CHAPTER 1
INTRODUCTION

1:1 INTRODUCTION

Nestling deep within a lush green corner of Northeast India is a wonderously beautiful little Shangrila called Manipur. Literally meaning "a jewelled land", this little corner is a veritable paradise on earth where mother nature has been extra generous in her bounty. It has an oval shaped plain surrounded on all sides by hills. The proposed area of investigation falls within this state.

Water is a sine qua non of life, the very basis for development of biotic community, existence of human culture and its growth. As per estimate by Goldschmidt, every square centimetre of the Earth’s surface has 273 litres of water which include 286.45 litres of sea water, 0.1 litre of freshwater, 4.5 litres of water in continental ice and 0.003 litres in water vapour (Rankama and Sahama 1950). In case of 3% of natural waters related to landscapes, an estimated 75% of water occurs in polar ice and glaciers. Only 14% of the natural water (i.e. 0.42 of 3%) is in groundwater below 762m and 3810m above sea level, 11% in groundwater below 762 m, 0.3% in lakes, 0.06% as soil moisture, 0.035% in the atmosphere and 0.03% is in streams. Even if man considers his own requirements coupled with his insatiable desire to progress only at the present rate, which is not possible, the demand on water resources shall rise exponentially with population explosion. It is expected that the world population shall reach 6122 million by the year 2000 and 8206 million by 2025 A.D. (WHO data). Waters of diverse specification for multitude uses and more so "safe water" for sustenance of life shall be needed to preserve the ecosystem. A growing problem, facing the world today, is the preservation of the quality of the water as it passes through the aquifer, diverse millieus, regime and micro- and macro-ecological barriers. This problem is especially serious because, once the quality of water is deteriorated, remedial action may be effective only after a period of many years, or it may become irreversible even at great cost. The unequalled ability of water as a natural solvent for ionic solutes reflects its dipolar nature and strong molecular polarizability thus making it vulnerable quality-wise, resource-wise, even at the slightest disequilibrium in the ecosystem and presently more so as a result of man’s activities.
Naturally, therefore, pollution is a dread that reaches back over the aeons to primitive man, in a cumulative way, affecting his environs by his activities which during this millennium attained monstrous proportions - a cause of concern for sustenance of life on the globe 'POLLUTION OF WATER' as defined by California State Water Control Board in 1963 is "any impairment of its qualities that adversely and unreasonably affects its subsequent beneficial use" (Claus and Halasi-Kun, 1972). Both the consumptive and non-consumptive uses of water and its imminent as well as frustrating resources depletion have led to evolving adequate scientific strategies in order to decipher change in water quality, causes, parametric evaluation of polluting factors, typification of waters for diverse usage, evolving measure to ward off pollutants, remedies and amelioration of the environmental hazards. This can be achieved on time to time monitoring of the surface water or any other type of water, since the degradation of any of these could affect the entire system. Groundwater is commonly understood to mean water occupying all the voids within a geologic stratum (Todd, 1980). The saturated zone is referred to as groundwater aquifer. A large portion of the fresh water resources comes from regionally extensive aquifer systems. Groundwater is normally pollution free, temperature controlled and extractable, and at the same time replenishable due to annual meteoric precipitation and recharge. Groundwater has been the only dependable natural recourse which can be used to supplement the shortage of water supply. Since groundwater is confined to sub-strata, controlled by geomorphological, structural, hydrometeorological and hydrogeological conditions, its exploration and exploitation are associated with a lot of problems. Scientific investigation is very essential to assess the potential of the renewable groundwater resource, and to identify suitable sites from where groundwater can be withdrawn efficiently over long periods.

Imphal valley of Manipur has limited water resources. One of the major problem being faced by the population is the shortage of drinking water. There are no major river systems. The increasing need of water for irrigation, domestic and industrial uses has to be met with by the availability of groundwater which too is limited.

1:2 STATEMENT OF THE PROBLEM

Manipur State is an intermontane valley. It mainly comprises the inland drainage conditions or an extensive closed basin. Like other states of India, Manipur has limited
fresh water resources because it lacks a major river system. Economy of the State is mainly based on agriculture and nearly 70% of the population live in villages.

Increasing water requirements for domestic, irrigation and agricultural practices are met with groundwater, which too is in limited quantity. Furthermore, increased use of fertilizers, pesticides and untreated effluents discharged on land have also led to the deterioration of chemical quality of ground and surface waters.

In view of the above consideration, hydrogeological and hydrogeochemical studies with reference to water quality in Imphal district (East and West Imphal) were undertaken.

1:3 OBJECTIVE AND SCOPE OF THE RESEARCH

The main objective of the present investigation is to provide a complete description of the hydrogeological and hydrogeochemical framework of the study area. One of the fundamental aim is to assess the quality of water, classify it for various uses besides study of the pollution and environmental aspects. In this endeavour, the main objectives undertaken for investigations pertaining to the following themes in the study area are :

1. Appraisal of the groundwater potential
2. Occurrence of groundwater and behaviour of water table in relation to regional geology.
3. Chemical characteristics of groundwater which affect its quality.
4. To estimate trace element concentration of the groundwater.
5. Critical evaluation of suitability of groundwater for domestic, agricultural and industrial purposes.
6. Problems of groundwater pollution.
7. Relationship between various ions present in groundwater, including statistical relationship.
8. Equilibrium analysis of groundwater with respect to various minerals.
9. Isotopic investigations of groundwater for determination of groundwater relationship to hydrological and geological parameters.

In order to achieve these objectives, field and laboratory investigations were carried out. The data accruing from present research work would help in establishing a model of conjunctive use of groundwater and in ascertaining the chemical quality of water
which is the dire necessity for proper planning and management of water resources in the study area. Analytical results of changes in chemical quality of groundwater shall enable the formation and implementation of a sound and efficient management system of groundwater in the study area.

1:4 THE STUDY AREA

Imphal district is situated in the North Central part of Manipur State (Fig. 1.1). It lies between latitudes 25°5' and 24°31' N and longitudes 93°45' and 94°10' E. It falls on the survey of India toposheet no. 83 - G/16, H/13, H/14, H/15, K/4, L/1 and L/2.

Imphal, the state capital, is connected by air from Delhi, Calcutta and Guwahati and with neighbouring states by roads through National Highway No. 39 and 53. Majority of the population of the state is concentrated in Imphal district.

1:4.1 Physiography and Relief

The study area forms an intermontane valley surrounded by rugged hills. The maximum relief of the hills surrounding the valley is 2331 m above mean sea level in the western side of the study area.

The study area occupies the central portion of the Imphal valley and extends in NNE - SSW direction, sloping from north to south. The general elevation varies from 824 m (in the extreme north) to 760 m (in the south) above mean sea-level. The study area forms an almost flat low lying area with slope ranging from 0 to 3%. A few isolated steeply rising hillocks with altitude of 908 m to 1126 m above mean sea level is also present.

1:4.2 Drainage

The Imphal river (Manipur river) which flows in southward direction drains the study area, whereas the eastern part is drained by the Irlil river (Fig. 1.2). These two rivers together form the major Manipur River System after meeting at Lilong area. The Khuga river originates from Churachanpur, initially flows in the N-S direction and turns eastward and joins Imphal river at Wanguleikha. Several other streams such as Nambul, Thongjaorock, Maklang, Mera Khong, and Leimatak etc. originating from western hills join and falls into the Loktak Lake, the biggest fresh water body in the N-E region of
The general drainage pattern in the study area shows dendritic to sub-dendritic and meandering drainage pattern (Fig 1.2). Most of the major streams/rivers flow from north to south.

1:4.3 Climate

The climate in the area is of sub-tropical to temperate type with distinct spatial variation showing highly contrasting meteorological conditions in various seasons. Summers extend from March to mid-May followed by rainy season which extend from mid-May to September. This is followed by winter season from October to February. Highest temperature occurs during the period of South-West monsoon being around 30 to 35°C. The average minimum temperature is about 4°C during December-January months. The average temperature variation from 1990 to August 1997 has been shown in Fig. 1.3.

The average annual precipitation from 1990 to August 1997 is shown in. (Fig. 1.4) The area experiences maximum rainfall during July to August.

1:4.4 Landuse

The study area experiences heavy rainfall of more than 1500mm, which favours good agriculture in the area. Rice cultivation is the main agricultural practice. The agricultural fields occupy the maximum area of coverage i.e. 1295 sq m of the total area. The following landuse classes have been identified in the area, viz. Built-up land/Human settlements with horticultural activities, Cropland/Agricultural fields, Shifting cultivation, Degraded forest/Scrub land and Marshy land/waste land/wet land. Surface water, fringed by marshy areas occupies a very large part of the southern portion of the area (Singh, 1996).

1:4.5 Drinking Water Supply

The study area lack adequate drinking water ammenities. Tap water is supplied by the State Public Health Engineering Department but the supply does not reach every nook and corner of the district. Existing infrastructure of the State PHED is far behind to achieve the task of drinking water supply. Where tap water is not available, the
population have resorted to the use of drinking water from ponds, rivers, tube wells/hand pumps etc. As more tube wells have come up in the previous years, the populace have turned to it for their drinking water. But a large number of tube wells cannot be installed in the district due to lack of systematic hydrogeological knowledge, encounter of natural gas pockets during drilling, high iron content in groundwater at places and lack of natural recharge to the alluvial aquifers.

1:4.6 Fauna and Flora

In the study area, a variety of fauna exist. These include elephants, wild pigs, leopards, buffaloes, horses and other four footed animals. Among the smaller kinds of fauna, variety of fishes, birds, amphibians, arthropods etc. are found in the region. Among the mammals fauna, mentioned can be made of the rare brow anterred deer (Sangai), barking deer, golden cat (Tokpa), fox etc.

The area has got diverse vegetation type. The main macro flora are Albizizia species (Khok), Cashonopsis species (Sawl), Bamboo, Pinus species (Uchan) etc.

1:5 REVIEW OF LITERATURE

1:5.1 Previous Study of the Area

The first report on the geology of Manipur was by Oldham (1883). Pascoe (1912) reported the occurrence of Barail rocks exposed in the west of the Imphal valley whereas the Disang rocks are in the east. Evans (1932) reported that stratigraphic succession of Upper Assam is continuous in Nagaland and Manipur States. Mathur and Evans (1964) gave an account of the tectonics of NE India. Brunschweiler (1966,1974) discussed geological section through Indo-Burma ranges. Anon (1974) compiled the geology and mineral resources of Manipur belt.

During the last few decades, many geologists of the Geological Survey of India and Oil and Natural Gas Commission have had carried out systematic geological mappings in different parts of Manipur. Most of these are in the form of unpublished official reports.

1:5.2 Hydrogeological Studies

Roy (1969) reported the existence of artesian condition at places in the valley portion. Central Groundwater Board (1975-76) undertook detailed hydrogeological survey

1:5.3 Pollution and Water Quality Studies

A number of cases of groundwater pollution have been reported in the literature but no systematic and detailed work in this area has been carried out so far. In other parts of the country, Tanwar (1981) carried out well water quality based on monitoring for four years and revealed that increase in concentration of chloride and sulphates of calcium and magnesium is the result of increased use of fertilisers in Haryana. Kakar (1981) observed a localised rise in nitrate concentration from 43 to 920 mg/l. Verma (1989) also gave a brief account of groundwater pollution in adjoining areas. Some other contributions have also been made by Handa (1975, 1983), Handa et al, (1981), Kakar and Das (1981), Goel (1983), Kumar (1983) Raju et al., (1983), Kakar (1985) and Akoijam and Anand (1997) studied the fluoride toxicity in the groundwater samples of Imphal district. They reported incidence of high fluoride in groundwater in some localities of Imphal district.

1:5.4 Geochemical Studies

The overall chemical quality of groundwater of the area is related to several processes and factors which may effect independently or together. The chemical composition of groundwater is controlled by many interrelated factors including geology, climate, soil, topography, landuse pattern, biological processes and time (Gorham, 1961). Kakar (1981) observed that in general, chemistry of groundwater is inter-linked with geology and hydrogeology of the area, physico-chemical characteristics of the soils and rocks through which water percolates, nature of plant cover, extent of pollution and various local factors. Feth et al., (1964) in the Sierra Nevada mountains (USA) demonstrated quantitatively the importance of soil-water interaction in determining the
groundwater chemistry. It is a generally accepted fact that weathering of silicate minerals have major control on continental aqueous chemistry. Its importance have been emphasised in both equilibrium weathering studies and studies concerning the importance of kinetic controls, Garrels and Mackenzie, (1967), Eriksson and Khunakasem (1968), Drever (1971), Tardy (1971). Besides silicate weathering, arid regions present other controls on water chemistry. Jones (1965) discussed the factors which control the chemistry of saline water lakes and noted the importance of the effects related to evaporation like, precipitation of low temperature authigenic minerals.

Garrels and Mackenzie (1967), Hardie and Eugster (1970) realized the importance of precipitation of secondary minerals while calculating the composition of saline lakes. Comprehensive evaporation-concentration models discussing the solute-fractionation mechanism have been presented by Fritz (1975). Significant studies devoted to the problem of geochemical evolution of groundwaters in arid regions have been conducted in many parts of the world. Greenman et al., (1965) and Swarzenski (1968) proposed 'solution-evaporation' hypothesis to explain the origin of saline groundwater zones. These authors attributed origin of salinity to reaction of groundwater with soluble secondary salts and clay minerals. Seaber et al., (1973) proposed that salinity problem has its origin in evaporation from water table.

A similar work involving geochemical investigation in Karnal and Panipat district was done to characterize the mineralogical control on the groundwater chemistry. Geochemical models based on thermodynamic equilibrium have been used for identifying the mechanism that controls the composition of natural waters (Thorstenson et al., 1979, Wallick, 1981, Lee, 1981, Hull, 1984, Bhatnagar, 1986 and many others. After the pioneering work of the ion-association model by Garrels and Thompson (1962), a number of techniques have been developed for calculating the chemical equilibria in complex systems.

A number of computer softwares based on geochemical principles have been developed and and some of the best known models are PATHI (Helgeson et al.,1970), MINEQL (Morel and Morgan, 1972), WATEQ (Truesdell and Jones, 1974), WATEQF Plummer et al., 1976), GEOCHIM (Sposito and Mattogold, 1980) and PHREEQE (Parkhurst et al., 1980). Computer codes briefly solve a set of simultaneous non-linear equations that describe mass balance, chemical equilibria and electric neutrality. A
comprehensive computer review of computer models has been given by Leggett (1977), Perrin (1977) and Runnells (1987). Plummer et al., (1983) and Plummer (1984) explained how these computer softwares can be used to develop reaction models based on hydrodynamic settings, aquifer mineralogy and water chemistry.
FIG. 1.1 LOCATION MAP STUDY AREA, IMPHAL DISTT., MANIPUR.
FIG. 1.2 DRAINAGE & RELIEF MAP OF IMPHAL DISTT., MANIPUR. (After Singh, 1993)
FIG. 1.3  AVERAGE TEMPERATURE (°C) OF IMPHAL DISTRICT, MANIPUR (1990-1997)
FIG. 1.4 AVERAGE YEARLY RAINFALL, IMPHAL DISTRICT, MANIPUR (1990-1997)