea plant and soil samples and their toxic impact at conditions favourable for uptake of elements (Sposito, 1984; Kabata-Pendias and Pendias,1992; Wong et al.,1998; Kabata-Pendias, 2000; Krauss et al., 2001; Kalita and Mahanta, 2006; Han et al., 2007; . Seenivasan et al., 2008; Shi et al., 2008; Giilten and Tiiysiiz, 2009; Dos Santos et al., 2009, Zhou et al.,2009).

5.2 Materials and methods

Samples of tea plants for the present study were collected from tea garden located around GGS-I, which has evidenced the effect of oil field waste water (Plate 3(b) in Chapter-III). Ten samples of tea plants, each containing leaves, stems and roots were collected and washed vigorously first under running water and finally with distilled water to remove all unwanted matter, specially dust, soil and sand. The samples were then dried at 110°C in a drying oven for two hours. Dried plant samples of leaves, stems and roots were ground separately and placed in Stoppard plastic bottles (Brook, 1983). Heavy metal contents in the samples of leaves, stems and roots were then estimated by Atomic Absorption Spectrophotometer (AAS) after proper digestion and analytical procedure (Brook, 1983).

The concentrations of metals were estimated with a PERKIN ELMER Atomic Absorption Spectrophotometer (Model Analyst - 100) using Perkin Elmer Hollow Cathode Lamps (HCL) as the light source. The detailed methodology followed has been discussed already in Chapter III (Subhead 3.4.2).

5.3 Results and Discussion

The results of the analysis of samples of the tea leaves, stems and roots for different metal contents are summarised in Table 5.1. It shows a range of variations of metal concentrations in the samples of leaves, stems and roots, and their mean values. The unit is expressed in microgram (μg) per gram (g) of dry material. It was observed that the total metal content was found highest in the leaves (1054.5 μg/g) followed by roots (789.5 μg/g) and stems (771.0 μg/g). Among all the metals investigated in this study, the concentration of Na was found to be the highest in the leaves and stems followed by K. The most abundant element in the roots was found to be the Fe. Concentration of Cd was found to be the lowest in leaves and stems, while the content of Cr was the lowest in roots. The descending order of different metal contents in different parts of tea plants is as follows –

Leaf: Na (309.0) > K (226.2) > Mn (156.0) > Ca (116.0) > Fe (80.0) > Mg (74.2) > Zn (69.2) > Cu (10.7) > Co (8.7) > Pb (2.6) > Ni (1.2) > Cr (0.6) > Cd (0.2)

Stem: Na (218.0) > K (112.0) > Fe (124.5) > Ca (96.0) > Mn (90.2) > Zn (76.9) > Mg (31.2) > Cu (9.0) > Co (7.6) > Pb (2.5) = Ni (2.5) > Cr (0.4) > Cd (0.5)

Root: Fe (249.6) > Mn (180.7) > Ca (156.0) > Zn (79.9) > Mg (59.0) > K (18.4) > Na (14.2) > Cu (14.0) > Pb (6.0) = Ni (6.0) > Co (4.4) > Cd (0.7) > Cr (0.6)

Table 5.1: Metal contents (µg/g) in different parts of the tea plants around GGS-I.

Metals	Parts					
	Leaf		Stem		Root	
	Range	Mean	Range	Mean	Range	Mean
Na	289.2-313.3	309.00	209.2-222.5	218.00	7.62-17.69	14.20
K	209.9-232.5	226.00	110.5-119.2	112.00	17.65-19.2	18.40
Mn	135.2-162.3	156 00	79.3-95.17	90.20	167.78-187.89	180.68
Ca	109.0-121 3	116.00	85.25-109.9	96.00	143.8-160.7	156.00
Fe	69.20-85.60	80.00	117.20-132.40	124.50	222.3-255.8	249.60
Mg	69.21-79.25	74.20	26.28-38.83	31.20	39.69-72.28	59.00
Zn	53 55-74.26	69.16	66.32-81.25	76.90	69.25-85.23	79.90
Cu	9.8-12.25	10.85	0.39-0.76	9.00	6.75-15.17	13.96
Co	7.12-9.11	8.72	6.55-8 23	7.64	3.23-4.67	4.40
Pb	1 98-2.95	2.60	1.88-2.76	2.54	5.97-6.66	6.02
Ni	0.95-1.35	1.20	1.66-2.97	2.54	4.32-6.97	6.02
Cr	0 35-0.87	0.56	0 39-0.76	0.43	0.49-0.64	0.60
Cd	0.19-0.33	0.20	0.02-0.06	0.05	0.48-0.79	0.67
Total	--	1054.5	--	771.0	--	789.5

Values are in µg/g of dry weight (dw);Total number of observations =10

The variation pattern of the metal contents in the three different parts of plants is shown in Figure 5.1. The pattern shows that in case of most of the metals ,the highest and the lowest concentrations were found either in the leaves or in the roots.

Concentrations of the metals in the stems were in between the two extremes, except for the metals Mn, Ca, Mg, Cu, Pb, Cr and Cd. Concentration of these metals were found to be the lowest in the stems. The concentrations of Na, K and Co were increased from the roots to the leaves, while reverse was the case for Fe, Zn and Ni. Higher concentrations of Zn, Pb, Ni, Fe, Mn, Cd, Cr and Cu were observed in the root of the plants. However, higher amounts of Mg, Co, Na, K and Ca were observed in the leaves while equal proportions of Cu, Zn and Co were observed in the stem and leaves of the plant.

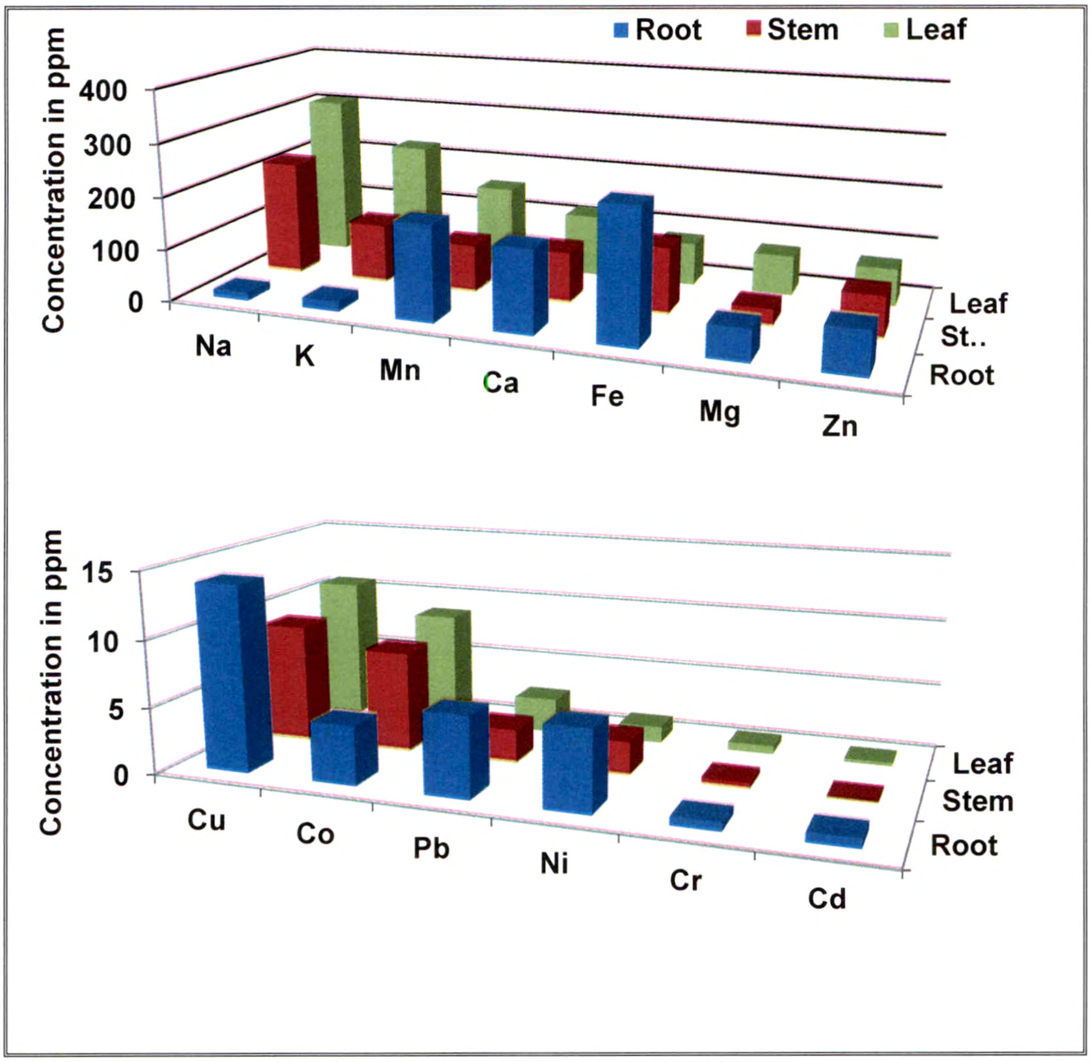

Figure 5.1: Metal contents in different fractions of the tea plants around GGS I.

Accessibility to root depends on a variety of factors: (i) soil type, pH, drainage status, presence of organic matter, sewage sludge and microbial activity, (ii) plant – species, parts, season of collection, and (iii) metal/metalloid – chemical form, location etc. Metals present in the ionic form in the soil solution are readily available, while those which are firmly bound to rock minerals are the least available. Availability of Co, Mn and Ni increases with decrease in pH. Uptake of metals like Cu is only marginally affected by alterations in pH of the soil.

Poor drainage enhances the release of Co, Ni and V, and also accumulation of organic matter which influences microbiological activity and metal uptake. Wide variations in metal uptake are observed in different plant species. Some plants are known to have special affinity for accumulating certain metals. The higher association of metal content with root can be considered as a restrictive translocation of metals under the existing physico-chemical conditions of soil (Wild, 1995). A part of the higher association of metal contents in leaves can be considered as the affect of aerosols generated from the non-stop flaring of oil and gas (Sharma and Agnihorti,1992; Baruah, 1996). Besides the root, metal may enter the plants through aerial parts including the leaf surface. High lead content may be observed in plants growing near busy traffic points (Bosque et al., 1990). Minute particles (<2μm) of some metals/metalloids, e.g. As, Cd, Cu, Se, and Zn, emanating from combustion sources may get dissolved in rain water and enter the plant through leaf surface. Foliar application of some fertilizers may contribute to the bioavailability of Cu, Fe, Mn, and Zn with variable affinity of absorption.

The extent to which plants take up metals (the biological availability) depends on the binding of trace analytes to soil constituents. In general, plants readily take up those species that are dissolved in soil solutions in ionic, chelated or complexed forms. Although adsorption by root is the main uptake pathway (Ross, 1994), it is also notable that tissues other than roots play a positive role in absorbing nutrients including trace metals. Uptake from it depends not only on the total content of the respective metal but also on its accessibility to roots and transfer across the soil-root inter-phase.

The present exploratory study has given ample evidences to state that a continuous biogeochemical monitoring of the area around oil installation is an utmost necessity as the reduced crop yield around these installations is becoming a common incident. Further, to evaluate possible impact of heavy metals on the tea plants and ecosystem around, a combined multidisciplinary effort covering the distribution pattern of heavy metals and their mobility in the associated physicochemical condition warrants for future studies. As the ecology of Northeast India is unique, it should not be allowed to destabilise by the unattended industrial development. Along with the technological development, the rich biodiversity of this region also should be preserved without disturbing the natural environmental attributes.

5.4 Conclusion

Plants absorb metals from soil, water and air. However, the chief source of metal absorption is the soil. Uptake from it depends not only on the total content of the respective metal, but also on its accessibility to roots and transfer across the soil-root inter-phase. The total amount of metal in a soil is in turn, affected by the inherent natural resources of the area in addition to the agricultural and industrial activities.

The metal content in root, stem and leaves of the tea plants indicate higher association of Cu, Cr, Cd, Zn, Pb, Ni, Mn and Fe in roots, whereas Na, K, Ca, Mg and

Co were found in higher proportion in leaves of the plants. Almost equal proportions of Cu, Zn and Co were observed in stem and leaves of the tea plant. The higher association in root can be explained as the effect of restrictive translocation of metals retained by the cell walls. A portion of the higher association of metal content in leaves can be considered as the effect of aerosols because of non-stop flaring activities around oil installations.

The study on soil quality along with the study on tea plants has given a strong foundation on the environmental degradation caused by the developmental activities going on around the oilfield areas and to explore and undertake the mechanism of absorption through a green process. It is therefore proposed to undertake a scientific approach to remove the heavy metals specifically those which are available above the background level at the soil system. To achieve this, phytoremediation of five heavy metals viz. Pb, Cd, Cu, Ni and Zn have been attempted by utilizing Vetiver plants and discussed in the preceding chapter.

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