



Acknowledgements

It gives me immense pleasure to thank my thesis supervisor Dr. H. P. Sarma for his constant help, encouragement and support throughout the course of this work. I would like to thank Dr. S. Kalita, Head, Department of Environmental Science, Gauhati University for permitting me to carry out the research work. My heartiest thanks have been extended to my extreme friend, Dr. Bhabajit Bhuyan for his incredible help throughout my research works. I solemnly acknowledge Late S. Rahman, former principal i/c & HOD, chemistry for facilitating me to avail UGC teacher fellowship under XI plan period. I would also like to take the opportunity to express my gratefulness to Sri Anil Ch. Sarma, Retired Selection Grade Lecturer, Department of Chemistry, Mangaldai College for his advice and encouragement which enthused me to join Ph.D works. I would like to thank my colleagues, Mrs. D. Saharia, Sri Niranjana Sarma and Dr. A.P. Sikdar for their useful and valuable suggestions during the tenure of my research. I would also like to take the opportunity to express my gratefulness to Sri Bichitra Kumar Medhi, principal, i/c, Mangaldai College and Sri Hariman Deka for the kind help extended by them.

I also acknowledge UGC, NERO, Guwahati, for allowing me Teacher Fellowship during XI Plan period for carrying out this research. I am also grateful to my wife Rumi, daughter, Akangkshya and son, Arohan, who enthused me during the work and awaited eagerly, along with me, for the completion of the work. Finally, even-though do not know how to, but I would like to express my gratefulness to my parents and brothers for bearing my whims and shouldering my all responsibilities during the tenure, to make me free.


(Kamala Kanta Borah)

- To study the potability of water.
- To identify the principal contaminants of a wide range of water sources.
- To help users at national or local level to establish which chemicals in a particular setting should be given priority in developing strategies for risk.
- To study the chemical indicators of soil quality in selected tea gardens of Darrang district, Assam by estimating the available nutrients present in the soil, which basically determine fertility.
- To arrive at some over all conclusion regarding the water-soil environment in and around the tea gardens of Darrang district.

Chapter 2: In this Chapter a brief discussion about the location, boundary, area, climate and weather, population, literacy and river systems of the study area are included. Sampling stations in and around the selected tea gardens of the study area are also specified along with sampling seasons.

Chapter 3: This chapter includes the methodologies adopted during the study. The chemical procedures adopted are extensive, though by no means exhaustive as for any one element, numerous procedures or variations of procedures can be found in the literature. Thirty soil samples were analyzed by selecting standard procedures (Jackson, M.L., 1973). The instruments were used in the limit of précised accuracy and chemicals used were of analytical grade. Twenty eight water samples were selected by random selection and compiled together in clean and sterile one-litre polythene canš rinsed with dilute HCl to set a representative sample and stored in an ice box. pH, conductivity were determined quickly after sampling. Iron, lead and arsenic were analysed by using Atomic Absorption Spectrometer (Perkin Elmer AA 200). Fluoride was measured by SPADNS method using UV-VIS spectrometer (Shimadzu 1240). Analytical techniques as described in “Standard Methods for the Examination of Water and Wastewater”

(APHA, 1995) were adopted for analysis of other water quality parameters. Data were also subjected to statistical treatment using NDA and correlation analysis. Some more statistical estimates derived from the normal distribution like sample variance, kurtosis, skewness, 1st, 2nd, 3rd quartile, inter quartile range (IQR), confidence limit were also made in the present study for analyzing soil and water quality data. Pearson Correlation analysis, t-test and ANNOVA were also performed.

Chapter 4: In Chapter 4, the experimental findings of the research are discussed.

Soils in and around the tea gardens of Darrang district, Assam are found to be hard setting and often characterized by fine-textured, tough subsoil with high clay contents. The mean bulk density of soil inside and outside the tea gardens of the study area was found to be 1.097gm/cm³ and 1.027gm/cm³ respectively. The soil in the area was found to be significantly acidic in nature with a mean value of 4.67 and 5.13 inside and outside the tea gardens respectively. Electrical conductance of soils (range: 94-6600µmhos/cm) in the study area have potential to cause specific ion toxicity or upset the nutritional balance in soils. The clayey soil of the area contains low to high soil organic carbon ranging from 0.86% - 3.52%.

The mean values of nitrogen and phosphorous fall within the normal range of ICAR(2005) both outside and inside of the tea gardens in the study area. However, the soils in and around the tea gardens of the study area are potassium deficient and is not in accordance with the rating (lower limit 272 kg/acre) given by ICAR' 2005. Nutrient imbalance is a matter of prime concern in the area with reduction in the availability of nutrients like calcium (range: 0.36-3.00 meq/100 gm), magnesium (range: 0.07-1.68 meq/100 gm) and increase in toxic levels of manganese (range: 41.60-256.60mg/kg), iron (range: 277.0-970.20 mg/kg) and sulphate-sulphur (range: 3.7-17.9mg/kg). Calcium and magnesium deficiency symptoms can be rather vague since the situation often is accompanied by a low soil pH. Different metals like Fe, Mn, Zn,

Cu, Pb, etc. in the soil are found to incline towards high value. Considering *t test* result, it is found that all the important soil quality parameters like NPK & %C inside as well as outside tea gardens of Darrang district, is significant.

It was also observed that the soil in the study area is acidic and K deficient. Various Statistical estimates derived from NDA, *t-test* and correlation imply that the distribution of N, P, K and C in the soils of the study area is widely off normal. The analysis of the soil samples of paddy fields around the plantation area of tea gardens of Darrang district also reveal that the soil health is not in accordance with the fertility rating chart given by (ICAR, 2005). The researchers feel that environmental aspects of soil quality of this area need serious attention in near future for better agricultural practices.

Results indicate that water samples inside tea gardens are more turbid and TSS concentrations of some water samples in the study area exceed the maximum admissible limit (5 mg/L) of United States Public Health (USPH) Standard. The conductance of water in the study area has values greater than the maximum permissible limit (0.3 mmho cm⁻¹) of USPH and indicates that water is markedly polluted with its reference. In all the sampling stations studied pH are within the W.H.O guide lines values for safe drinking water. The Phosphate content of water needs serious attention as all of the samples except a few exceeded the USPH guide line value of 0.1 mg/L. The highest alkalinity value of 187.70 was observed in the post monsoon season. It is observed that the water is soft for most of the samples and all the samples in study area are as per the maximum limit prescribed by W.H.O for portability purposes. In the present study the calcium concentration does not exceed the ISI limit of 75 mg/L. Chloride, sulphate, fluoride and nitrate are within W.H.O permissible limits. The iron contents of drinking water need immediate attention and the data exceeds the W.H.O guide line value of 0.3 mg/L in most cases. The distribution of fluoride in drinking water of Darrang district was found to be within the permissible limit of W.H.O. with an average of 0.4912 mg/l.

The concentrations of copper and zinc in the groundwater of the area are either low or moderate and within the guideline values of WHO. In most of the samples under investigation, the cadmium contents were much above the guideline value of 0.003 ppm as set by WHO. The cadmium contamination of groundwater in the area should be accorded maximum attention. Although information on drinking water quality of Northeastern India is very little, results reported by various agencies have been alarming. During this study, the physical parameters studied are Conductivity, Total Solid (TS), Total Dissolved solid (TDS) and Total Suspended Solid (TSS). The chemical parameters studied are pH, Alkalinity, Fluoride (F^-), Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Dissolve Oxygen (D.O), Phosphate (PO_4^{3-}), Total Hardness, Calcium (Ca), Magnesium (Mg), Lead (Pb), Arsenic (As), Iron(Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Cadmium(Cd), Sodium (Na) and Potassium (K) . Comparing the water content of metals with the recommended maximum values for drinking purposes, it is found that a sizeable number of water samples contain, lead and cadmium at an alert level. The concentrations of copper, manganese, arsenic and zinc in the drinking water of the area are either low or moderate and within the guideline values of WHO. During the study, seasonal variations are also observed for all the metals under investigation. Except for sodium and potassium, higher values for all the metals are obtained in the pre monsoon than in post monsoon season. By comparing the mean values of the metals, it is observed that the metal content of drinking water inside the tea gardens in the pre monsoon and post monsoon follows the trend $Na > K > Fe > Zn > Pb > Cd > Cu > Mn > As$ and $Na > K > Fe > Zn > Cd > Pb > Cu > Mn > As$ respectively. Whereas it follows the trend $Na > K > Fe > Mn > Zn > Pb > Cd > Cu > As$ in both the seasons outside the tea gardens.

Various Statistical estimates derived from NDA, t-test and correlation imply that the distribution of the studied water quality parameters in the study area is widely off normal. All the water samples analyzed in the present investigation are contaminated

with phosphate, lead and cadmium, which need immediate attention for future protection of water in the area.

Chapter 5: In Chapter 5, the conclusions of research works are included.

A comprehensive analytical and statistical analysis of distribution of soil and water quality parameters in the tea garden belt of undivided of Darrang district, Assam has been presented in this study. The focus of the study is on rural rather than urban areas, due to the particular difficulties associated with applying mitigation measures in scattered rural communities. The quality of soils in the tea garden belt of Darrang district, Assam has declined significantly due to excessive use of agro-chemicals and poor management practices. The long-term exploitation of soil under the tea gardens in Darrang district, Assam has led to impoverishment of soil fertility and stabilization of yields, despite increasing application of external inputs such as fertilizers and pesticides. Soil nutrient imbalance is the key issue that needs to be taken up in the area. This study reinforced the extensive nature of degradation of soil in the area under study. It is, therefore, important that we value and conserve our soils so that they will continue to be useful in the future. Nationally, and regionally, there is an urgency to develop guidelines for protection and monitoring of the quality of soil and land resources. The water sources, selected for this study, have been in use for a long time for meeting drinking water needs and other domestic purposes. The observed variations in quality of water samples in the study area suggest that the area is sensitive to contamination as excessive rainfall or over-irrigation can cause downward movement of water through the soil profile. The supply of pure and safe water is inadequate in the study area and was almost non-existent in the rural areas of Darrang district, Assam. The concentration of Fe, Pb, Cd and PO_4^{-3} in the water sources of the area is beyond the national and international permissible limits for drinking water. Unfortunately, the people in Darrang district are still unaware of water contamination and its hazardous effects. The efforts are much less

than needed to mitigate the crisis. Hence, the immediate involvement of the research community is needed to combat the slow-onset disaster and save the poor people. For a rural and backward district like Darrang of Assam where the majority of the people live below the poverty line, the provision of safe drinking water is one of the prior conditions for overall social development. Follow-up monitoring and education are integral to sustaining the impact of the first intervention and to safeguarding the population's health. The role of the health sector for supplying better quality water among the public to maximize health gains should be advocated in the area. The key recommendations of this study are to take a more strategic approach to the soil and water quality indicators in the study area at project, regional and national levels. This includes the targeted integration of studied parameters as a risk factor in water supply and irrigation investments undertaken in the area, rather than treating it as a special issue to be dealt with by special authorities or agencies. This study outlines that academia is needed to make soil and water related research more strategic and effective at a regional level.

The thesis concludes with the list of bibliography and the research papers published pertaining to the study. The present study, however, fulfilled the limited purpose of strengthening database which may be helpful in formulating strategy for future protection of soil and water in the area.
