CHAPTER V

SUMMARY AND CONCLUSIONS
5.1 INTRODUCTION

India is currently facing critical water supply and drinking water quality problems. Water supplies in India are no longer unlimited. In many parts of the country, water supplies are threatened by contamination and future water supplies are uncertain. There is evidence of prevailing contamination of water resources in many areas of India. Fluorosis is widely prevalent in many parts of our country. 25-30 million Indians are exposed to the risk of contacting fluorosis in various endemic regions and half a million are crippled by it. Hence fluorosis has become a major public health problem in India.

Fluoride accounts for about 0.3 g/kg of the Earth's crust and exists in the form of fluorides in a number of minerals. The most important source of fluoride in drinking water is naturally occurring. Inorganic fluoride-containing minerals are used widely in industry for a wide range of purposes, including aluminium production. Fluorides can be released to the environment from the phosphate-containing rock. Fluoride-rich groundwater is well known in granite aquifers in India and the world.
This study examines the fluoride content of well water in different parts of Talupula area of Anantapur district, Andhra Pradesh. It also focuses on fluorides and their relationship to water-quality parameters and their impacts on humans through groundwater resources. In order to identify the exact magnitude of the problem an investigation has been undertaken in the endemic fluoride region of Talupula. It is located (Lat. 14° 11' –14° 17' N; Long. 78° 15' – 78° 21' E) in the Anantapur District of Andhra Pradesh. This area is included in the Survey of India topo sheet No. 57 J/8, having an areal extent of about 95 sq. km. of the area covered in this region are inherently enriched with fluorides threatening several ecosystems. The arid climate of the region, the granitic rocks and the low freshwater exchange due to periodical drought conditions are the factors responsible for the higher incidence of fluorides in the groundwater resources. Apart from these prevailing natural conditions, years of neglect and lack of restoration programs on terrestrial and aquatic environments have led to accumulative impacts on groundwater, soils, plants, and animals including humans. The people dependent on these groundwater resources are prone to dental fluorosis and mild skeletal fluorosis.

The important geological formations of this area are granites, gneisses and schistose rocks. The present study addresses the different aspects viz., groundwater, termite mound soils, human excreta and urine samples for their fluoride content and associated elements.

The study is broadly divided into two major categories, viz., 1) Biogeochemistry, and (2) Hydrogeochemistry. The first part deals with biogeochemistry involving (i) termite mounds and their adjacent termite free soils and (ii) the second part, hydrogeochemistry deals with the chemical quality of water. This study also involves human excreta and urine for fluoride and its associated chemical elements.
5.2 BIOGEOCHEMISTRY OF TERMITE MOUNDS

5.2.1 Introduction

The termites, pale coloured soft bodied social insects often called white ants. It is commonly seen in tropical countries. Most termites use soil, together with saliva and faeces, to construct their nests. Nests may be subterranean, epigean (mounds) attached to the outside of shrubs and trees. Above the ground nests are continually being eroded and reconstructed, which redistributes soil over the surface. There is a vast amount of literature on the biological aspects of termite mounds. But the geological studies on these mounds are a few. Therefore, an attempt has been made to study the termite mounds derived from the subsoil.

In the study area, samples of twenty termite mounds and their adjacent termite free soil samples were systematically collected. The pedological aspects consisting of physical, textural, physico-chemical and geochemical properties have been discussed.

5.2.2 Physical properties

Bulk Density

In the present study, bulk density values ranges from 1.03 to 1.34 gm/cc (average of 1.18) in termite soils and it ranges from 1.20 to 1.65 gm/cc (mean value of 1.40) in the adjacent soils. In general, the termite mounds show low values of bulk density than the surface soils. Low bulk density in termite soils is attributed to high organic matter. Bulk density variations depend on the proportions and specific gravity of organic and inorganic particles, and porosity. High bulk density is due to reduction in organic matter, eluviation, and sandy texture.
Organic Matter

In termite soils the minimum and maximum organic matter percentages are 1.77 and 6.36 respectively (mean value of 4.41%). In the case of surrounding soils it varies from 1.14 to 4.42 (average value of 3.19%). The termites modify the physical properties of soils. Soil altering actions of ants include depositing subsoil on the surface of their nests, reducing the bulk density of soils by developing a system of channels and chambers, and increasing the concentration of organic and inorganic nutrients in the soil they inhibit. Ants also impede soil horizonation through the process of pedoturbation.

Usually higher concentrations of organic matter and plant nutrients are found in termite mounds than the surrounding soils. Anderson and Wood (1984) also state that the selection of large, defined food sources by termites, such as leaf litter or rotten wood, can result in a high proportion of organic matter in the mounds.

The elevated amount of organic matter in the termite mounds with the adjacent surface soils are probably due to the faecal material and saliva being incorporated in the mound as a cementing agent for the lining of gallery walls (Gillman et al., 1972).

5.2.3 Textural Properties

In this study, it is revealed that the termite mounds contain silt + clay proportions in large amounts when compared with the surrounding surface soils. From this, it is presumed that the termite mounds derive from the subsoil and the finer sized fractions (silt + clay) are being preferentially selected. The sand component in general is lower in termite soils than their adjacent surface soil. This may be attributed to the higher intensity
of disintegration and decomposition by the microbial activity associated with termites. Similarly Miedema et al. (1994) have studied on the micromorphological aspects of termite activity in Niger and states that the termite mound showed frequent infillings. Contrasting partial fabrics suggested that the termites had explored underlying strata. Termite amended soil is the very good growth site, which was relatively enriched with organic matter and clayey fine material, caused the better fertility and increased water-holding capacity.

The grain-size parameters reveal that the median and mean values are more in termite soils than the surrounding soils. Converse is true with regard to sorting. The scatter diagrams consisting of various combinations of grain-size parameters show that high degree of positive correlation exists between mean and median and inverse relationship between skewness vs mean and median in both soils and termite soils.

The analysis of the particle-size distribution of the soils suggests that the excavating activities of termite mounds primarily include the translocation of subsoil to the surface mounds. The termite species provide a homogenized vegetation–regolith sample featuring sharp geochemical responses in the finer, silty-clay fraction. The silty-clay material from the wall of the nests, contains the clearest geochemical signature most related to the underlying regolith profile. Unlike the neighbouring soils, which often can be derived from colluvium, alluvium and aeolian material derived from hundreds of kilometres away, the termites contain fresh, local geochemical signatures.
5.2.4 Physico-chemical Properties

The physico-chemical properties discussed in this work include hydrogen- ion concentration in terms of pH units, and specific conductance. Generally, pH is in basic and is varying from 7.8 to 8.7 with a mean value of 8.29 in termite soils and in its adjacent soils it is ranging from 7.5 to 8.5 with an average value of 7.91.

The conductivity is varying from 575 to 960 micro mhos/cm (average value of 867) in termite soils and it is 525 to 910 micro mhos/cm (mean value of 779) in the adjoining soils. The differential selection of clay rich material, and/or the incorporation of faecal material into the mound structure, also results in higher mineral element concentration in the mounds than the surrounding soil. The results presented here suggest that they could be important in determining nutrient availability. Both pH and conductivity values are higher in termite soils than in their adjacent surface soils is due to the termite activity and its nutrients.

5.2.5 Multi-element Analysis of Termite Mounds

Termite mounds are among the most conspicuous figures of many tropical ecosystems. Termites process considerable quantities of material in their mound building activities, strongly influencing the soil properties as compared to surrounding soil (Lee and Wood, 1971; Pomeroy, 1983; Arshad, 1981; Lobry de Bruyn and Conacher, 1990; Maduakor et al., 1995; Park et al., 1994). These modifications have a great impact on the vegetation, through spatial and temporal effects, even when the termite colony is dead and the mound material subject to erosion (Belsky et al., 1983; Soyer, 1983). Thus the termites have been referred to as large soil builders and ecosystem engineers (Jones et al., 1994; Black et al., 1997; Dangerfield et al., 1998). Many studies emphasized the role of
termites on soil texture and chemical properties (Badawi et al., 1982; Laker et al., 1982; Pomeroy, 1983; Wood et al., 1983), soil nutrient cycling and soil metabolism (Abbadie and Lepage, 1989; Arshad et al., 1982; Menaut et al., 1985). The vegetation surrounding the termite mounds has been studied by different workers (Malaisse and Anastassiou-Socquet, 1977; Belsky et al., 1983).

In this study the pedochemical properties of termite mounds and their adjacent surface soils in a part of the fluorosis affected area of Talupula. There is a thick distribution of termite mounds in this AREA. The pedochemical properties include mainly the chemical analyses viz., F, Zn, Cu, Pb, Cr and Ni in both termite soils and their adjoining soils. Generally these elements have been concentrated in more amounts in termite soils than the adjacent surface soils.

The absence or presence of an element in a particular horizon of soil profile is determined by biogeochemical cycling of elements involving progressive differentiation of soil horizon, and differential migration of elements in vertical and lateral directions. Due to such cycling of elements, the above-cited major and trace elements have migrated into sub-soil horizons depleting the concentration of these elements in the surface soil. From these sub-soil horizons termites bring mineral particles for their mound construction and incorporated in the mound, thus enriching these elemental concentrations in termite mounds. This study reinforces the view of termites as soil engineers in semi-arid region of Talupula, modifying their environment in both of its biotic and abiotic components. In natural ecosystems, termites are typical ecosystem
engineers and, in semi-arid ecosystems, often keystone species. It is thus likely that termites play a major beneficial role through promotion of essential ecological processes in agro ecosystems in conflict with their well-established role as pests.

5.3 HYDROGEOCHEMISTRY

Groundwater is an important resource for mankind existence and economic development. Due to the scarcity of surface water, Andhra Pradesh has to depend on groundwater resources to a great extent. In arid and semi-arid areas of the state, groundwater is the only water resource for drinking and agriculture purposes. The problem of high fluoride concentration in groundwater resources has now become one of the most important toxicological and geoenvironmental issues in India. The natural chemistry of ground water is controlled largely by the dissolution of the geologic materials through which the water flows. Contaminants can enter ground water by a variety of means, but most commonly from resources at the ground surface. The dominant processes that influence the migration of contaminants in a particular region depend on the geological and geochemical conditions, as well as the chemical and biological characteristics of the contaminant.

The natural chemistry of ground water is controlled largely by the dissolution of the geologic materials through which the water flows. The dominant processes that influence the migration of contaminants in a particular region depend on the geological and geochemical conditions, as well as the chemical and biological characteristics of the contaminant.

Determination of physical and chemical quality is essential for assessing the suitability of water for various purposes like drinking, domestic, industrial and agricultural purposes. Chemical analysis forms the basis of interpretation of the quality of
water in relation to source, geology, climate, and use. Water being an excellent solvent, it is important to know the geochemistry of dissolved constituents and methods of reporting analytical data.

It is an important aspect of groundwater in order to know its use for domestic, irrigation, and industrial purposes. The study area comes under endemic fluorosis region. This study examines the fluoride content of well water in different parts of Talupula area of Ananataur district. It is therefore essential to conduct field and laboratory investigations to characterize, understand, and interpret observed anomalies in ground water in the regional context. About 60 water samples were collected and fluoride was analysed using Lovibond PC Spectrometer (SN 100537, Germany). Various other parameters such as calcium, magnesium, sodium, potassium, bicarbonate, sulphate, chloride, dissolved solids, hardness, specific conductance, and hydrogen-ion concentration (pH) were measured. To know the suitability of waters for drinking and irrigation, parameters like Non Carbonate Hardness (NCH), Sodium Adsorption Ratio (SAR), Integrated effect of EC and SAR, Percent Sodium, Potential Salinity, Permeability Index (PI), Indices of Exchange (IBE), Kelly’s Ratio, and Gibbs Ratio were determined.

The physical observations of the samples indicated that they are colorless and odorless in nature. The analyzed parameters are briefly explained with reference to the range, reasons for the changes at different locations, variation of fluoride and relationship with other chemical parameters. The ground waters in the study area are alkaline in nature with greater mineralization and possess very hard waters. They possess low buffering capacity and high sulphate levels. The fluoride concentration ranges between 0.78 and 6.10 mg/l. The alkaline pH and high bicarbonate are responsible for release of fluoride bearing minerals into groundwater.
Based on the classification of total dissolved solids as suggested by Gorrel (1958), all the water samples are fresh water category. The Piper’s diagram confirms that all the ground waters in the study area are characterized as alkaline earth’s (Ca + Mg) exceeds alkalies (Na + K) and all the ground waters in the study area described as weak acids (CO$_3$ + HCO$_3$) exceed strong acids (SO$_4$ + Cl + F); In the present study, it is noted that generally all the samples are falling under area 5 indicating that the carbonate hardness (secondary alkalinity) exceeds 50%.

Richard’s classification of sodium adsorption ratio proposes that the ground waters of the study area are excellent for irrigation. The graphical diagram of irrigated water (U.S. Salinity Laboratory, 1954) and the integrated effect of EC and SAR has concluded that that the ground waters of the study area have fallen under C3S1 (high salinity) and C2S1 (medium salinity with low sodium) categories. Further, these waters are rated as satisfactory for agricultural purposes. The Wilcox diagram (percent sodium versus conductivity) illustrates that the ground waters in the study area falling under the categories of “Good to permissible”, and “Excellent to good”.

The permeability index classification as per Doncen (1964) delineates that the ground waters in the study area are good for irrigation with 75% or more of maximum permeability. The indices of Base Exchange conclude that all the ground waters in the study area shows that majority of the samples fall in the negative zones indicating the exchange of Mg and Ca of the water with Na and K of the rocks.

The Kelly’s ratio proposes that the ground water in the study area shows that the values ranged from 0.12 to 1.24. Generally, the majority of the samples are suitable for irrigation. The Gibbs ratio diagram elucidate that the ground waters of the study areas are influenced by the rocks in the aquifers. The lithology is responsible for the release of elements predominantly in large amounts to ground water. These cations are solubilised and removed by leaching, leaving a residue deprived of its easily soluble bases.
5.4 URINE AND FAECAL MATERIAL OF HUMAN BEINGS

When assessing the safety of various levels of fluoride ingestion it is important to consider the fluoride intake from all potential sources. These sources might include drinking water, fluoride oral care products and the environment as well as food and beverages. As urine is the main excretion route for ingested fluoride, analysis of the fluoride concentration in urine is a useful way to estimate the overall fluoride intake of a population. The study is being undertaken in the fluorosis affected area of Talupula to examine the concentration of fluorine and associated elements (Zn, Cu, Mn, Cd, and Cr) in the urine and faecal material of human beings. Composite samples of faecal material and urine from ten male persons of Talupula (F-affected) and ten male members of unaffected, Tirupati were collected. The fluoride was estimated by using Lovibond PC Spectrometer (SN 100537, Germany) following the method of SPANDS colorimetric method and the trace elements viz., Zn, Cu, Mn, Cd, and Cr were analysed by atomic absorption spectrometry (AAS).

From this study it is inferred that higher concentrations of F were observed in the urine (2.50 ppm) relative to faecal material (1.05 ppm) in the F-affected area of Talupula, The faecal material and urine are showing higher concentration of elements during winter than in the summer season in both Tirupati and Talupula areas.

5.5 CONCLUSIONS

The studies conducted in this area have revealed that the geochemical alteration of rock formations superimposed by pedological modifications by the termite and associated microorganisms control the mobility of elements in mounds. It is also clear that termites together with the microorganisms continuously modify the physical, textural, and physico-chemical and pedochemical characters of the mounds. The resultant disturbance
of soil profiles, changes in soil texture and changes in the nature and distribution of organic matter appear to be more significant than changes in chemical properties. This it play important role in the humification process.

In conclusion, termite mounds appear as major source of functional heterogeneity in the Talupula area of Ananatapur district. From this it may be concluded that mound building termites and their associated microorganisms control the translocation of different elements, thereby playing a significant role in the biogeochemical cycling of elements in the tropics.

Because of the territorial nature of termites, the geochemical signature expressed in the termites is likely to have been derived proximal to the mound. This could include a combination of chemical attributes from vegetation, groundwater, the regolith profile and, to a lesser extent, the upper soil profile. Termites can provide a homogenized expression of these other media for geochemical sampling, and promise to be an effective exploration tool sampling at local to tenement scales.

The water samples in the study area show enrichment of sodium, magnesium, and calcium among cations and bicarbonate among anions. The observed incidence of fluorosis is alarming in the surrounding regions of Talupula village. Generally, the large percentage of the groundwater samples possesses fluoride concentrations greater than 1.5 ppm. Based on fluoride levels, the well water is unsuitable for drinking. The main factors that control the quality of water are associated with lithology and soil. The arid climate with high evaporation and insignificant natural recharge might have accelerated the increase in fluoride concentration in the groundwater of this area. The main sources of fluoride in natural waters are fluorite and fluor-apatite, as well as micas and
hornblende in which the fluoride ion replaces the hydroxyl group. The occurrence of fluoride in water is normally due to the rock types, which host these minerals. If a particular zone, containing fluoride minerals as one of its constituents, is weathered down to fine particles and comes into contact with alkaline water, then the possibility of water containing fluoride increases. Low concentration of fluoride in wells nearer to the surface storage structures indicates the influence of recharge from these leaky reservoirs, causing a dilution in fluoride concentration. The study suggests that in areas of high fluoride concentration, it is necessary to harness the surplus runoff generated during the high intensity events and practice artificial recharge for creation of a safe drinking water source. It is recommended that the Nalgonda technique is one of the best de-fluoridation methods because total alkalinity exceeds total hardness in the groundwater. The emphasis on public awareness about the adverse effects to human health of high F concentrations in drinking water and education on the mechanisms necessary to improve the health status of the population are essential. Greater intake of calcium and tamarind in the diet of the inhabitants of the endemic regions could alleviate the fluorosis problem to certain extent. Government authorities and non-governmental organizations in this region are thriving to solve the fluorosis problem and have suggested various defluoridation techniques. Feasible and cost effective biological techniques need to be adopted to remediate the affected land. Further, rainwater harvesting has also to be implemented to tackle this fluoride menace.

Groundwater over exploitation through lack of demand management strategies and the easy availability of economic and technological incentives and tools have resulted in the unsustainable use of ground water in some parts of the country. The market has
performed imperfectly. It would be useful to look back at the history and culture of water use and learn some lessons from it to be transferred appropriately in a modern context. Open wells are used as source of water withdrawal for a long stretch of centuries as a technique. This method used the dynamic water table and the limitations of the lifting devices made sure that the static water table was hardly touched. A built-in corrective system where one could not reach water to exploit till it came back to a level that could ensure environmental sustainability of groundwater resources. Mass organizations must bring this to the notice of the society and work for spreading the message of sustainable use. The first contact of any individual with water is for drinking and domestic purpose. Through rainwater harvesting, fluoride free and nitrate free water can be delivered at household levels. This engages families with rain as also provide them with sound health necessary for economic activities.

The concentration of fluorine in the urine and faecal material of human beings of endemic fluorosis area of Talupula has shown that the higher concentrations of F were observed in the urine (2.50 ppm) relative to faecal material (1.05 ppm). From this study it is concluded that the urinary fluoride concentration can been used as an indicator for fluorosis risk.