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RESEARCH ARTICLE

HEAVY METALS AND ITS IMPACT ON TEA CULTIVATED SOIL AND TEA LEAF IN SIVASAGAR DISTRICT OF ASSAM, INDIA

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ABSTRACT

Tea is the most popular beverage in the world and contains several essential nutrients, which are beneficial for human health. Tea leaves also contains heavy metals which are harmful for human health. In this study, the concentration of heavy metals in tea cultivated soil and tea leaf were determined by atomic absorption spectroscopy (AAS). The concentration of Cd, Cr, Ni and Pb in all the soil samples ranged from 1.28-2.58, 48.26-78.42, 43.12-65.28 and 22.74-49.85 mg/kg respectively. The concentration of heavy metals in leaves samples were ranged from 2.02-2.67, 60.28-84.34, 56.18-79.20 and 30.96-50.12 mg/kg respectively. The concentration of heavy metals in the tea soil and tea leaves can be arranged in the following order, with regards to their total contents: Cr > Ni > Pb > Cd. The concentration of heavy metals in tea leaf is slightly higher than the tea cultivated soil. The concentration of heavy metals are within the tolerable level.

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INTRODUCTION

The concentration of heavy metals in the tea soil and the tea leaves is a serious problem regarding on the environment. To increase the optimum quantity of tea, tea planters were applied sufficient amount of fertilizers on soil, and also used fungicides to control the herbs in the tea cultivated soil. But fertilizers and fungicides itself contain sufficient amount of heavy metals. Soil is a good medium of acting as a sink for natural and anthropogenic pollutants (Chakraborty *et al*., 2004). Humans are responsible for introducing heavy metals into the environment. Heavy metals were no longer restricted to local area but also distributed over a wide area by means of air, water and soil. When the heavy metals are carried into the soil, they will accumulate there with time and enter into the food chain causing harm to human health (Xing and Chen, 2004). The uptake of heavy metals by plants from soil depends on their concentration in soil, soil pH, organic matter, clay content, cation exchange capacity, and on their specific geochemical properties (Bansal, 2004). Anthropogenic contamination with heavy metals is a worldwide problem that causes massive water and soil pollution (Caussy *et al*., 2003). Heavy metals that have contaminated industrial areas, roadside soils, riverbanks and urban areas are among the most serious environmental hazards (Magrisso *et al*., 2009). Numerous studies on contaminated soil suggest that physiochemical soil properties such as pH and clay and organic matter content are the major factors controlling heavy metal toxicity and bioavailability (Jacob and Joseph, 1994). Heavy metal uptake and accumulation by plants depends on metal speciation, mixed contamination, soil factors and plant characteristics (Bargagli, 1998; Brooks, 1998). The accumulation of heavy metals in plants has been a serious environmental concern because their uptake by plants from contaminated soils is the principal processes by which heavy metals enter the food chain and then to men and animals and are relatively toxic at levels slightly above than those required for maintaining normal metabolic activities of body (Hapke, 1991; Chakraborty *et al*., 2004).The objectives of these investigations were to assess the heavy metals concentration in tea cultivated soil and the tea leaves grown on these soils.The objectives of these investigations were to assess the heavy metals concentration in tea cultivated soil and the tea leaves grown on these soils.

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MATERIAL AND METHODS

Field description: Sivasagar district is historically one of the most important districts of Assam. It is located between $25^0 45^/$ to $27^0 15^/$ N latitudes and $94^0 25^/$ to $95^0 25^/$ E longitudes. The geographical area covered by Sivasagar district is 2668 sq km.

Climate: Sivasagar district carries a pleasant weather throughout the year. The temperature ranges from 8^0C to 18^0C in winter and 15^0C to 35^0C during summer. The district is characterized by highly humid atmosphere and abundant rains. The average annual rainfall is about 230 cm.

Physico-chemical properties of soil: In the plains of Sivasagar, the soil is alluvial. The soil adjacent to the river banks is sandy and away from the bank is muddy. The main crops grown in this district are tea and rice.

Procedure used: This research was conducted in the tea estates in Sivasagar district in the year 2012. Thirty soil and thirty leaf samples were collected from the ten tea estates in the month of December, because no fertilization or compost was applied in this month in the tea estates. Leaf samples were collected from the same plots as the soil samples. Composite soil samples and control soil were taken from 0 to 30 cm depth and prepared for necessary analysis in laboratory (Jaction, 1995). The map of the study areas are given in Figures 1(a) and 1(b) and the location of sampling stations were determined by using Global Positioning System (GPS) shown in Figure 2. Soil pH was determined by using procedure (Thomas, 1996). Organic matter was determined by the procedure (Wakley and Black, 1974). Heavy metals (Cd, Cr, Ni and Pb) were determined on each sample by using the procedure (Pinta, 1974; Gupta, 2007).

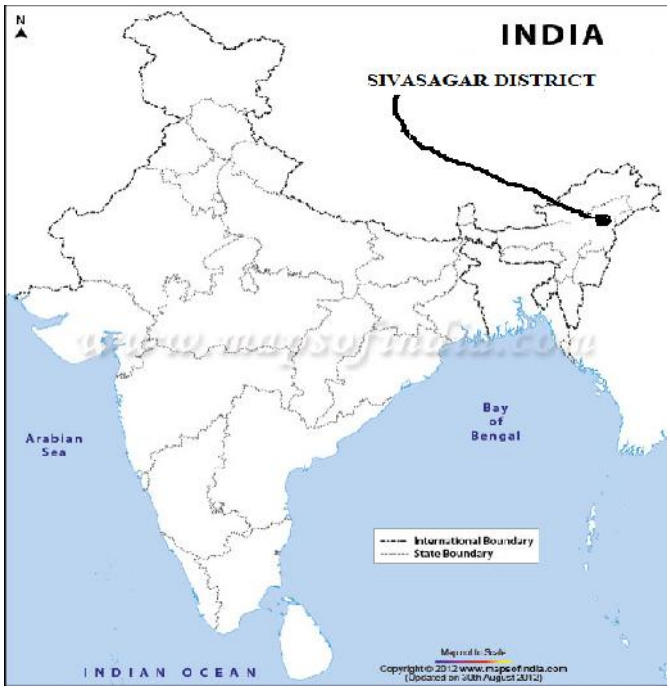

Figure 1(a). Map of study area (India)

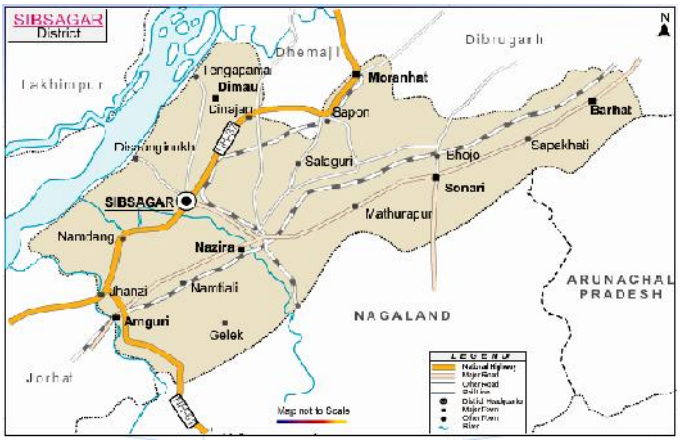

Figure 1(b). Map of study area (Sivasagar district)

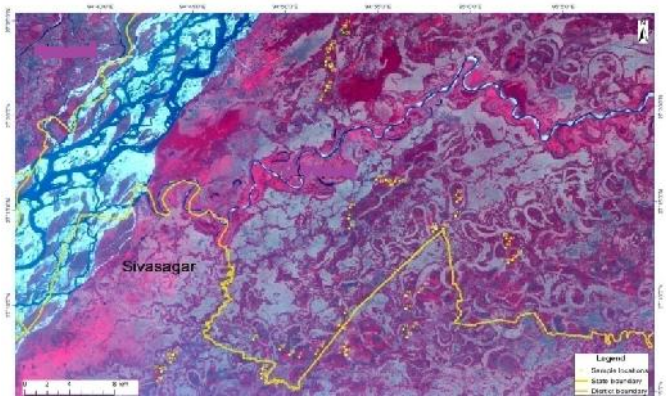

Figure 2. Location of soil sampling stations

Leaf samples were taken in the month of December from the same locations and brought to the laboratory, washed with distilled water, dried at 65^0C temperature and ground. Heavy metals were then estimated by AAS after proper digestion and analytical procedure ((Pinta, 1974; Gupta, 2007).

RESULTS AND DISCUSSION

Heavy metals concentration of soil samples

The pH, organic matter and heavy metals related to thirty soil samples collected from the 10 tea estates in Sivasagar district were given in table 1. The pH values of soil samples ranged from 4.42 to 5.54. At the control soil, pH is found as 4.48. It was found that soil samples were moderately acidic and adequate for tea soil. Organic matter of soil samples ranged from 1.86 to 3.28 %. When the soil samples were evaluated as for organic matter content they were sufficient for tea estates soil. The organic carbon of the tea cultivated soil samples were higher than the control soil in tea estate , this may be due to addition of fertilizers, animal wastes, tea leaves and branches into the soil. Cd contents of soil samples were 1.28 to 2.58 mg/kg; Cr contents were 48.26 to 78.42 mg/kg; Ni contents were 43.12 to 65.28 mg/kg and Pb contents were 22.74 to 49.85 mg/kg respectively. The concentration of heavy metals Cd, Cr, Ni and Pb increases with increase in organic matter content in the soil (Wesley, 2004. The soil samples showing high levels of heavy metal concentration had high organic matter content.

Table 1. Soil properties and total heavy metal contents (mg/kg) of tea estates soil

Samples	pH	%TOM	Cd	Cr	Ni	Pb
1	4.69	2.03	1.61	55.76	49.67	29.32
2	5.54	2.98	2.58	78.42	65.28	49.85
3	5.10	2.50	2.05	67.03	58.64	39.08
4	5.25	2.62	2.17	70.65	61.43	42.37
5	5.39	2.77	2.34	74.40	62.86	45.42
6	5.48	2.85	2.45	78.14	64.92	48.49
7	4.96	2.36	1.89	63.29	54.88	35.80
8	4.42	1.72	1.28	48.26	43.12	22.74
9	4.56	1.88	1.46	52.04	46.90	26.02
10	4.82	2.19	1.75	59.52	52.45	32.54
Min	4.42	1.72	1.28	48.26	43.12	22.74
Max	5.54	2.98	2.58	78.42	65.28	49.85
Control	4.48	1.64	1.22	28.86	38.24	18.56

(Each value is the mean of three sampling sites from each of the tea estates)

A complexation reaction occurs between heavy metals and organic matter content and results in the retention of heavy metal in the soil (Kumari *et al.*, 2001). Increase in pH in the soil results in increase heavy metal concentration in the soil. The higher pH favors the heavy metal retention in soil; it limits the heavy metal uptake by tea plants. The heavy metal uptake by plants decreases as the pH value increases. The acidic pH favors the uptake and causes harmful effect to the living beings through the food chain. The pH value of the tea estate soil was found to be acidic. This indicates that the uptake by plants was high and the biological system was contaminated by the heavy metals. Soil pH and high total organic matter content have a higher retention capacity of heavy metal in soil. The present studies agree with findings of following workers (William and David, 1976; Bansal, 2004 and Xing and Chen, 2004).This indicates that the uptake by plants was high and the biological system was contaminated by the heavy metals. Soil pH and high total organic matter content have a higher retention capacity of heavy metal in soil. The present studies agree with findings of following workers (William and David, 1976; Bansal, 2004 and Xing and Chen, 2004). The maximum permissible limits of heavy metal concentration in soil (ECDGE, 2010) is given in Table 2. Many studies have indicated that the accumulation of heavy metals in soil has had an adverse effect on the growth and development of wide variety of plant species. Although low quantity of some heavy metals are necessary for the proper functioning of most plant system, higher concentrations have been found to be responsible for metabolic disturbance and growth inhibition of some plants. Some of the heavy metal plays an essential biological role in plant and human metabolism. It was found that the concentration heavy metals of the tea estate soil still below its maximum limits.

Table 2. Allowable limits of heavy metal concentration in soil (mg/kg)

Heavy metal	Austria	Germany	France	Luxem bourg	Nether lands	Sweden	United Kingdom
Cd	1 to 2	1	2	1 to 3	0.5	0.4	3
Cr	100	60	150	100 to 200	30	60	400
Ni	50 to 70	50	50	30 to 75	15	30	75
Pb	100	70	100	50 to 300	40	40	300

Source: ECDGE (2010)

It was suspect that the concentration of heavy metals in tea cultivated soil might be increase by the application of fertilizers, animal wastes and fungicides for improvement of tea productivity. The degree of soil pollution by the heavy metals from various anthropogenic activities, such as application of fertilizers, animal wastes and herbicides are the normal work for tea estates (Rao, 1998 and Rao and Sharma, 1998). The range of concentration of heavy metals in some fertilizers and lime materials (Kabata-Pendius and Pendius, 1984) and (Gunnarsson,1983) is give in Table 3.

Table 3. Range of concentration of heavy metals in some fertilizers and lime materials (in mg/kg)

Heavy metal	N[a]	P[b]	NPK[b]	Lime [a]
Cd	0.05 to 8.5	0.1 to 170	1.0 to 10	0.1 to 24
Cr	0.3 to 2.9	66 to 245	20 to 72	10 to 15
Ni	7.0 to 34	7.0 to 38	9.0 to 20	10 to 20
Pb	2.0 to 27	7.0 to 225	10 to 130	20 to 250

a =Pendius and Pendius, 1984, b =Gunnarsson, 1990

According to the following workers (Singanan *et al*., 1995 and Gupta *et al*., 2000) a good correlation is predicted if the linear regression co-efficient "r" is > 7. Table 4 shows that the correlation results between pH and organic matter with heavy metal elements in tea soil. It was found that pH of the soil correlated positively and significantly with heavy metals. Also, there was positive correlation between organic matter contents and heavy metal elements.

Table 4. Correlation between heavy metals and soil properties of the soil samples

Soil	Cd	Cr	Ni	Pb
Properties	correlation coefficient value(r)	correlation coefficient value(r)	correlation coefficient value(r)	correlation coefficient value(r)
Soil pH	0.88	0.84	0.78	0.80
TOM	0.84	0.90	0.86	0.84

Heavy metal concentration of tea leaf samples

Heavy metal concentration of tea leaf samples are given in Table

Table 5. Total heavy metal contents (mg/kg) of tea leaf

Samples	Cd	Cr	Ni	Pb
1	2.18	65.94	61.86	35.82
2	2.67	84.34	79.20	50.12
3	2.41	75.28	70.56	43.03
4	2.49	78.26	73.35	45.43
5	2.54	81.74	76.24	47.84
6	2.66	83.56	79.12	50.03
7	2.34	71.88	67.62	40.62
8	2.02	60.28	56.18	30.96
9	2.07	63.22	59.05	33.08
10	2.27	69.24	64.44	38.23
Min	2.02	60.28	56.18	30.96
Max	2.67	84.34	79.20	50.12

(Each value is the mean of three sampling sites from each of the tea estates)

According to the results Cd, Cr, Ni and Pb contents of tea leaf samples were ranged from 1.78 to 2.96, 68.44 to 95.42, 47.62 to 69.94 and 34.72 to 56.64 mg/kg respectively. The heavy metal concentration in the tea leaves can be arranged in the following order, with regards to their total concentration: Cr > Ni > Pb > Cd. The Cd concentration of tea leaves in the different tea estates in the different region in the world varied from small amount to a large amount depending on the soil structures. In this research the Cr contents of tea leaves have attained little higher concentration value. In this study, it was found that the contents of heavy metal in tea leaves were below the allowable limits and trends to high level. The total heavy metal components in tea plants depend on many factors, primarily the age of the tea leaves, but also the soil conditions, rainfall, altitude, genetic makeup of the plant. It was stated that the metal contents in tea leaves differ according to the type of tea and geological conditions. The heavy metal concentrations in different parts of the tea plant namely, young leaves, old leaves, branches were different in different locations. In this research it was observed that the tea leaf samples result are similar with soil analysis results and the heavy metal Cd, Cr,

Ni and Pb concentration of tea leaves are higher than the soil samples. Foliar application of some fertilizers may contribute the high concentration of heavy metals in tea leaves. Tea plants absorbed heavy metals from soil, water and air. The chief source of heavy metal absorption is soil. Uptake from it depends not only on the total content of the respective metal but also on its accessibility to roots and transfer in a soil is turn, affected by the inherent resources of the area in addition the agricultural and industrial activities (Kotoky *et al*., 2013).

Conclusion

The results shows that the heavy metal concentration of tea leaves were higher than the tea cultivated soil. The heavy metal concentrations of soil and leaf samples were found to be below the allowable limits. The concentration of heavy metals in the tea soil and tea leaves can be arranged in the following order, with regards to their total contents: Cr > Ni > Pb > Cd. The determination of heavy metal concentrations by AAS method is a useful technique for characterizing and heavy metal pollution. The present study need to be continue to monitor the concentration of toxic heavy metals such as Cd, Cr, Ni and Pb in soil and tea leaves in order to identify their toxicity on time. The application of fertilizers, animal wastes and fungicides into the soil not only supply the essential nutrients but also enrich the soil contaminated with the heavy metals. Therefore, there is a need for optimization of fertilizers, animal wastes and fungicides for improvement of the soil productivity without creating any type of environmental problems.

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