INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Determination Of Micronutrients Concentration In Tea Cultivated Soil In Dibrugarh And Sivasagar Districts Of Assam, India

Tara Nath Nath
Associate Professor, Department of Chemistry, Moran College, Moranhat , Sivasagar, Assam, India.

Abstract:
A study of the micronutrient status of soils of two upper Assam districts of Dibrugarh and Sivasagar was made at 60 different locations. The objective of the experiment was to study the status of micronutrients after continuous tea cultivation and their relationship with various physiochemical properties. Soil samples were collected at the three depths of 0-15, 15-30 and 30-60 cm and analyzed for Copper, Iron, Manganese, Zinc and hot water soluble Boron. The Copper, Iron, Manganese, Zinc and Boron ranged from 16.73—36.33 mg/kg (average 26.53), 15.35—31.73 mg/kg (average 23.54), 13.17—29.13 mg/kg (average 21.15); 49.3—107.7 mg/kg (average 78.5), 44.1—99.6 mg/kg (average 71.9), 32.1—85.3 mg/kg (average 58.7); 118.53—420.53 mg/kg (average 269.53), 103.73—390.33 mg/kg (average 247.03), 92.07—377.50 mg/kg (average 234.79); 21.43—65.20 mg/kg (average 43.32), 21.07—56.47 mg/kg (average 38.77), 17.70—48.87 mg/kg (average 33.29); 3.09—3.97 mg/kg (average 3.53), 2.76—3.67 mg/kg(average 3.22), 2.41—3.27 mg/kg (average 2.84) for the surface , subsurface (I) and subsurface (II) soil respectively. All the micronutrients gave positive significant correlation with soil pH and organic matter and gave negative significantly correlated with clay content. Other physiochemical properties of soil showed either negative or positive non-significant correlation with micronutrient during the study.

Key words: *Micronutrient, soil, tea cultivation, physiochemical properties.*

1.Introduction

Soil fertility is an important factor, which determines the growth of plant. Soil fertility is determined by the presence or absence of nutrients i.e. macro and micronutrients. Out of the 16 plants nutrients Boron, Copper, Iron, Manganese, Molybdenum, Zinc and Chlorine are referred as micronutrients. These elements are required in minute quantities for plant growth. Although micronutrients are required in minute quantities but have the same agronomic importance as macronutrients have and play a vital role in the growth of plants. Micronutrients also increase plant productivity, leaf and grain yield. Most of the micronutrients are associated with the enzymatic system of plants. Whenever a micronutrient is deficient the abnormal growth of plant results which sometime cause complete failure of crop plants. Grains and flower formation does not take place in severe deficiency.

The main sources of these micronutrients are parent material, sewage sludge, cow dung, farmyard manure and organic matter. These nutrients are present in small amounts ranging from few mg kg^{-1} to several thousand mg kg^{-1} in soils.The availability of micronutrients is particularly sensitive to changes in soil environment. The factors that affect the contents of such micronutrients are organic matter, soil pH, lime content, sand, silt, and clay contents revealed from different research experiments. Numerous studies on contaminated soils suggest that physicochemical soil properties such as pH, organic matter content and clay are the major factors controlling micronutrients toxicity and bioavailability (Janssen et al. 1997; Peijnenburg et al. 1999; Peijnenburg 2002). The content of solid-phase humic substances is greatly affecting the adsorption capacity for heavy metals by cation exchange and formation of chelate complexes. Carboxyl groups play a predominant role in metal binding in both humic and fulvic acids (Alloway 1995). Presence of dissolved organic matter may, on the contrary, also decrease heavy metal adsorption, as found for Cu by Mesquita and Carranca (2005). Schnitzer and Kerndorff (1980) investigated the sorption of heavy metals (including Cu, Cr, Pb, and Zn) to humic acid at different pH values and found that Pb was adsorbed to the highest extent in the pH range investigated (2.4 to 5.8) and Zn to the least extent. Thus, the influence from organic matter on the overall adsorption is dependent on the actual heavy metal.

2.Materials And Methods

To measure the soil quality of the tea estate soil, an area of forty kilometer radius from Moran was identified. The area falls under the administrative control of two districts, Sivasagar and Dibrugarh. Tea is the most important commercial crop in the area.

Within this area, twenty tea estates (14 tea estates from Dibrugarh district and 6 tea estates from Sivasagar district) were selected for soil characterization and analysis. The total planted area in these estates covers an area of about 7000 hectares. After a detailed survey of the area, 60 sites in total were selected for sampling. The approximate locations of the sampling sites are shown in Fig 1.

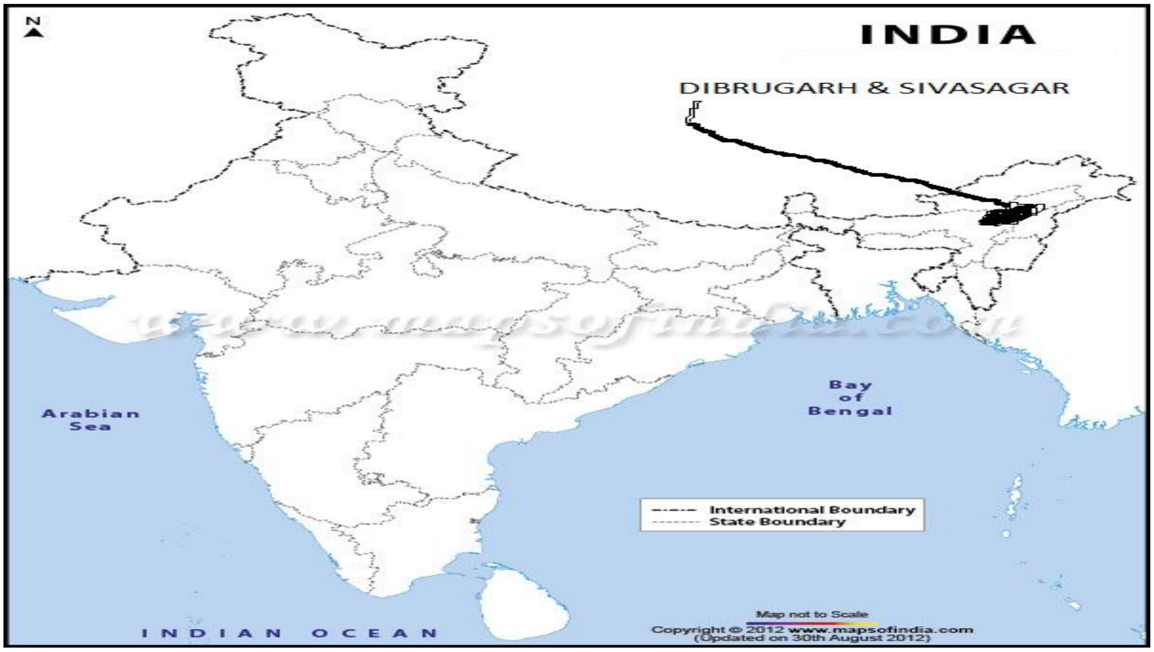
Soil samples were collected every year at the same time, in the months of January and February, because no fertilization or compost was applied during these months in the tea estates. Soil control sample was equally collected from the nearby the tea estate area with no fertilization. Three sets of soil samples were collected from each site at three different depths, 0-15 cm (surface soil), 15-30 cm (subsurface soil I) and 30-60 cm (subsurface soil II) for three consecutive years (2007-2009).

The soil samples were collected from midway between two tea plants, after removal of the surface debris. At each site, a hand-operated auger was used to dig out the soil cores from appropriate depth. Several such cores were collected from a single site from a (7 ×10) m grid for each depth, put in a polythene pack and brought to the laboratory. The cores from a particular site were visually inspected for the presence of plant debris, pebbles, etc., which were separated and removed, and the cores were spread out over a stout paper for drying in air in a shade. Entry of dust particles from air was prevented by covering the soil samples with superfine wire net. The big lumps were broken down and plant roots, pebbles and undesirable matter, still remaining, were removed. The dried samples were ground into powder, sieved through 2 mm sieve and preserved in clean polythene bags for analysis (Trivedy et al., 1987; Gupta, 2007).

2.1.Determination

To determine the micronutrients Cu, Fe, Mn and Zn, the soil samples are digested with a tri-acid mixture of concentrated HCl, HNO_3 and H_2SO_4 (Pinta, 1975). The advantages of the dissolution of heavy metals in soils using concentrated inorganic acids are low cost and low salt matrix in the final solution for the determination of total heavy metal content (Hossner, 1996). 1.0 g of the sieved soil sample is digested with 30 ml of acid mixture (4 parts of concentrated H_2SO_4, 2 parts of concentrated HCl and 1 part of concentrated HNO_3), the mixture is heated gently at first, and then more strongly until white fumes are no longer evolved. The digested soil is taken up with hot dilute HCl (1:1) and kept overnight and filtered through a filter paper (Whatman No. 42) and washed several times with distilled water. The volume of the filtrate is made up to 100 ml. The concentration of the metals is measured with the atomic absorption spectrophotometer (Varian Spectra AA 220). Water soluble boron is the available form of boron. Water soluble boron is estimated by Carmine reagent method (Jackson, 1973) by extracting it from the soil samples with water.

The pH value of the soil samples was determined by pH-meter (Model LI-120, Elico, India) using 1:5 soil-water suspensions in distilled water (Schofield and Taylor, 1955). The instrument was calibrated with pH = 4.0 and 9.2 buffers. 1:5 soil-water suspensions was prepared in a beaker by taking about 20 g soil and appropriate volume of distilled water and was allowed to stand for half an hour after 5 minutes vigorous shaking. The pH reading was then taken. Before each determination, the electrode was washed with a jet of distilled water and dried with the help of tissue paper. Organic matter was determined by Walkley and Black (1974). Soil texture was determined by hydrometer method (Bouyoucos, 1962).



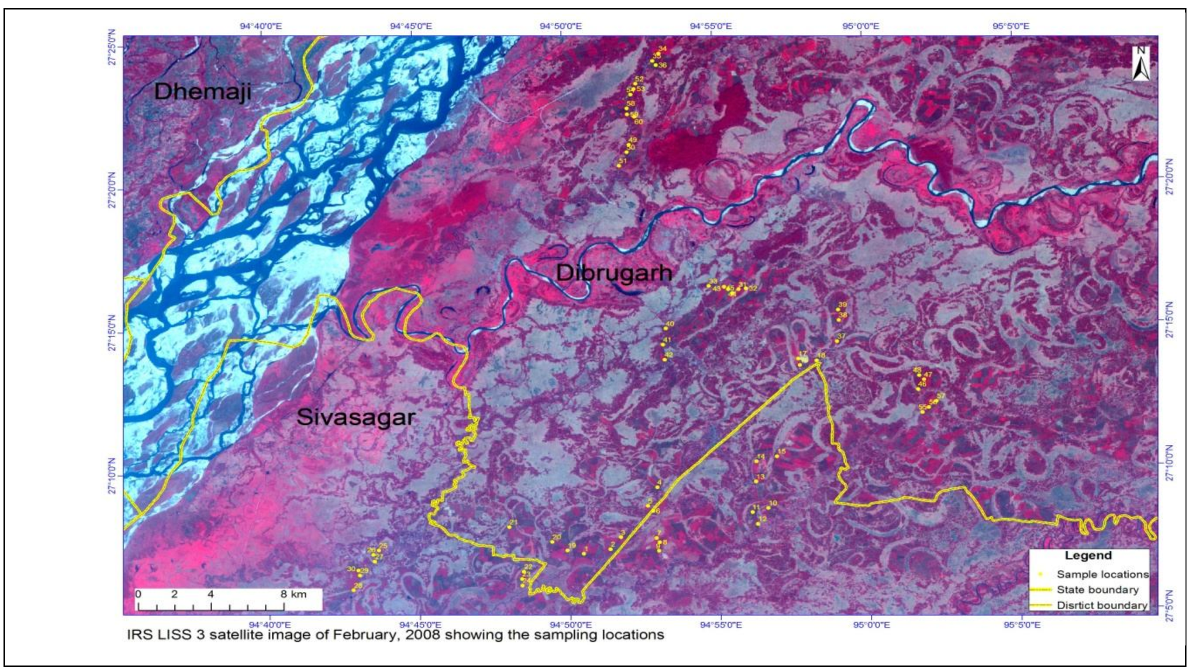


Figure 1: Location of the study area and soil sampling stations

2.Results And Discussion

The range and average values of the physico-chemical of the soil samples are shown in the Table-1. The results showed that majority of the soil sites were acidic in nature with high amount of organic matter. Considering textural classes most of the sites were sandy loam, sandy clay loam and loamy sand. The soil pH ranged from 4.48 to 5.62 (average 5.05). The organic matter content ranged from 1.87 to 3.60 % (average 2.74 %) for the surface soil, 1.19 to 2.81% (average 2.00%) for the subsurface soil (I) and 0.88 to 2.46 (average 1.67%) for the subsurface soil (II) respectively. The bulk density content ranged from 0.85 to 1.28 g cm^{-3} (average 1.07 g cm^{-3}). The water holding capacity ranged from 49.02 to 62.94 % (average 55.98 %). The hydraulic conductivity ranged from 0.20 to 0.37 cm/min (average 0.29 cm/min). The sand, silt and clay ranged from 73.09 to 89.12% (average 81.11%), 0.02 to 0.04% (average 0.03%) and 10.85 to 26.89% (average 18.87%) respectively. The range and average values of micronutrient for the surface, subsurface (I) and subsurface (II) soil are presented in Tables 2 to 4.

S/N	Parameters	Range	Average	Control	
1	Soil pH	4.48 —5.62	5.05	6.04	
2	Total organic matter (%)[surface soil]	1.87—3.60	2.74	1.34	
3	Total organic matter (%)[Subsurface soil, I]	1.19—2.81	2.00	1.20	
4	Total organic matter (%)[Subsurface soil, II]	0.88—2.46	1.67	0.80	
5	Sand (%)	73.09— 89.12	81.11	80.00	
6	Silt (%)	0.02 —0.04	0.03	0.02	
7	Clay (%)	10.85 —26.89	18.87	19.98	

Table 1: Range And Average Values Of Physio-Chemical Properties Of Soil Samples

S/N	Micronutrient	Surface soil		
		Range (mg/kg)	Average (mg/kg)	Control (mg/kg)
1	Cu	16.73—36.33	26.53	12.8
2	Fe	49.3—107.7	78.5	40.52
3	Mn	118.53—420.53	269.53	98.04
4	Zn	21.43—65.20	43.32	20.82
5	B	3.09—3.97	3.53	2.16

Table 2: Range and average values of Micronutrients of surface soil samples

S/N	Micronutrient	Subsurface (I) soil		
		Range (mg/kg)	Average (mg/kg)	Control (mg/kg)
1	Cu	15.35—31.73	23.54	10.5
2	Fe	44.1—99.6	71.9	36.8
3	Mn	103.73—390.33	247.03	86.28
4	Zn	21.07—56.47	38.77	18.68
5	B	2.76—3.67	3.22	1.96

Table 3: Range and average values of Micronutrients of subsurface (I) soil samples

S/N	Micronutrient	Subsurface (II) soil		
		Range (mg/kg)	Average (mg/kg)	Control (mg/kg)
1	Cu	13.17—29.13	21.15	8.4
2	Fe	32.1—85.3	58.7	30.22
3	Mn	92.07—377.50	234.79	78.8
4	Zn	17.70—48.87	33.29	16.9
5	B	2.41—3.27	2.84	1.68

Table 4: Range and average values of Micronutrients of subsurface (II) soil samples

3.Correlation Studies

Simple linear correlation studies of Cu, Fe, Mn and Zn, and hot water soluble B were made with various physio-chemical characteristics are shown in Table-5.

Relation between Copper and Physio-Chemical properties: The r-value between Copper and soil pH was +0.94. It showed that there was positive significant correlation between

Copper and soil pH. These results were supported by Misra (1968),William and David (1976), Mengal and Krickby (1987), Sanchez-Camazano et al. (1994), Mitra and Gupta (1999), Srinivas and Suresh Kumar (2001), Kusuma Kumari et al. (2001), Bansal (2004) and Jacob and Joseph (2008), who calculated positive correlation between Copper and soil pH. Increase in pH in the soil results in increase micronutrient concentration in the soil i.e., alkaline pH favours the micronutrient accumulation in the soil.

Soil	**Cu**	**Fe**	**Mn**	**Zn**	**B**
Properties	r-value	r-value	r-value	r-value	r-value
Soil pH	0.96	0.99	0.99	0.98	0.96
TOM	0.94	0.95	0.95	0.94	0.97
Clay	-0.97	-0.99	-0.99	-0.98	-0.98

Table 5: Correlation between micronutrients and soil properties of the soil samples of tea estates of Dibrugarh and Sivasagar districts

All the soil samples exhibited a positive correlation with pH. The data given in Table-5 shows that Copper was positively significantly correlated with organic matter. The r-value was 0.98. Similar results were reported by William and David (1976), Ranganayakulu et al. (1981), Bansal et al. (1992), Khalifa *et al.* (1996), Rajakumar *et al.* (1996), Senthil Kumar et al. (2001), Kusuma Kumari et al. (2001), Wesley (2004) and Jacob and Joseph (2008) who found positive significant correlation between Copper and organic matter. The data presented in Table-4 shows the correlation of Copper with clay content in soil. The r-value was -0.90. The result showed that there was negative significant correlation between Copper and clay. These results were similar to Olaniya et al. (1992) and Sanchez-Camazano et al. (1994), Narasimha Rao and Sarma (1998), Misra and Gupta (1999) and Bansal (2004) who reported negative correlation between these two but disagreement with Kusuma Kumari et al. (2001) they were reported non significant positive correlation with Cu and clay.

3.1.Relation Between Iron And Physio-Chemical Properties

The r-value between iron and soil pH was +0.94. It showed that there was positive significant correlation between iron and soil pH. These results were supported by Misra (1968),William and David (1976), Mengal and Krickby (1987), Sanchez-Camazano et al. (1994), Mitra and Gupta (1999), Srinivas and Suresh Kumar (2001), Kusuma Kumari et al. (2001), Bansal (2004) and Jacob and Joseph (2008), who calculated positive correlation between Fe and soil pH. Increase in pH in the soil results in increase micronutrient concentration in the soil i.e., alkaline pH favours the micronutrient accumulation in the soil. All the soil samples exhibited a positive correlation with pH. The data given in Table-5 shows that Fe was positively significantly correlated with organic matter. The r-value was 0.98. Similar results were reported by William and David (1976), Ranganayakulu et al. (1981), Bansal et al. (1992), Khalifa *et al.* (1996), Rajakumar *et al.* (1996), Senthil Kumar et al. (2001), Kusuma Kumari et al. (2001), Goldberg *et al.* (2002), Wesley (2004) and Jacob and Joseph (2008) who found positive significant correlation between Fe and organic matter. The results revealed that Iron had a positive significant correlation with organic matter content. It means that soil rich in organic matter contain more Iron. The data presented in Table-4 shows the correlation of Fe with clay content in soil. The r-value was -0.90. The result showed that there was negative significant correlation between Fe and clay. These results were similar to Olaniya et al. (1992) and Sanchez-Camazano et al. (1994), Narasimha Rao and Sarma (1998), Mitra and Gupta (1999) and Bansal (2004) who reported negative correlation between these two but Kusuma Kumari et al. (2001) reported non significant positive correlation with Fe and clay.

3.2.Relation Between Manganese And Physio-Chemical Properties

The r-value between manganese and soil pH was +0.94. It showed that there was positive significant correlation between Mn and soil pH. These results were supported by Misra (1968),William and David (1976), Mengal and Krickby (1987), Sanchez-Camazano et al. (1994), Mitra and Gupta (1999), Srinivas and Suresh Kumar (2001), Bansal (2004) and Jacob and Joseph (2008), who calculated positive correlation between Mn and soil pH. Increase in pH in the soil results in increase micronutrient concentration in the soil i.e., alkaline pH favours the micronutrient accumulation in the soil. All the soil samples exhibited a positive correlation with pH. But Kusuma Kumari et al. (2001) and Senthil Kumar et al. (2001) were found non significant negative correlation with Mn and pH. The data given in Table-4 shows that Mn was positively significantly correlated with organic matter. The r-value was 0.98. Similar results were reported by William and David (1976), Ranganayakulu et al. (1981), Bansal et al. (1992), Khattak et al. (1994), Khalifa *et al.* (1996), Rajakumar et al. (1996), Chinchmalatpure et al. (2000), Senthil Kumar et al. (2001), Kusuma Kumari et al. (2001), Wesley (2004) and Jacob and Joseph

(2008) who found positive significant correlation between Mn and organic matter. The data presented in Table-4 shows the correlation of Mn with clay content in soil. The r-value was -0.90. The result showed that there was negative significant correlation between Mn and clay. These results were similar to Olaniya et al. (1992) and Sanchez-Camazano et al. (1994), Narasimha Rao and Sarma (1998), Mitra and Gupta (1999), Kusuma Kumari et al. (2001), Senthil Kumar et al. (2001), and Bansal (2004) who reported negative correlation between these two. This result was dissimilar to the findings of Sharma *et al*. (1996) and Chinchamalatpure *et al*. (2000) and who reported positive correlation between Manganese and clay content.

3.3.Relation Between Zinc And Physio-Chemical Properties

The r value obtained between Zinc and soil pH was 0.86. It means there was positive significant correlation between Zinc and soil pH. Similar results were studied by Misra (1968),William and David (1976), Mengal and Krickby (1987), Sanchez-Camazano et al. (1994), Sheeja et al. (1994), Sadashiva et al. (1995), Mitra and Gupta (1999), Patiram et al. (2000), Srinivas and Suresh Kumar (2001), Bansal (2004) and Jacob and Joseph (2008). But Kusuma Kumari et al. (2001) and Senthil Kumar et al. (2001) were found significant negative correlation with Zn and pH. The correlation coefficient (r) obtained between Zinc and organic matter was 0.92. It concluded that Zinc was positive significant correlated with organic matter. The positive correlation may be due to the formation of organic complexes between organic matter and Zinc that protect it from leaching. These results were similar to the findings of Perveen et al. (1993) and Chinchmalatpure et al. (2000). The r value obtained between Zinc and clay was -0.90. The result was negatively significant. These results were similar to Olaniya et al. (1992) and Sanchez-Camazano et al. (1994), Narasimha Rao and Sarma (1998), Mitra and Gupta (1999) and Bansal (2004), but disagreement with Patil and Sonar (1994) and Sharma et al. (1996), Kusuma Kumari et al. (2001) and Senthil Kumar et al. (2001) who reported positive correlation between Zinc and clay content.

3.4.Relation Between Hot Water Soluble Boron And Physio-Chemical Properties

The correlation coefficient (r) obtained between hot water soluble Boron and soil pH was 0.96. The result was positively significant. This result was supported by Phukan and Bhattacharyya (2001) but disagreement with Abid *et al.* (2002) was reported negative correlation. The r-value recorded between hot water soluble Boron and organic matter was 0.98. It means hot water soluble Boron was positively significantly correlated with organic matter. These findings were in agreement with Perveen *et al*. (1993) and Goldberg *et al*. (2002) who reported positive significant correlation between hot water soluble Boron and organic matter content. The correlation value (r) between hot water soluble Boron and clay was -0.98. The result was negatively significant between hot water soluble Boron and clay content. This result was disagreement with the findings of Goldberg *et al*. (2002) and Nuttall *et al*. (2003) who reported positive correlation between hot water soluble Boron and clay content.

4.Conclusion

The results of this study showed that there was no deficiency of the micronutrient concentration in the study area when mean values of soil samples were taken into consideration. The micronutrient concentrations of tea estate soil were found in increasing trends but lower the toxic level for tea plants. To overcome the micronutrients deficiency in some places of tea estate soil, the application of sufficient amount of fertilizer helps the increase in tea production.

5.Acknowledgement

The author is grateful to University Grant Commission for providing financial assistance to carry out this project work. Also thanks to the Department of chemistry, Gauhati University, Guwahati, Assam, India for assisting in the laboratory analysis of the soil samples.

6.Reference

1. Abid Niaz, M. Ibrahim, Ahmad Nisar and S. A. Anwar. (2002). Boron contents of light and medium textured soils and cotton plants. International J. Agric. and Biology. 4:534-536.
2. Alloway, B. J. (1995). Soil processes and the behaviour of heavy metals. In B. J. Alloway(Ed.), Heavy metals in soils. London: Blackie Academic & Professional.
3. Bansal, R.L., V.K. Nayyar and P.N.Takkar. (1992). Accumulation and bioactivity of Zn, Cu, Mn and Fe in soils polluted with Industrial waste water. J.Indian Society of Soil Science. 40 (40: 796-799.
4. Bansal. O.P. (2004). Uptake of heavy metals by crops plants. Poll Res. 23(3): 501-506.
5. Black, C. A. 1965.Methods of soil analysis-part-II. Soc. Agron. Inc. Publ.Madison.Wisconsin, USA.
6. Bouyoucos, G.J. (1962). Hydrometer Method improved for making particle size Analysis of Soil-Agron. J, 54, pp 464.
7. Chinchmalatpure, A.R. Brij-Lal, O. Challa and J. Sehgal. (2000). Available micronutrient status of soils on different parent materials and landforms in a micro-watershed of Wunna catchment near Nagpur (Maharashtra). Agropedology. 2000, 10: 1, 53-58.
8. Goldberg, S., P. J. Shouse, S. M. Lesch, C. M. Grieve, J. A. Poss, H. S. Forster and D. L. Suarez. (2002). Soil boron extractions as indicators of boron content of field grown crops. Soil Science. 167(11): 720-728.
9. Gupta, P.K. (2007). Methods in Environmental Analysis Water, Soil and Air, (2nd edn). Agrobios (India).
10. Jacob. C. and P.V. Joseph. (2008). Study of heavy metal levels in the soils of Pala Municipality area, Kerala. Poll Res. 27(2): 279-283.
11. Hossner, L.R. (1996). Dissolution for total elemental analysis, in D.L. Sparks et al.(Eds.), methods of soil analysis, part 3, chemical Methods, SSSA, Madison, WI, USA, pp 49-64.
12. Jackson, M.L. (1973). In: Soil Chemical Analysis, Prentice Hall (India), Pvt. Ltd. New Delhi.
13. Jackson, M.L. (1995). In: Soil Chemical Analysis, Advanced Course .Prentice Hall (India), New Delhi.
14. Janssen, R. P. T., Posthuma, L., Baerselman, R., & Den Hollander, H. A. (1997).

Equilibrium partitioning to heavy metals in Dutch field soils. II. Prediction of metal accumulation in earthworms.Environmental Toxicology and Chemistry, 16, 2479-2488.

15. Khalifa, E. M., M. A. El-Desoky, M. A. Gameh and M. E. Faragallah (1996). Status of some micronutrients and their relations to mineral composition of the Nile valley desert interference zone soils, East of Assiut city. Assiut Journal of Agricultural Sciences. 27(3): 107-127.
16. Khattak, J. K., M. Sharif and S. Naz. (1994). Nutrient status of citrus orchard soils in Peshawar Valley. Sarhad Journal of Agriculture. 10(4): 451-460.
17. Kusuma Kumari, T., B. Maruthi Rao and N. Ranganayakulu. (2001). Characterization and Distritribution of Cationic Micronutrients in Typical Soil Profiles of Tirumala Hills. IJEP 21 (9): 847-849.
18. Mengal, K. and E.A. Krickby. (1987). Principles of plant nutrition. International Potash Institute. Warblanfen-Berlin, Switzerland.
19. Mesquita, M. E., & Carranca, C. (2005).Effect of dissolved organic matter on copper zinc competitive adsorption by a sandy soil at different pH values. Environmental Technology, 26(9), 1065–1072.
20. Misra, R. 1968. Ecology workbook. Oxford and IBH Publishing, New Delhi.
21. Mitra, A. and S.K.Gupta. (1999). Effect of sewage water irrigation on essential plant nutrient pollutant element status in a vegetable growing area around Calcutta. J.India Soc. Soil.Sci. 47, 99-105.
22. Narasimha Rao, S.L. and D.R.R. Sarma(1998). Trace metals in soils near an industrial belt in Visakhapatnam, India. Poll Res. 17(4): 377-380.
23. Nuttall, J. G., R. D. Armstrong, D. J. Connor and V. J. Matassa.(2003). Interrelationships between edaphic factors potentially limiting cereal growth on alkaline soils in north-western Victoria. Australian Journal of Soil Research. 41(2): 277-292.
24. Olaniya, M.S., M.P. Khandekar., I. Rahman and A.D. Bhide. (1992). Mobility of metals in soil: A case study, Indian J. Environ. Hlth. 34(4): 261-271.
25. Patil, Y. M. and K. R. Sonar. (1994. Status of major and micronutrients of swell-shrink soils of Maharashtra. Journal of Maharashtra Agricultural Universities. 19(2): 169-172.
26. Patiram, R., C. Upadhyaya, C. S. Singh, R. Munna and M. Ram. (2000).Micronutrient cation status of mandarin (Citrus reticulata Blanco)

orchards of Sikkim. Journal of the Indian Society of Soil Science. 48(2): 246-249.

27. Peijnenburg, W. J. G. M. (2002).Bioavailability of metals to soil in vertebrates. In H. E. Allen (Ed.), Bioavailability of metals in terrestrial ecosystems: importance of partitioning for bioavailability to invertebrates, microbes, and plants (pp. 89–112). Pensacola: SETAC.
28. Peijnenburg, W. J. G. M., Baerselman, R., de Groot, A. C., Jager, T., Posthuma, L., & Van Veen, R. P. M. (1999). Relating environmental availability to bioavailability: soiltype- dependent metal accumulation in the oligochaete Eisenia andrei. Ecotoxicology and Environmental Safety, 44, 294–310.
29. Perveen, S., M. Tariq, Farmanullah, J. K. Khattak and A. Hamid.(1993). Study of micronutrient status of some important sites of N.W.F.P., Pakistan. Sarhad Journal of Agriculture. 9(5): 467-473.
30. Phukan, S and Bhattcharyya, K.G. (2001).Soil quality alterations with respect to a pulp and paper mill-a case study at Jagiroad,Assam,IJEP 21(9):839-846.
31. Pinta, M. (1975). Detection and determination of trace elements, ANA, Arbor Science Publication INC.
32. Rajakumar,G. R., C. V. Patil, S. S. Prakash, N. A. Yeledhalli and K. K. Math. (1996). Micronutrient distribution in paddy soils in relation to parent material and soil properties. Karnataka Journal of Agricultural Sciences. 9(2): 231-235.
33. Ranganayakulu, C., et al., (1981).Distribution of cationic micronutrients in typical soil profiles and surface soils of Alfisols of Chittoor district. M.Sc. (Ag.) thesis. A.P.A.U., Hyderabad.
34. Sadashiva, V., D. K. Prabhuraj and A. S.P. Murthy.(1995). Status of micronutrients in soils of Kabini Command Area (India). University of Agricultural Sciences Bangalore. 24(3): 41-43.
35. Sanchez-Camazano, M., M.J. Sanchez Martin and L.F. Lorenzo.(1994). Lead and Cadmium in soils and vegetables grom urban gardens of Salamanca (Spain). The Science of total Environment. 146/147, 163-168.
36. Schofield, R.K. and Taylor, A.W. (1955). The measurement of pH, Soil Sci Soc, Amer. Proc. 19, pp 164-167.
37. Schnitzer, M., & Kerndorff, H. (1980). Effects of pollution on humic substances. Environ Sci Health B, 15(4), 431–456.

38. Schnitzer, M. and Kerndorff, H. (1980). Effects of pollution on humic substances. Environ Sci Health B, 15(4), 431-456.
39. Senthil, R.D., R. Narayanaswamy and M.V. Sriramchandrasekhar. (2001). Spectroscopic study on the soil pollution by heavy metals in the Vicinity of Sugar Mills in Sethiyathope, TamilNadu . Env. Pol. & Health Hazards. Pp 23-27.
40. Sharma, B. D., P.S. Sidhu, Singh Gurmel, S. S. Mukhopadhyay and G. Singh. (1996). Elemental distribution and mineralogy of arid zone soils of Punjab. Journal of the Indian Society of Soil Science. 44(4): 746-752
41. Sheeja, S., S. Kabeerathumma, N. G. Pilla and M. M. Nair. (1994). Availability and distribution of micronutrients in cassava growing soils of Andhra Pradesh. Journal of Root Crops. 20(2): 75-80.
42. Srinivas, N. and K. Suresh Kumar.(2001).Physico-chemical Characteristics of Agricultural Soils of Visakhapatnam. IJEP, 21 (9): 822-824.
43. Trivedy, R.K., Goel, P.K. and Trisal, C.L. (1987). Practical methods in ecology and environmental science. Enviro. Media Publication. Karad (India). U. S. Salinity Lab. Staff. 1951. Diagnosis and Improvement of Saline and Alkaline Soils. U.S.D.A Hand Book No. 60. Washington D.C.
44. Walkley, A. and Black, C.A. (1974). Critical examination of rapid method of determining organic carbon in soil. Soil Sc. 63: 251-164.
45. Wesley, S.G. 2004. Bioaccumulation of heavy metals by the intertidal Molluscs of Kanyakumari waters, Indian Pollution Research, 23(10: 37-40.
46. William, C.H. and D.J. David. (1976). Study on accumulated in soil of Cd residues from phosphate fertilizers and their effect on Cadmium content of plants. Soil Sci.,