*International Research Journal of Environment Sciences*_____ ISSN 2319–1414
Vol. **2(6),** 25-30, June **(2013)** *Int. Res. J. Environment Sci.*

The Status of Micronutrients (Mn, Fe, Cu, Zn) in Tea Plantations in Dibrugarh district of Assam, India

Nath T.N.
Department of Chemistry, Moran College, P.O.-Moranhat, Dist-Sivasagar, Assam, INDIA

Available online at: www.isca.in
Received 16th April 2013, revised 23rd April 2013, accepted 25th May 2013

Abstract

This research was carried out to determine the concentrations of micronutrients of tea plantations in Dibrugarh district. Soil and leaf samples were collected from the ten tea estates in the month of December every year during the period of 2007 to 2009. Soil samples were taken from 0 to 30 cm depth. Leaf samples (two apical leaves and the bud) were collected from the same plots as the soil samples. According to the results, Mn, Fe, Cu and Zn concentration of soil varied within the range of 118.53 to 420.57; 89.34 to 307.72; 12.73 to 26.32 and 21.43 to 45.28 mg/kg respectively. Mn, Fe,Cu and Zn concentration of leaf samples were ranged as 224.36 to 568.64; 212.85 to 546.42; 14.34 to 29.78 and 24.82 to 58.26 mg/kg respectively. From the study it was found that the micronutrients concentration of the tea leaves was higher than the concentration of the tea soil. It was also detected that there was no micronutrients deficiency in the study area, when mean values for both soil and leaves samples were taken into consideration.

Keywords: Micronutrients, productivity, deficiency and harvested.

Introduction

Tea is one of the most popular beverages and an important commercial crop spread over many areas of the world. The sub-tropical climate of Northeastern India is extremely favourable to the cultivation of many plantation crops. Among the three important crops viz, tea, coffee and rubber, tea was introduced in Assam as an industrial crop during the middle of nineteenth century, which has spread to other non-traditional states in the region in recent years. Suitable land and climate conditions provide favourable environment for tea cultivation in Assam. Tea is the major source of revenue to the economy of the state. The data reveal that 7.5 per cent (2.79 lakh hectors), area under tea cultivation in the region.

Assam is the largest producer of tea in India (about 53 per cent of the total production). Its share in the region is about 96.8 per cent of area and 98 per cent of production. The productivity of tea is about 1850 kilograms per hector. Tea plant grows well on high land well drained soils having a good depth, acidic pH in the range of 4.5 to 5.5 and more than 2% organic matter. Shallow and compacted sub-soils limit root growth. Tea plants growing on such soils are liable to suffer from draught during dry period and water logging during the rainy months. Since 1980, organic tea consumption has grown by leaps and bounds. Tea qualifies as organic only when environment-friendly techniques are employed in its production. India too has joined this new green revolution with many farmers already growing organic tea or converting their plantations to do so. However many barriers have to be overcome before this sector realizes its full potential. The tea production system, like that of many other upland crops is undergoing major changes in response to population pressure and improved market access. As a consequence, there has been an increase in both land –use intensity and soil degradation[1]. Whereas tea plantations remain productive for long periods, yields tend to decline in the latter years. This drop in productivity is traditionally attributed to natural aging of the plants[2].

Degradation in soil quality is often associated with the type of intensive land use involved in tea production. Moreover, because crop growth and productivity are a reflection of soil quality, any degradation of the soil can be expected to adversely affect the stability of system. Tea is one of most popular beverages among the people in the world. The quality of tea leaf used in the manufacturing process is highly important and concentration of the micronutrients in tea soil and the tea leaf affect the tea quality[3]. The plants, when they do not possess the elements they need sufficiently, their growth is lessened and stopped at last. The availability of nutrient elements is closely related with growth of plant, nutrition and useful mineral matter concentration of earth. The concentration of nutrients element of tea leaf are related with the soil environment[4]. Fresh tea leaf has a mineral content which may vary depending on the earth structure on which it is grown, maintenance and fertilizing. Therefore, it was deemed that the determination of concentration of micronutrients in tea soil and tea leaves during long-term tea production could help enhance the sustainability of tea cultivation.

Material and Methods

Field description: This study was conducted in tea plantation areas with high tea productivity. Ten tea estates selected for

study in the Dibrugarh district of Assam. Dibrugarh district is situated in the eastern part of Assam. The district extends from $27^0 05.38^/$ N to $27^0 42.30^/$ N Latitudes and $94^0 33.46^/$ E to $95^0 29.80^/$ E Longitudes. The geographical area covered by Dibrugarh district is 3381 sq km. The area of the Dibrugarh district experiences subtropical monsoon climate with mild winter, warm and humid summer. Rainfall decreases from south to north and east to west in the area. The average annual rainfall in this district is 276 cm with a total number of 193 rainy days.

Physico-chemical properties of soil: The soils of the area are basically the products of the fluvial processes of the Brahmaputra and its tributaries. The plains are composed of alluvium which may be classified as new and old. The new alluvium varies mostly from clayey to sandy loam in texture and is slightly acidic in reaction. In certain parts, both the old and new alluvium are so combined that it is difficult to distinguish them. The pH ranges between 4.2 and 5.5. The new alluvium is less acidic as compared to the old alluvium. Its pH value varies from 5.5 to 9.9. Tea is abundantly grown in the old alluvium as it has high percentage of acid. The tea estates are located over relatively high lands with discernible slopes containing both old and new alluvium.

Procedure used: This research was conducted in the tea estates in Dibrugarh district. Sixty Soil and leaf samples were collected from the ten tea estates in the month of December every year during the period of 2007 to 2009, because no fertilization or compost was applied during this month in the tea estates. Leaf samples (two apical leaves and the bud) 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[5,6]. Location of sampling stations was determined using Global Positioning System (GPS) shown in figure1and map of study area is given in figure 2. Soil pH was determined by using procedure[7]. Organic matter was determined by the procedure[8]. Micronutrients (Mn, Fe, Cu and Zn) were determined on each sample by using the procedure [9]. Leaf samples were taken in the month of December every year from the same locations brought to laboratory, washed with distilled water, dried at 65^0C temperature and ground. Micronutrients were then estimated by AAS after proper digestion and analytical procedure[9].

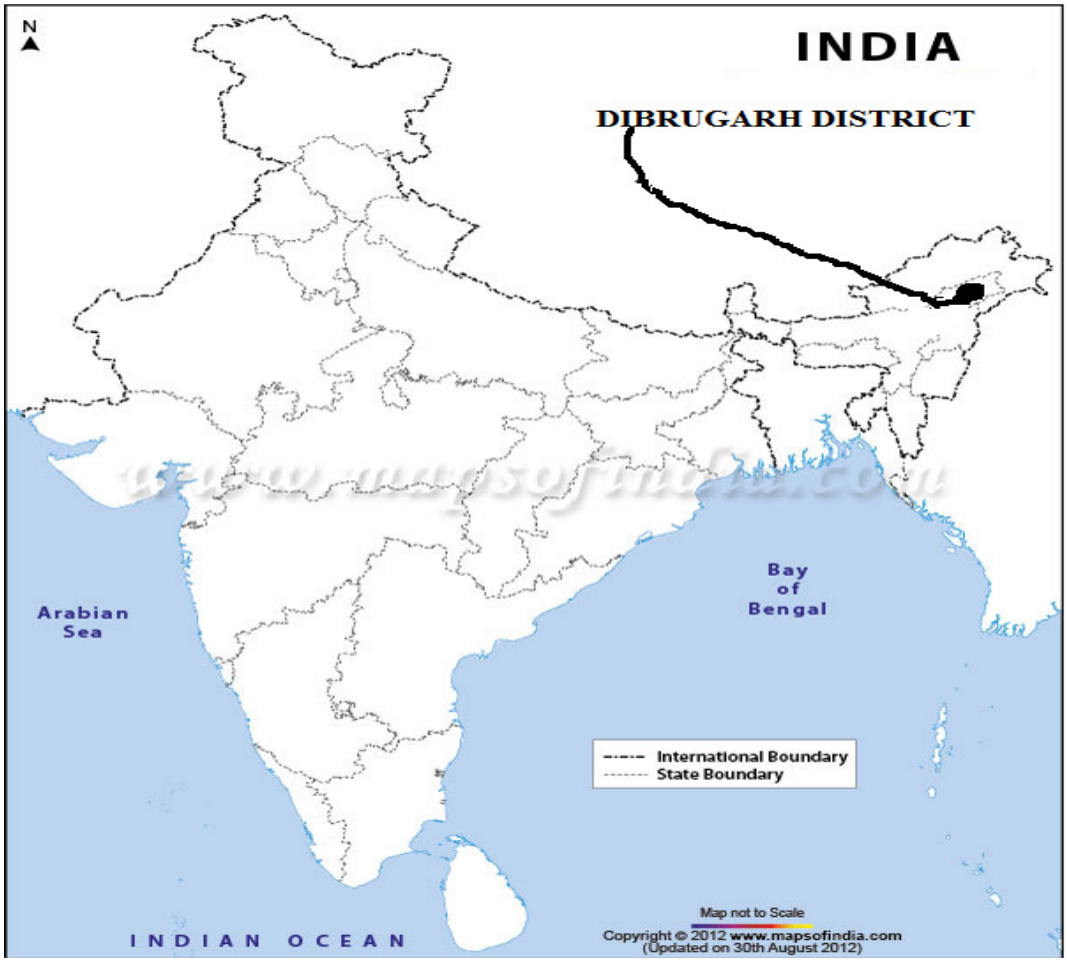
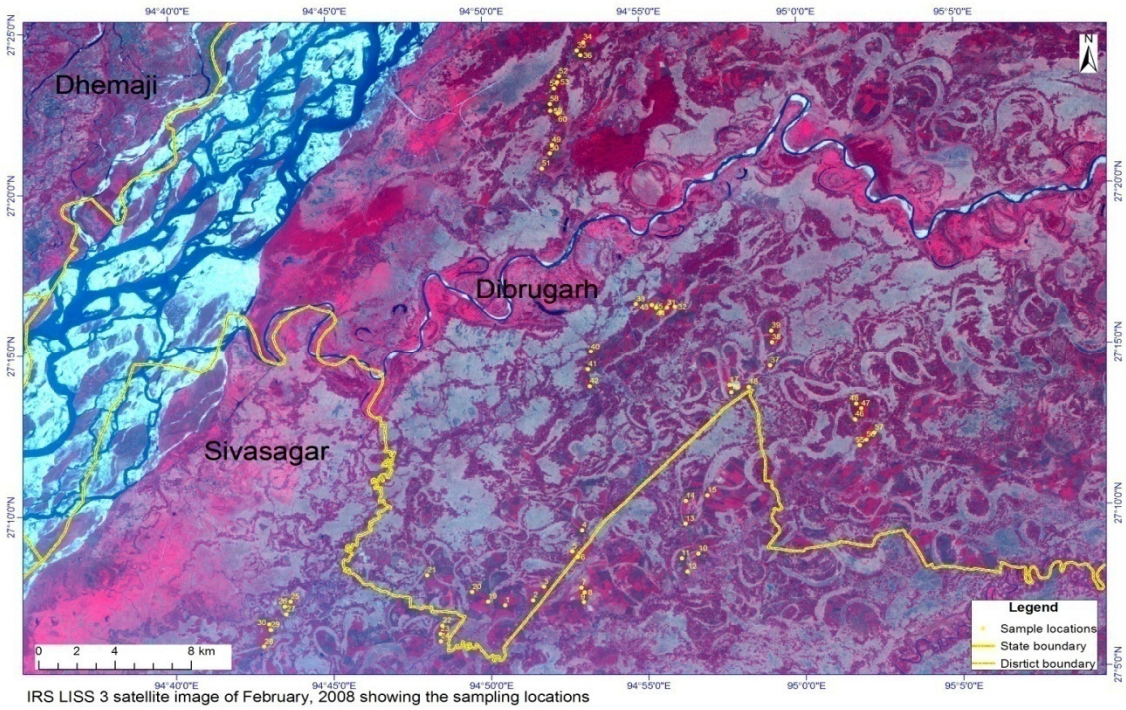


Figure-1a



IRS LISS 3 satellite image of February, 2008 showing the sampling locations

Figure-1b
Location of soil sampling stations

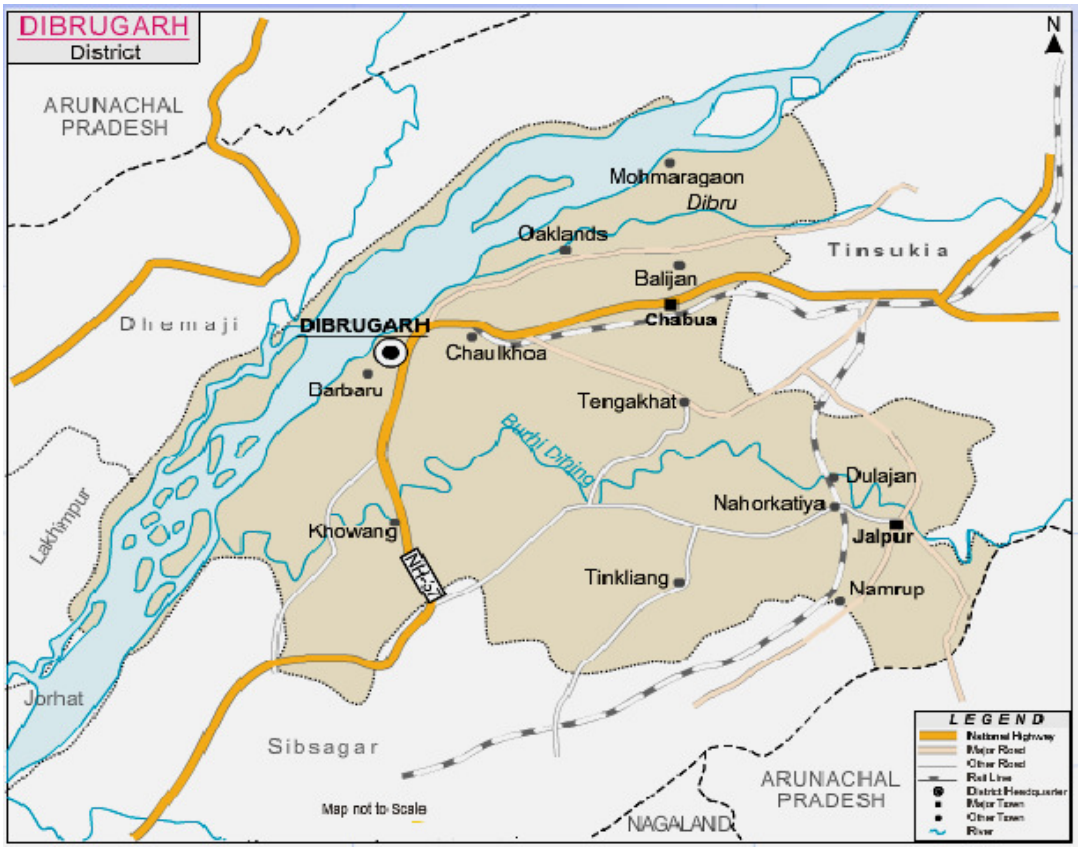


Figure-2
Map of Dibrugrah district

Results and Discussion

Micronutrient content of soil samples: Minimum, maximum and average values of the pH, organic matter and micronutrients related to 60 soil samples collected from the 10 tea estates in Dibrugarh district were given in table 1 and 2. The pH values of soil samples ranged from 4.48 to 5.62. When the soil samples were evaluated according to pH values it was found that soil samples were moderately acidic and adequate for tea soil. Organic matter of soil samples ranged from 1.87 to 3.64%. When the soil samples were evaluated as for organic matter content they were sufficient for tea estates soil. The organic carbon of the soil samples were higher in tea estate soil, this may be due to addition of fertilizers, animal wastes, tea leaves and branches into the soil. Mn contents of soil samples were 118.53 to 420.57 mg/kg; Fe contents were 89.34 to 307.72 mg/kg; Cu contents were 16.73 to 36.32 mg/kg and Zn contents were 21.43 to 65.28 mg/kg respectively.

Table-1
pH and total organic matter content (%) of the soil samples

Properties	Minimum	Maximum	Average	Standard deviation
pH	4.48	5.62	5.14	0.35
Total organic matter(%)	1.87	3.64	2.94	0.51

Table-2
Micronutrient element contents of the soil samples (mg/kg)

Micronutrients	Minimum	Maximum	Average	Standard deviation	Control
Mn	118.53	420.57	326.46	91.94	94.65
Fe	89.34	307.72	290.42	88.62	39.36
Cu	12.73	26.32	14.96	5.12	10.22
Zn	21.43	45.28	42.16	12.34	18.72

The concentration of micronutrient metals Mn, Fe, Cu and Zn increases with increase in organic matter content in the soil. The soil samples showing high levels of micronutrient metal concentration had high organic matter content. A complexation reaction occurs between micronutrient metals and organic matter content and results in the retention of micronutrient metal in the soil. Increase in pH in the soil results in increase micronutrient metal concentration in the soil. Even though the higher pH favors the micronutrients retention in soil, it limits the micronutrient metal uptake by tea plants. The micronutrient 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 micronutrient metals. Soil pH and high total organic matter content have a higher retention capacity of micronutrient metal in soil. The maximum permissible limits of micronutrients in soils are 2 to 250 mg/kg for copper and 10 to 300 mg/kg for zinc respectively[10-12]. Many studies have indicated that the accumulation of micronutrient metals in soil has had an adverse effect on the growth and development of wide variety of plant species. Although low quantity of some micronutrient metals much as copper and zinc are necessary for the proper functioning of most plant system, higher concentrations of copper and zinc have been found to be responsible for metabolic disturbance and growth inhibition of some plants. Trace metal play an essential biological role in plant and human metabolism. Copper and Zinc are considered as good source of protein[13]. Zinc occurs naturally in many foods and so is present in all human wastes which are flushed down the toilets. This is the largest domestic single contribution of Zinc from domestic activities[14]. Micronutrient metals are naturally present in soils as natural components. The presence of micronutrient metals in the environment has accelerated due to human activities. Zinc concentration above $500kg^{-1}$ reduces the ability of soil to absorb iron and manganese[15]. Soil forms a repository micronutrient element because soil particles such as clay and humus have charges that help the metal cations to bind themselves with the soil, and thus prevent their release, though temporarily. The soluble forms of micronutrient metals are more dangerous because they are readily available to plants and animals[16]. It was found that the concentration of micronutrient metals of the tea estate soil increases during the study period but still below its maximum limits. Table 3 shows that the correlation results between pH and organic matter with micronutrient elements in tea soil found that pH of the soil correlated positively and significantly with micronutrients, Mn, Fe, Cu and Zn. Also, there was positive correlation between organic matter contents and micronutrient elements.

Table-3
Correlation between micronutrients and soil properties of the soil samples

Soil Properties	Cu	Fe	Mn	Zn
	correlation coefficient value(r)	correlation coefficient value(r)	correlation coefficient value(r)	correlation coefficient value(r)
Soil pH	0.88	0.92	0.92	0.78
TOM	0.94	0.95	0.92	0.94

Micronutrient contents of tea leaf samples: Micronutrient contents of tea leaf samples are given in table 4. According to the results Mn, Fe, Cu and Zn contents of tea leaf samples were ranged from 224.36 to 568.64; 212.85 to 546.42; 14.34 to 29.78 and 24.82 to 58.26 mg/kg respectively. It was found that the average Mn, Fe, Cu and Zn contents of tea leaves were 412.28, 410.56, 19.42 and 48.78 mg/kg , respectively.The micronutrients concentration in the tea leaves can be arranged in the following order, with regards to their total contents: Mn> Fe> Zn> Cu. The results obtained in this study agree with the finding[17].The manganese concentration of tea leaves show disagreement with the findings[18-20]. The table 5 shows the allowable limit value of

Mn, Fe, Cu and Zn concentration of tea leaves according to the quality[21,22]. It was reported that Mn content of more than 4000 mg/kg in a tea plant would be able to adversely affected while Mn content in the tea leaves in between 12 to 45 mg/kg were suffered in Mn deficiency[23].

Table-4
Micronutrient element contents of the tea leaf samples (mg/kg)

Micronutrients	Minimum	Maximum	Average	Standard deviation
Mn	224.36	568.64	412.28	92.62
Fe	212.85	546.42	410.56	90.76
Cu	14.34	29.78	19.42	5.48
Zn	24.82	58.26	48.78	15.24

Table-5
Allowable limit value of Fe, Cu, Zn and Mn contents of tea leave according to Jone et al. (1991) and Bergmann (1992)

Micronutrients	Limit value(mg/kg)	Description	Ratio
Fe(Jone et al., 1991)	<500	Deficiency	20
	500-1000	Sufficient	80
	>1000	Excessive	nil
Zn(Jone et al., 1991)	<30	Deficiency	5
	30-50	Sufficient	95
	>50	Excessive	nil
Cu(Bergmann, 1992)	<7	Deficiency	nil
	7--15	Sufficient	70
	>15	Excessive	30
Mn(Bergmann , 1992)	100-5000	Sufficient	100
Zn(Bergmann, 1992)	30-80	Sufficient	95

The Fe contents 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. It was reported that the Fe contents of tea leaves during the second offshoot periods had changed from 21.99 to 118 mg/kg [24]. In this study it was found that the iron concentration of tea leaves was higher during the study period which is adequate for the tea leaves.It was reported that the Cu contents in tea leaves collected different offshoot periods were ranged 13 to 23.60 mg/kg [24]. In this research the Cu contents of tea leaves have attained little higher concentration value. In this research it was found that the Zn contents in tea leaves show similarity with the findings[25,26]. In addition the zinc concentration of tea leaves was found disagreement with the findings[27,28]. In this study, it was found that the contents of micronutrient in tea leaves were sufficient and trends to high level. It was reported that the ability of tea plants to accumulate metals, particularly Mn and Fe, and to a lesser extent of zinc and copper[29]. The total 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[30]. The micronutrient 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 micronutrients Mn, Fe, Cu and Zn concentration of tea leaves are higher than the soil samples. Therefore, Mn, Fe, Cu and Zn deficient for tea plant is not seen commonly, because the plant is grown in acid soil and Mn, Fe, Cu and Zn deficient is not seen in tea plant.

Conclusion

According to soil and leaf samples analysis results of the investigation, Mn, Fe, Cu and Zn contents were sufficient and increasing trends. To compensate micronutrient deficiency in the tea plant, the fertilizer program should carefully be chosen to enhance the tea quality and production. To maintain the optimum pH ranged 5.0 to 5.8 for tea plant required sufficient amount of lime applied to the soils.

Acknowledgement

The author is grateful to Professor K.G. Bhattachayya and the Department of chemistry, Gauhati University, Guwahati, Assam, India for assisting in the laboratory analysis of the soil and leaf samples

References

1. Pande S., Socio-economic context and priorities for strategic research on Asian upland rice ecosystems. In: Piggin C., Courtoirs B. and Schmit V. (Eds.), Upland Rice Research in Partnership. Discussion Paper Series **16**, IRRL, Philippines, 103-124 (**1996**)

2. Doran J. W. and Parkin T. B., Defining and assessing soil quality. In: Doran J.W., Colman D.C., Bezdicek D.F. and Stewart B.A. (Eds.). Defining Soil Quality for a Sustainable Environment. *SSSA Special Publication,* **35**, 3-23 (**1994**)

3. Kacar B., Fertilization of tea plant. General Directory of Tea Management, Cay-Kur Press, Ankara, **4**, 356 (in Turkish), (**1984)**

4. Ozyazici M.A., Ozyzici G. and Dengiz D., Determination of micronutrients in tea plantations in the eastern Black Sea Region, Turkey, *African Journal Of Agricultural Research,* **6(22**), 5174-5180 (**2011)**

5. R.K Odunaike., Alausa S.K., Alausa I.M. and Akinijemi L.P., Elevation of Heavy Metals in the Environment of Aragba and Uvwiamughe in the Niger Delta Region of Nigeria after an Oil Spillage, *Int. Res. J. Environment Sci*., **2(3**), 1-5(**2013)**

6. Jackson M. L., In: Soil Chemical Analysis, Advanced Course .Prentice Hall (India), New Delhi, (**1995**)

7. Thomas G.W., Soil pH and soil acidity. Sparks et al.(Ed.). Method of soil analysis, Part 3,Chemical methods, SSSA Book Series No **5**, SSSA and ASA, Madison, 475-490 (**1996)**

8. Walkley A. and Black C.A., Critical examination of rapid method of determining organic carbon in soil, *Soil Sc.,* **63**, 251-164 (**1974**)

9. Pinta M., Detection and determination of trace elements, ANA, *Arbor Science Publication INC*, (**1975**)

10. Kabata-Pendias A. and Pendias A., Trace Elements in soils and plants. CRC Press, Boca Raton, Fla, (**1984**)

11. Fergusson J.E., In: The heavy elements, chemistry, Environmental impact and health effects. Pregamon Press. Oxford. Food and Agriculture Organization of the United Nations- Production FAOSTAT, (**1990)**

12. Alloway B.J., Heavy Metals in Soils. Blackie, London, (**1990**)

13. Nwajei G.E. ,Okwagi P., Nwajei R.I. and Obi-Iyeke G. E., Analytical Assessment of Trace Elements in Soils, Tomato Leaves and Fruits in the Vicinity of Paint Industry, Nigeria, *Res. J. Recent sci.*, **1(4)**, 22-26 (**2012**)

14. Murhekar Gopalkrushna Haribhau., Trace metals contamination of surface water samples in and Around Akot City in Maharashtra, India, *Res, J. Recent Sci*., **1(7)**, 5-9 (**201**2)

15. Francis Amala Rejula and Masilamoni Dhinakaran., Removal of Zinc(II) by Non living Biomass of Agaricus Bisporus*, Res. J. Recent Sci*., **1(9)**, 13-17(**2012**)

16. Prasanth K.M. , Sreekala P.P., Sandip S. , Kripa P.K. and Sreejesh K.K., Heavy metals and its Fraction as in soils of Koratty Region, Kerala*, Res. J. Recent Sci.*, **2(ISC-2012**), 171-176 (**2013**)

17. Taban S., Okay Y. and Kunter B., Effects of foliar fertilizer applied different periods and doses on leaf quality and mineral elements concentrations of tea plants, Tarim Bilimleri Dergisi, **6(10)** 58-62 (in Turkish), (**2000**)

18. Adiloglu A. and Adiloglu S., An Investigation on Nutritional Status of Tea (Camellia Sinensis L.) Grown in Eastern Black Sea Region of Turkey, *Pakistan Journal of Biological sciences,* **9(3)**, 365-370 (**2006)**

19. Kacar B., Przemeck E., Ozgumus A., Turan C., Katkat A .V. and Kayikcioglu I., A research about micronutrients status of tea plant and its soils in Turkey. TUBITAK, TOAG Report**, 321**, 1-67 (in Turkish), (**1979**)

20. Street R., Ozakova J., Drabek O. and Mladkova L., The status of micronutrients (Cu,Fe, Mn,Zn) in tea and tea infusions in selected samples imported to the Czech republic. Czech *J.Food Sci*., **24(2)**, 62-71 (**2006)**

21. Jones J.B. Jr., Wolf B. and Mills H.A., Plant analysis handbook. Micro-Macro Publishing, Inc., Georgia 30607, USA, (**1991**)

22. Bergmann W., Nutritional disorders of plants, 386 (**1992)**

23. Tolhurst J. A. H., Manganese deficiency symptoms of tea. *Tea Q.,* **34**, 148-149 (**1963**)

24. Horuz A. and Korkmaz A., Yield, nitrogen content and mineral matter composition of tea plant harvested in different shoot periods*. J.Fac.Agric*., OMU, 2006, **21(1)**, 49-54 (**2006)**

25. Arslan N. and Togrul H., Quality parameters in Turkish teas and the distribution ratios of minerals into the liquors at different liquoring conditions. GIDA, **20(3)**, 179-185 (**1995**)

26. Ozdemir F., Topuz A. and Erbas M., Mineral contents of different classes of black tea produced by Orthodox and Caykur methods Tr. *J.Agric.For.,* **23(4)**, 808-815 (in Turkish) **(1999)**

27. Stagge G.V. and Millon D.J., The nutritional and therapeutic value of tea, *J. Sci.Fd.Agric*., **26**, 1439-1459 (**1975**)

28. Michie N.D. and Dixon E.J., Distribution of lead other metals in tea leaves, dust and liquors, *J. Sci. Food Agric.,* **28,** 215-224 (**1977**)

29. Saud S. and Oud A.L., Heavy metal contents in tea and herbs leaves, *Pakistan Journal of Biological Science*, **6**, 202-208 (**2003**)

30. Marcus A., Fisher A., Ree G. and Hill J., Preliminary study using trace element concentrations and a chemometics approach to determine the geological origin of tea, *Journal of Analytical Atomic Spectrometry,* **113**, 521-525 (**1996)**