Chapter 2

Study Area

West Bengal

West Bengal is situated in a strategic position in eastern India and lies between 21°31' and 27°14' north latitudes and between 86°35' and 89°53' east longitude. The Tropic of Cancer passes through the state. The state extends from the snow clad Himalayas in the north to the Bay of Bengal in the south. Broadly speaking, West Bengal has two natural divisions- the Himalayan north and the alluvial plain south of it. The Bay of Bengal forms the southern coastline of the state.

The Himalayan region in the north Bengal has three general divisions-the high altitude mountain region, the foothills or the Terai region and the mixed deciduous forest and grassland region known as the Dooars. Swift flowing rivers like the Teesta, Torsha, Rangeet and the Mahananda flow through these areas. These rivers are perennial. The important rivers in the plains of Bengal include the Ganga, Hughly, Rupnarayan and Damodar. The plains of the Ganga and other associated rivers form one of the most fertile regions in the world. The Ganga flows through the state at one of its narrowest points and flows into Bangladesh. Unlike the rivers of the north the southern rivers like the Damodar, Rupnarayan are not perennial rivers. The land usage in West Bengal is as follows- arable land: 62.8 %; forests: 13.38 %; the rest is for other purposes.

West Bengal has 18 districts. Sampling was done in the districts of Maldah, Murshidabad, Nadia, North 24 Parganas, South 24 Parganas. The sampling locations of ground water and soils of West Bengal have been illustrated in the figure 2.1 and 2.2 respectively. A brief description of these districts are given below.
Study Area

Maldah

The district of Maldah is located in the Northern Sector of the river Ganga and included in the delta formed by the rivers, Ganga and Mahananda.

Maldah is located at the latitude from $25^\circ 32' 08''$ to $24^\circ 48'20''$ in the north and at the longitude from $88^\circ 28'0$ to $87^\circ 45'50''$ in the east. It is bounded on the north by the district of West Dinajpur and Bihar, on the south by Murshidabad district and Bangladesh, on the west by Bihar and on the east by Bangladesh. The district has been divided into two parts by the river Mahananda. The district of Maldah is low-lying plain without any hills, but some high land may also be seen in the district, its land sloping towards South. The soil of the area is alluvial formed by the rivers of Ganga, Kalindi, Tangan, Purarbhaba and Mahananda.

The soils of Maldah can be classified as Typic Ustochrepts, Typic Ustifluvents (characteristics of Ingriz bazaar and Kaliachak areas) and Typic Ustifluvents, Fluventic Ustochrepts (characteristics of Manikchak, Dhulian, Sujapur areas of the district) as per the NBSS publications (1995). The NBSS follows the USDA system of soil classification. The first name describes the dominant soil type. (The details of the various soil types are given in the Appendix 2).

Figure 2.3 locates the sampling sites of depth profile of soil of Maldah, West Bengal.

Murshidabad

Murshidabad is located centrally in the lower Ganga Valley. The plain land of the district is formed with the alluvial soil deposited by the main rivers of the district. The main rivers of the district like Ganga, Bhagirathi, Bhairab and Jalangi bring much silt along with them and spread it over the plains making them rich and fertile. The district has no hillock or mountain and the land is flat and without any dulation.

It covers an area of 5,341 sq. kms. It is bounded on the north by Ganga river, on the South by Bardhaman and Nadia district, on the east by Bangladesh and on the west by Santhal parganas of Bihar and Birbhum district. The soils of Murshidabad can be classified as Aeric Haplaquepts, Typic Ustochrepts (characteristics of Jangipur area of the district) and Typic Fluvaquents, Typic Ustochrepts (characteristics of the Berhampur and Beldanga areas of the district) (NBSS 1995).
Nadia

Nadia is located at 24°53' and 24°11' north latitude and 89°9' and 88°48' east longitude. It is located at the central track of the land of the state of West Bengal, purely plain in nature without any dulation. It is formed by the alluvial soil of the river Bhagirathi, a river flowing out of the river Ganga. The main rivers of the district like Bhagirathi and its tributaries namely, Jalangi and Churni have changed the geo-physical features of the district. Bhagirathi is the main river of the district and it has played a significant role in the natural formation of the district. The soils of Nadia can be classified as Typic Ustifluvents, Aeric Haplaquepts (characteristics of Shantipur area of the district) (NBSS 1995).

North 24 Parganas

The district North 24 Parganas is the second most populous district in West Bengal. It is situated at the international border of Bangladesh. This district is a new addition to the political map and administrative set up of the state of West Bengal. It has been officially commissioned as a new district only from 1 March 1986 with Barasat as the district headquarters.

The total territory of the district covers an area of 4,094 sq. kms. It is located in the Gangetic delta with the characteristics of a deltaic land. The district is bounded on the North by Nadia district on the east by Bangladesh on the South 24 Parganas district and on the west by the river Hughly. The land of the district is a vast alluvial plain and without any dulations.

The area of the district is divided into three distinctly different zones: (1) the highly industrialized north zone, (2) the moderately industrialized north-eastern zone and (3) the highly agricultural north-eastern zone. The arable land of the district and divided into three main classes: (1) comparatively high land along with the banks of the rivers, (2) the low lying depression that extended along below the river banks and (3) the plain alluvial lands. The main rivers of the district are Hughly, Ichhmati, Jamuna and Kalindi. The soils of North 24 Parganas can be classified as Aeric Haplaquepts, Aquic Ustifluvents (NBSS 1995).

South-24 Parganas

The district of South 24 Parganas is included in the Presidency Division of the State of West Bengal. It is the second largest and the fourth most populous district,
Study Area

located at the south east corner of the state. It is a new district formed with the southern areas of the original 24 Paraganas district. This district has been created after bifurcation of the twenty four Paragnas district into two: north and south and has been commissioned as a new district only from 1 March 1986.

The total territory of the district covers an area of 10,121 sq.kms. It is located in the Gangetic delta with the characteristics of deltaic land, locally known as the land of ‘Bhati’, because of the course of rivers, which are southwards and falling towards the Bay of Bengal. The district is bounded on the north by North 24 Parganas district, on the east by Bangladesh on the south by Bay of Bengal and on the west by the river Houghli. The land of the district is plain and without a by hillocks or rocks. The soil is alluvial and loamy.

The soils of South 24 Parganas can be classified as Aeric Haplqueants, Aeric Haplqueupts (characteristics of Baj Baj/baruipur/Diamond Harbour/Bhangur areas of the district) and Aeric Haplqueupts Typic Haplqueupts (characteristics of the rest of the areas of the district) (NBSS 1995).

The main rivers of the district are Houghli, Raimangal, Thakurani, Bidyadhari and Matla passing through the different parts of the district. The district is full of small rivers and canals. However, due to them, they have been converted into fallow lands. All the rivers of the district flow towards south in the direction of Bay of Bengal.

In the district of South 24 Parganas, there is a specific forest area like Sunderban, which is the largest forest area in West Bengal.

Rajasthan

Rajasthan is situated in the north-western part of India. It lies between latitudes 23°3' and 30°12' north and longitudes 69°30' and 78°17' east. Compared to many countries that are located in a similar latitudinal belt, such as in northern Arabia, Rajasthan has a less harsh climate.

The Aravali mountain ranges that run from Delhi to Gujarat divide the state through south-east and north-west. The north-west region covering two-thirds of the state consist mostly of a series of sand dunes. Bikaner, Jaisalmer, Jodhpur and part of the Jhunjhunu districts form part of this region. The eastern region has large fertile tracts.
Khetri copper mines falls in the district of Jhunjhunu while Zawar zinc mines in Udaipur. A brief discussion on districts of Jhunjhunu and Udaipur follows.

**Jhunjhunu**

The district is situated in the north-eastern portion of Rajasthan and lies between 27°38' and 28°31' north latitudes and 75°02' and 76°06' east longitudes. It is bounded on the north-west by Churu district, on the north-east by Hissar and Mahendargarh districts of Haryana State and on the west, south and south-east by Sikar district. Most of the district consists of a mass of rolling hills and remaining part nearer to the south-eastern border contains some offshoots of the Aravali range of hills, running in Southeastern direction. A range of Aravali hills enter the district in the extreme south of Udaipurwati tehsil, and extends upto Singhana and Khetri in the east. In general, the elevation above mean sea level is between 300 to 450 meters. The highest peak 1,051 metre high is to the south of Lohagarh village.

Sand shifting and active dunes are the main hazards to cultivation. Soil erosion is the result of constant deforestation and mining activity which has bared slopes. The drainage is inland and is related to the Kantli river system, which is a non-perennial river and flows in the district. This river covers a large area of the district and flows in south to north direction. It originates in the Kiandera block hills of Sikar district and enters this district from the southwestern portion of Udaipurwati tehsil. After passing through the area of all the tehsils of the district, it ultimately enters Churu district. Besides, there are four major streams, namely Dohan, Chandravati, Udaipur Lohagarh-ki-Nadi and Sukh Nadi. There is no lake in the district but sacred tanks are in existence for bathing purpose. There is also a Bund of ‘Ajit Sagar’ under irrigation Department, which is at about 11 km. from Khetri town on Nizampoor road.

The district has a dry climate with a hot summer. In summer sand storms are characteristic features of the district. The cold season starts by about the middle of November and continues till about the beginning of March. The hot season follows thereafter and extends upto the end of June. The south-west monsoon is from July to mid-September. On an average there are 27 rainy days in a year.

A major part of the district is covered by recent to sub-recent blown sand, however, the small area of eastern part is occupied exclusively by the rocks of Delhi Super Group and later intrusive. The Delhi Super Group is represented by quartzites, marble, schists and phylite of Alwar Group and assemblage of the succeeding Ajabgarh...
Group. The rocks have been intruded by amphibolite, granite and rhyolite which was considered to have provided the material for the base metal mineralisation in the area.

The soils of Jhunjhunu can be classified as Typic Torripsamments, Typic Camborthids (NBSS, 1995). The district is a well-known copper district in the country. The details of the Khetri copper complex are given separately.

**Khetri Copper Complex**

Khetri copper complex is located 11 Kms north-east of Khetri town, 190 Kms southwest of New Delhi and 180 Kms north of Jaipur, in the state of Rajasthan between the latitudes N 28°5'95"-28°03'35" and longitudes E 75°49'45"-75°47'40" having the average mean sea level altitude of 370 metres. The average rainfall is 500 mm per year. In summer the maximum temperature is 45°C while minimum is 12°C. In winter the maximum temperature is 25°C and 2°C is the minimum.

Prospecting was started by GSI in 1954. Khetri copper complex was handed over to HCL in November 1967. The Capacity production is 31,000 Metric Tonnes of Electrolytic copper per annum (as per the record of 1990)

Stratigraphic position of this mine can be described as Alwar and Ajabgarh suite of rocks of Delhi system. The host rock is garnet chlorite quartz rock and amphibolite chlorite quartz rock. Sulphide mineralisation consists of Chalcopyrite, pyrrhotite and Rynite.

Khetri Copper Complex is at the northern end of a large copper belt extending from Singhana to Raghunathgarh covering a length of nearly 76 Kms. It includes two mines: one at Khetri and the other at Kolihan, a concentrator, a smelter, an Electrolytic refinery and an acid-cum-fertilizer plant alongwith all auxiliary facilities. An open cast mine at Chandmari and Dariba copper Project in Alwar district also form a part of the Khetri Copper Complex. It (HCL) is a major constituent of Hindustan Copper Limited and is situated in the Jhunjhunu district of Rajasthan.

Ore mineralization in Khetri deposit is represented by the primary sulphides-pyrrhotite, pyrite and chalcopyrite with magnetite at places. The main gangue minerals are quartz, calcite which accompany some of the phases of mineralisation. The mines in KCC have a copper content of 1 percent.

All along this copper belt there is evidence of intense ancient mining activity. There are large number of pits, shafts and inclines throughout its strike length. Sampling locations of ground water and soils of Khetri have been given in fig 2.4.
Study Area

Udaipur

Udaipur district is situated in the southern part of Rajasthan and is oval in shape with very narrow strip stretching towards the north. It lies between 23°46' and 26°2' north latitudes and 73°0' and 74°35' east longitudes. It is bounded on the north by Amjer and Pali district, on the south by Dungarpur and Banswara, on the east by Bhilwara and Chittaurgarh and on the west by Pali and Sirohi districts.

The district is encircled by Aravali ranges from north to south. The northern part of the district consists generally of elevated plateaus while the eastern part has vast stretches of fertile plains. The southern part is covered with rocks, hills and dense forests whereas the western portion known as the Hilly Tracts of Mewar is composed of Aravali range.

Except over hard or partially weathered rocks, all types of soils in the district are deep to moderately deep. Sandy loam soil is available in the Panchayat Samiti areas of Bhim, Deogarh and Amet, clay loam soil in Kumbhalgarh, Gogunda, Kotra, Jhadoi, Bhinder while the red loam soil in Kherwara, Sarada, Salumbar and Dhariawad. Generally the soils in the western parts of the district are stony while yellowish brown soil is met in the small portion of eastern and southern parts. The soils of Udaipur can be described as Rock Outcrops, uthic Ustorthents (NBSS, 1995).

The river Banas and its tributaries flows through the eastern parts of the district. Other rivers in the district include Som, Kakham, Wakal, Sein, Sabarmati, Tiri and Berach. All these are non-perennial rivers which flow only through the rainy seasons. Besides, there are several artificial tanks and lakes in the district.

The district has, on the whole, moderate and healthy climate without significant seasonal variations. January is the coldest month while May and June are the hottest month. Generally the rainfall decreases from the south-west to the north-east. On an average, there are thirty one rainy days in a year.

Geologically, the rock formation of the Aravali series cover the major parts of the district. According to the Mines and Geological Department of the State Government the general stratigraphic sequences of the rocks in the district is classified as following: Post-Delhi: Erinpura Granites; Delhi Super Group: Ajabgarh series-Schist, Gneiss, marble amphibolitise Alwar series-Quartzites; Post-Aravali: Ultrabasics and basic rocks Granites; Aravali super group: Phyllites, schist, quartzite
dolomite, conglomerate marble meta-volcanics; Pre-Aravali: Schist, gnesis and migamatites.

Udaipur district is particularly rich in mineral resources as a large variety of important minerals are found in the district. The important, metallic and non-metallic mineral found in the district are ores of copper, lead, zinc and silver. Among industrial minerals rock phosphate, asbestos, calcite, limestone, emeralds and marble etc. are important.

Lead and zinc deposits are available in Zawar which includes mines in Hameta Mangra to parsad and Rajpur Dariba deposits between Dariba and Bethumbi. These deposits are worked by the Hindustan Zinc Limited. The details of the Zawar zinc mines are discussed separately.

**Zawar**

Zawar is situated 44 Kms. south of Udaipur. It is connected by an 11 Km road with Tiri village located 32 Km from Udaipur on National Highway number. 8. The Udaipur – Ahmedabad metre-gauge line passes through Zawar.

Zawar lies in a terrain of undulating topography, the low lying flat valleys regularly interspersed with small hillocks. The main hill features with the mineralized dolomite and quartzite horizons, however, attain elevations of over 200 above the average valley level which is at about 350-400 msl.

The Tiri River, a tributary of the Mahi River, provides the main drainage. The Tiri has been impounded upstream by Hindustan Zinc Limited to make available water for industrial and domestic purposes. The river is non-perennial.

The climate is semi-temperate, with minimum and maximum temperatures being 5°C and 40°C in winter and summer respectively. Rainfall is in the range of 600-650 mm with most of the precipitation occurring during the monsoon months. It is during these few months that the otherwise denuded terrain acquires a green hue. Most of the vegetation is of the shrub variety. Agricultural holdings are small and isolated being confined to nala and river courses. Villages are few and scattered.

Hindustan Zinc Limited holds a mining lease covering over 51 sq. kms over a potential mineralized strike length of 30 kms. The lease is divided into five blocks numbered 1, 1A, 2, 3 and 4 and stretching in a north-south direction parallel to NH- 8. The main activity has been confined to block 1 where Mochia, Balaria, Zawarmala and Baroi form the main production centres.
However, the Zawar group of mines has since been sold to a private enterprise called Sterlite industries.

The rocks in Zawar belt constitute part of the Pre-Cambrian Aravali System and include an assemblage of low grade metamorphosed sediments comprising mainly greywackes, phyllites, dolomites and quartzite. The overlying rocks unconformably belong to the Pre-Cambrian basement complex of gneiss, schists and intrusive granites.

Zawar area has witnessed at least two periods of tectonic activity. The Post-Aravali activity folded the rocks into the Zawar anticlinorium plunging north whereas the subsequent Post-Delhi orogeny modified the geometry of the anticlinorium giving rise to a cross-folded structure with an east-west trending and westerly plunging overturned anticline. The Bowa-Mocia-Balaria complex represents the later structure with Mochia and Balaria mines occurring on the northern limb of the fold. The original northerly trending structure is represented by Zawar Mala and Baroi - Haran Magra.

The stratigraphic sequence in ascending order is basically greywacke, lower phyllite, dolomite, quartzite and upper phyllite.

Mineralization is confined to the main dolomite horizon and occupies shears, faults and fracture planes. Ore zones comprise of stringers and veins of variable widths ranging from a few millimetres to several metres with intervening barren partings. Ore bodies are of lensoidal nature, the lenses overlap with each other and are interconnected by link veins.

Sphalerite is the predominant sulphide mineral in the ore, the second most abundant being pyrite. Galena is more locally concentrated but is the main mineral at Baroi. Native silver, chalcopyrite, arsenopyrite and pyrrhotite are also known to occur. Cadmium and silver values are present in sold solution with sphalerite and galena respectively.

But for rainy season, mines are essentially dry. The sampling locations of ground water and soils of Zawar, Rajasthan have been given in the fig 2.5.
Figure 2.1: Sampling locations of Ground Water in West Bengal, India
Figure 2.2: Sampling locations of Soil samples in West Bengal, India
Figure 2.3: Sampling locations of Depth Profile of Soils of Maldah, West Bengal
Figure 2.4: Sampling locations of Ground Water and Soils of Khetri, Rajasthan
Figure 2.5: Sampling locations of Ground Water and Soils of Zawar, Rajasthan