CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Water is elixir of life, without it life is not possible. The socioeconomic growth of a region is severely constrained by non-availability of safe drinking water (Kumar et al., 2005). Civilizations have flourished with the development of reliable water supplies and they collapsed as the water supply failed. Fresh water is the most precious and one of the most vital resources of all. Requirement of water for drinking and domestic purposes depends on physical as well as socio-economic development of the area. Most of the water situations and problems are local and regional in nature. Since long distance inter-regional transportation in large quantities is impracticable, the need of place of region for fresh water has to be made from its own resources and supplies. The quality of water has been continuously declining globally in general and in developing countries in particular, due to natural and anthropogenic processes (Carpenter et al., 1998; Chen et al., 2002). Water quality also gets modified during the course of movement of water through the hydrological cycle and through certain processes like evaporation, transpiration, selective uptake by vegetation, oxidation-reduction, cation exchange, dissociation of minerals and precipitation of secondary minerals, mixing of water, leaching of fertilizers & manures and biological processes (Appelo and Postma, 1993; Gupta et al., 2008).

Water is an important constituent of the earth geosystem. There is plenty of water on the earth surface, the fresh water, however is limited and a large part of it is in a polluted state at present. Polluted water is the greatest source of disease. Almost half of the world’s population do not have proper water supply. Only 2.7 percent of the total global content of approximately 1.4 billion cubic kilometers water is fresh and suitable for human consumption. Of this again, about 77.2 percent is permanently frozen, 22.4 percent occur as ground water and soil moisture, 0.35 percent is contained in lakes and wetlands and less than 0.01 percent in rivers and streams. Obviously, the amount of water actually available above the ground, that is, in the atmosphere, is a very small fraction and is estimated to be $1 \times 10^{-5}$ of the total water resources of the world (Rao, 1979).
minimum requirement of clean drinking water per person is about 3 litres per day or one cubic metre per year. Thus the minimal amount of drinking water at the global level needed for survival annually is only 5 billion cubic metres or 5 cubic kilometers. However, this requirement is not fulfilled in all parts of the world (Sharma, 1987).

About 86 percent of the rural population lacks an adequate water supply and that 92 percent lack adequate facilities for excreta disposal. Only 28 percent of the urban population has sanitation and sewerage facilities and about 29 percent have no sanitation facilities of any kind. About 38 percent of urban population in India, who are below poverty line, has no access to water (Singh et al, 2003). It is estimated that about 40 countries and one billion people will not have adequate water supplies in the near future. By 2025 it will be 2.3 billion people. Today 6 billion human beings compete for this scarce resource and by 2050; 10 billion will go thirsty (Panda, 2003).

Potable water is one that is free from disease causing microorganisms (pathogens), low in concentrations of compounds that are acutely toxic or that have serious long term effects on health. Potable water should also be clear, not saline, and free from compounds that can cause colour, taste and odour (Pritchard et al, 2007). Quantifying the major ion composition of stream waters also has broad implications i.e. water quality type, hydrogeology characteristics, rock-weathering processes and rainfall chemistry (Brennan and Lowenstein, 2002; Cruz and Amaral, 2004). The chemical composition of ground water is controlled by many factors viz. composition of precipitation, geological structure and mineralogy of water sheds and aquifers and geological processes within the aquifers (Andre et al., 2005).

Keeping in view the importance and the vulnerability of water quality towards the human health, number of studies on assessment of drinking and irrigation water quality have been carried out mainly for mining/industrial areas in different parts of India (Agrawal and Jagetia, 1997; Niranjanbabu et al, 1997; Mazumdar and Gupta, 2000; Dasgupta and Purohit, 2001; Khurshid et al, 2002; Sujatha and Reddy, 2003; Sreedevi, 2004; Pulle et al, 2005; Hussain et al, 2005;
Sunitha et al., 2005; Subbarao, 2006; Mishra et al (2003). Broadly all have concluded that water was found suitable either for drinking or irrigation purposes. Gupta et al (2008) have studied the geochemistry of ground water of Burdwan district of West Bengal in order to assess its suitability for drinking purposes. A study of surface and ground water in the Chalakudy river basin, southwestern India has been conducted to assess the quality by Basu et al, (2007). Jeelani and Shah (2007) have studied the hydrogeochemistry of water samples from the four basins of Dal Lake of Kashmir valley and reported that the lake is alkaline in nature dominated by \( \text{Ca}^{2+} \), \( \text{Mg}^{2+} \) and \( \text{HCO}_3^- \) ions. In the industrialized sub-urbs of Pondicherry, alarming situation due to the presence of excessive concentration of such toxic elements as As, Hg, Fe, Mn, and Cd has been reported in ground water and surface water. Further, the major water quality parameters \textit{viz.} Electrical Conductivity (EC), Total Dissolved Solids (TDS), Hardness, Alkalinity, \( \text{SO}_4^{2-} \) and Biological Oxygen Demand (BOD) have been found to be exceeding the permissible limits during all seasons in sub-urbs of Pondichery (Abbasi and Vinithan, 1999).

India is a country known to be for studded with scenic beauty, comprising of various landforms criss-crossed by rivers. There are fourteen major rivers in India that share 83 percent of the total drainage basin and contribute 85 percent of the total surface flow (Chaudhuri, 1983). India receives an average annual rainfall equivalent to about 4,000 billion cubic metres which are unevenly distributed both spatially as well as temporally (Engleman and Roy, 1993). The relationship between water quality and human activities is extremely complicated. With rapid growing population and improved living standards, the pressure on water resources is increasing. Exploitation of water from the resources for domestic, industrial and agricultural purposes puts resources \textit{Viz.} Rivers, lakes, estuaries \textit{etc.} into degraded state. The growth of population and industries are responsible for the increase in the total volume of sewage on one hand and the degree of toxicity due to industrial effluent on the other, in which the share of obnoxious matter has markedly increased (Gaitonde, 1995; Murugesan et al, 2002). These increased volume of sewage and toxicity thereby, resulting into Eutrophication of water bodies and in turn leading to the invasion of foreign vegetative species (Murugesan et al, 2005).
1.2 LOCATION AND ACCESSIBILITY OF STUDY AREA

Mizoram is located between 22°19’N and 24°19’N latitude and 92°16’E and 93°26’E longitude covering a geographical area of 21,081 sq.km (Plate–I). The state is bounded by Chin Hills (Myanmar) in the east, Manipur and Cachar District of Assam in the north, Tripura and Bangladesh in the west and again Myanmar in the south. The average length of the state (from N-S) is 277 Kms whereas the average width (from E-W) is 121 Kms.

Mizoram is connected by NH 54, an all weather road to Silchar, Assam. Aizawl, the state capital is about 180 Kms from Silchar (Assam) whereas the second largest town of the state, Lunglei, is about 410 Kms away from Silchar. The state is also approachable from Churachanpur (Manipur) and Tripura but the roads that connect these places are not operational throughout the year. Rail link has been established at Bairabi from where passenger as well as goods train services are available regularly. It is also connected to Kolkata, Imphal and Guwahati by air route. The Airport is at Lengpui, about 30 km. away from Aizawl and about 75 km from Kolasib.

The area under study in situated in and around the Kolasib town. Kolasib is the district headquarters of Kolasib district of Mizoram situated over the tightly folded chain of hillocks. It is situated between 23°70’ S and 24°50’N latitude and 92°50’ W and 93° longitude. The total area of the district is 1472.12 Sq.Km of which 70 percent of the total area of the District is under Forest cover. Total number of villages in the district is 34, four sub-towns namely-Kawnpui, Bualpui, Bairabi, Vairengte and one full-fledged town, Kolasib. It is bounded by Cachar and Hailakandi district, Assam on the north and north west respectively, on the south and east by Aizawl district and on the south west by Mamit district, Mizoram. As per 2001 census, the population of Kolasib district is 65,960.

1.3 CLIMATE AND RAINFALL OF MIZORAM

Mizoram enjoys a moderate climate. It is generally not so hot in summer but fairly cold in winter. The winter temperature ranges from 7°C to 20°C. The summer temperature is usually between 17°C to 30°C. The average temperature of
Kolasib in winter is 11.8°C to 21.30°C and in summer, it varies 20.80°C to 29.80°C. During the cold season, an individual minimum temperature may go as down as 5°C.

The air is highly humid throughout the year. Relative humidity is highest during southwest monsoon, reaches above 90 percent. Wind speed is generally gentle except in March to July. During those days, the disturbances in Bay of Bengal also affect Mizoram in general and Kolasib in particular.

Mizoram comes under the influence of monsoon with the beginning of May. Therefore, the maximum rain is received in between May and September. Mizoram has annual rainfall of 2540 mm. while the average annual rainfall in Kolasib is 3500 mm. The northwest parts of the state get maximum rainfall (over 3500 mm.). The southern parts also get high rainfall over 2500 mm. The climate of Kolasib is characterized by its pleasant cool weather, relative humidity and abundant rainfall.

Table 1: Rainfall data of the study area for five years

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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<tr>
<td>Month</td>
<td>Rainfall in mm</td>
<td>Rainfall in mm</td>
<td>Rainfall in mm</td>
<td>Rainfall in mm</td>
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<tr>
<td>February</td>
<td>30.0</td>
<td>10.0</td>
<td>70.0</td>
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<tr>
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<tr>
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<td>3268.00</td>
<td>3443.00</td>
<td>3698.00</td>
<td>3758.00</td>
</tr>
</tbody>
</table>

(Source: Indian Council of Agricultural Research, ICAR, Kolasib, Mizoram)

1.4 VEGETATION

Mizoram is very rich in vegetation. Forest and paddy fields cover major part of the area. Forest of Mizoram is very rich where teak trees and bamboos are
grown in abundance. It is covered by various kinds of medicinal plants and food trees. Since time unmemorable these ethno medicinal plants have been used in the treatment of various kinds of ailments. Lorrain (1940) was the first to document the ethno medicinal plants of Mizoram and gave details of the traditional medicinal plants used by the Lushais. Lalramnghinglova (1991) has documented 437 plants with their local names, botanical names, family, distribution, description and medicinal uses. However, due to jhoom type of cultivation, the forest cover is decreasing every year. Horticultural crops have also acquired great importance in the state due to diversified topography, agro climatic conditions and soil resources.

1.5 PEOPLE, THEIR LIVING CONDITION AND FOOD HABITS

Majority of the people living in the study area are Mizos. The Mizos are divided into several tribes - the Lushais, Pawis, Paithes, Raltes, Pang, Himars, Kukis etc. Society is based largely around tribal villages. The chief's house and the zawlbuk (community house for young, single men) are the focus of village life. Mizo and English are the official languages. The literacy rate in Mizoram is about 82 percent, one of the highest in India. More than 80 percent of the population is Christians; the great majority is Protestants who were converted by missionaries during the 19th century. There are Muslim, Buddhist, and Hindu minorities. The nomadic Chakmas practice a combination of Hinduism, Buddhism, and animism (the worship of nature deities and other spirits).

Though mostly Christians, the hill people have kept alive their rich cultural heritage, colourful customs and lively traditions. An interesting tradition amongst the Mizos is the code of Ethics which revolves around tlawmngaihna, an untranslatable term which means that every Mizo is duty bound to be hospitable, kind, unselfish and helpful to the poor and needy.

Festivals and dances of the Mizos have a unique tribal flavour. Other than Christmas and New Year's Day which are the most popular festivals, Chapchar Kut (after clearing of jungles for cultivation of the jhum crop in February-March), Pawl Kut (after harvesting in December) and Mim Kut (dedicated to departed souls after the maize harvest in September) are the other occasions celebrated with much gusto. The most popular dances of Mizoram are Cheraw (Bamboo dance), Khuallam (dance for visitors or guests), Chheih Lam (at the end of a day's work) and Solakar or Sarlamkai (prevalent among the Mara and Pawi tribes).
Food habits of the people constitute two substantial meals throughout the day. They mainly consume rice, pork, chicken, beef, egg, fish etc. Other than potato and common vegetables they depend on leafy vegetables for their vegetable needs.

1.6 PHYSIOGRAPHY OF MIZORAM

1.6.1 Drainage System of Mizoram

The Mizo Hills have ranges running from north to south. The average height of the hills is about 900 m. The hills are steep and separated by rivers which flow either to the north or to the south, creating deep gorges in between the north-south hill ranges. There are innumerable rivers, streams and brooks in the state. In the north, the Tlawng (Dhaleswari), the Turial (Sonai) and the Tuivawl start from the middle of Mizoram and flowing north, fall in the Barak River in Cachar district of Assam. In the south, the Karnafuli flows north from the southern tip of the state and near about the middle it flows to Bangladesh where it has been tapped for a huge hydel project. The Koladyne River enters Mizoram from Myanmar and flowing south, it enters Myanmar again. The drainage system as a whole is said to be dendritic in nature and the streams are youthful stage and nallas have much straightened and deep courses.

1.6.2 Geomorphology of Mizoram

As the terrain is very immature, topographical features show prominent relief. The major geomorphic elements are both structural and topographic ‘highs’ and ‘depression flats’ and ‘slopes’ sculptured on the topographic surface in a linear fashion. The physiographic expression of the state is imparted by approximately N-S trending steep, mostly anticline, longitudinal (linear fashion), parallel to sub-parallel hill ranges and synclinal narrow valleys with series of parallel hummocks or topographic highs. In general, the western limbs of the anticlines are gentler than the eastern limbs. In many cases, steep rock scarps are produced due to faulting especially along the highly dipping fault planes. The other geomorphic elements are the high dissected ridges with the formation of deep gorges, spurs, keels and cols, which developed due to intensive erosion during the isostatic adjustment. The difference of elevation between valley floor and hill tops greatly
varies from east to west. The steep hill ranges are more towards east than towards west.

The major drainage pattern having different bifurcation ratios follows the N-S trending depressions and gorges in the low level topography in between them. The depressions and gorges, in most cases, are the physiographic expressions of the faults or other structural patterns.

**1.7 SCOPE OF PRESENT STUDY**

The majority of research work undertaken on water in developing countries (Chilton and Smith-Carrington, 1984; Lewis and Chilton, 1984) has focused on surface and borehole water quality with hardly any work being undertaken on shallow wells. Shallow wells are one of the most important types of water supplies for domestic purposes for rural districts in Malawi (Staines, 2002). The quantity of water supplied by the PHED department in the study area is not enough to meet the daily requirement of water for drinking and other household activities of the people. As on May 12, 2009, the Kolasib town has only 1801 water connections for a population of 19008. According to the record of the PHED, Kolasib, the population benefited by water connections is 11,317 suggesting the fact that 7,691 people of Kolasib town are forced to fetch water for their daily needs from *tuikhurs* (spring) (Plate III-IV) or other sources including rain water (Plate VI). Water in rocks circulates through the secondary openings represented by joints, cracks, fissures and such other planes of discontinuity. The weathered residuum of the hard rocks as well as the fractures, joints, fissures, faults and other zones of discontinuity are the principal repositories of groundwater in the area (Singh *et al*, 2007). Similarly, Vairengte and Bilkhawthlir have 547 and 194 connections for 7715 and 4084 population respectively. Kawnpui is a sub-division headquarters in the district but it has only 256 water connections. People of the study area have been consuming water for their drinking and household purposes without any treatment.

In fact, there have been no detailed investigations carried out to evaluate the quality of potable water in the study area. The objective of the present work is:

- To assess the physical, chemical and bacteriological characteristics of potable water.
To determine the level of concentration of various heavy metals and trace elements in potable water.

To understand the sources of various contaminants in order to suggest remedies.

To develop a data-base on water quality.

1.8 LITERATURE REVIEW

A number of studies have been carried out on water chemistry across the world. According to Garrel (1965) dissolution of rocks removes certain ions such as Ca\(^{2+}\), Mg\(^{2+}\), Na\(^+\) and K\(^+\) but at the equilibrium state between rock and water the ions which have been mobilized into the aqueous phase will be removed from the system producing secondary minerals such as calcite and clay. Other than rocks, HCO\(_3^-\) in water is derived from carbon dioxide extracted from air and produced in soil by biochemical activity (Hem, 1985). The rain water when passes down the organic rich soil the carbon dioxide gas present in the unsaturated pore spaces reacts with water to form carbonic acid, which in turn helps in dissolution of organically and chemically precipitated calcite and dolomite in soil (Merrits, 1997). The study of Jalali (2006) has demonstrated that the chemical composition of groundwater differs according to water types. They have concluded in their study that dissolution of halite, gypsum, dolomite, calcite and pyrite weathering determines Cl\(^-\), SO\(_4^{2-}\), HCO\(_3^-\), Na\(^+\), Ca\(^{2+}\) and Mg\(^{2+}\) content in groundwater. Langmuir (1997) has observed that the most surface water and shallow groundwater, due to precipitation process as the source is Ca\(^{2+}\)-HCO\(_3^-\) water type, with decrease in Na\(^+\) attributes to its intake in the formation of clay, helped by the pH range which is near neutral or less. But with increase in depth, an increase in pH takes place, which can be related to carbonate dissolution induced by cation exchange with replacement of Na\(^+\) ion (Adams et al, 2001; Parkhurst, 1995). This process results in the formation of Na\(^+\)-HCO\(_3^-\) type of groundwater. Recently, many research projects have examined the relationship between nitrate levels and depth of wells (Hudak, 1999, 2000; Lee et al, 2003; Lake et al, 2003). Gerba and Mc Nabb (1981) have discussed fate and transport of pathogens and microbial activity in groundwater environments as aspects of microbial groundwater pollution. Ladd et al (1982) have studied groundwater and stream water in Alberta, Canada and have found acridine orange direct counts (AODC) of bacteria in saturated zone groundwater are about one log higher than the AODC of stream
water in their study location. The hydrological drought has been defined by Yevjevich (1967) as the climate that leads to spatial and temporal water deficits.

Hem (1985) has pointed that some mineral surfaces that are exposed to water at neutral pH, have a net positive charge, where solute anions are retained. Ibanez et al (2007) have defined groundwater as water that occupies voids and spaces between soil, sand and/ or gravel particles, clay, silt and rocks. They have also pointed out that groundwater is present within cracks in the bedrock and can be found under the earth’s surface, either flowing slowly as underground lakes or ponds. Surface water is understood as that which is contained in streams, rivers, ponds, lakes, swamps, marshes and springs. According to Ibanez et al. (2007), in small streams and rivers, the biological processes do not influence the water composition significantly because the rapid flow will dilute the effect whereas in large, slow moving rivers, the biological processes have enough time to alter the water composition through biodegradation and excretion processes. Surface water is open to pollution of all kinds. Contaminants are contributed to lakes and rivers from diverse and intermittent sources such as industries and municipal wastes, runoff from urban and agricultural areas and erosion of soil (Henry and Heinke, 2004).

A number of studies have been carried out on major and small rivers like Amazon (Konhauser et al, 1994), Congo (Dupre et al, 1996), Mississippi (Shiller and Boyle, 1987) and Fraser (Cameron et al, 1995) for metals and trace elements. These studies have made an attempt to determine the effects of lithology, relief, water discharge, climate and anthropogenic perturbations on the water chemistry. Several studies have been employed for analysis or the closely related Principal Component Analysis (PCA). Many of these studies have been spatially oriented, such as the identification of weathering sources of dissolved species at different locations (Reeder et al, 1972; Puckett and Bricker, 1992) and the sources of ions in deposition across a region (Hooper and Peters, 1989). Reid et al (1981) identified processes controlling the chemical composition of both precipitation and runoff for a stream in Northeast Scotland, and Williams et al (1983) performed the similar study for a stream on Dart moor, England.
Since the discovery of chloroform in chlorinated drinking waters in 1974, the potential carcinogenicity of halogenated disinfection byproducts (DBPs) is now recognized as a secondary health risk (Rook, 1974). Richardson et al (2002) and Weinberg (2002) have recognized over 500 DBPs with adverse human health risk potential. Arbuckle et al (2002) have grouped these species into several major groups such as trihalomethanes, haloaceticacids, haloaceticnitriles, chloral hydrate, hydroxyfuranone, haloketones, haloaldehydes etc.

A lot of works have been done on the fluoride content in drinking water. Robertson (1984) has studied on the basins of Arizona and has reported concentration of fluoride between 1 and 10 mg/l in groundwater of the area. Granites and volcanic rocks are the common natural sources of fluoride in groundwater in several parts of the world (Apambire et al, 1997). Saether et al (1995) and Kim and Jeong (2005) have concluded in their study that the high concentration of fluoride in groundwater is not always derived from hard rock. Chae et al (2007) have focused on fluorine geochemistry in bedrock groundwater of South Korea and have come to the conclusion that the geological source of fluoride in groundwater is related to the mineral composition of metamorphic rocks and granitoids. They have suggested that the high fluoride in groundwater originates from geological sources and it can be removed by fluorite precipitation when Calcium concentration is maintained. Some researchers have studied the relationship between fluoride concentration and water-rock interaction in various aquifers with different geological settings (Nordstrom and Jenne, 1977; Edmunds et al, 1984; Nordstrom et al, 1989; Gaciri and Davies, 1993). Fluoride concentrations frequently are proportional to the degree of water-rock interaction because fluoride primarily originates from the geology (Gizaw, 1996; Banks et al, 1995; Dowgiallo, 2000; Frengstad et al, 2001; Carrillo- Rivera et al, 2002). It is also reported that fluoride in groundwater is negatively related to anthropogenic contaminants that may infiltrate from the land surface (Petti and Backman, 1995; Kim and Jeong, 2005).

The geochemical study of water and sediments of some of the largest rivers of the world originating from Himalaya have been investigated by many workers (Raymahashay, 1973; Abbas and Subramanian, 1984; Sarin et al, 1989,1990,1992;
Subramanian, 1979; Pande et al., 1994; Haris et al, 1998 and Pande et al, 2000). Rao et al (2007) have worked on principal component analysis in groundwater quality in a developing urban area of Andhra Pradesh and have reported that groundwater of Guntur urban area shows both the fresh (TDS<1000 mg/l) and brackish (TDS>1000mg/l) environments with Na\(^+\): HCO\(_3\)\(^-\) & Na\(^+\): Cl\(^-\) faces respectively. They have also suggested that the quality of groundwater is mainly controlled by salinity and pollution processes. According to Choubisa et al (1996), prolonged use of alkaline drinking waters contaminated with fluoride cause dental and skeletal fluorosis not only in villagers but also in their domestic animals. Nayak and Sawant (1996) have reported that the heavy metal content in drinking water of Mumbai city is within the maximum permissible limits yet there has to be a routine monitoring system to ascertain good quality water at the consumer end points. Pandian and Sankar (2007) have worked on hydrogeochemistry and groundwater quality of Vaippar river basin of Tamil Nadu and have reported limited seasonal variations in quality. They have found that nearly 50 percent pre-monsoon samples are suitable for all uses, while 24 percent are useful only for irrigation; the remaining 26 percent is unsuitable for any use. Sahu and Vaishnav (2006) in their study of fluoride in groundwater around the BALCO, Korba area have concluded that fluoride ion concentrations in open wells and hand pumps of some villages have been found above the permissible limit. They also witnessed skeletal and dental fluorosis in youths under twenty years of age. Madhnure et al (2008) and Saxena and Ahmed (2003) have shown that rock-water interaction is the main process in which F\(^-\)-rich minerals are decomposed or dissociated from the source rock and F\(^-\) is dissolved in groundwater by dissolution. Ramakrishnan (1998) has observed that high concentration of fluoride in deeper aquifers compared to shallow aquifers is due to its high residence time in the aquifer system, thereby having longer contact time for dissolution of F\(^-\)-bearing minerals present.

According to Sivasankaran et al (2004), the inputs of nitrogenous nutrients and phosphorus in the groundwater system are primarily due to leaching from the fertilizers applied to croplands. Majumdar and Gupta (2000) have reported that nitrate formed by the biochemical activities by micro-organisms or added in chemically synthesized forms to lithosphere and biosphere enters
hydrosphere with relative ease, as all these environmental components are
dynamically interconnected. They have further observed that nitrate concentration
in groundwater is increasing with increasing use of nitrogenous fertilizers in Indian
agriculture. Umar and Absar (2007) have tried to understand the sources of
dissolved ions and evaluate the influence of anthropogenic activities.

Venugopal et al (2009) have suggested that rivers play a major role in assimilating
or carrying of industrial and municipal waste water, run-off from agricultural
fields, roadways and streets, which are responsible for river pollution. Tiwari et al
(2005) have assessed the water quality of Ganga River in Bihar region of India.
The report suggests that water analyzed from four major drainages of River Ganga
in Patna shows that the drain water is highly polluted mainly due to raw sewage is
being discharged into the outfall drains. The analyses show that TDS, lead,
chromium and cadmium are present more than permissible limits in drinking water
at some stations. The TDS pick up in the domestic sewage in Indian cities is
generally 400 mg/l (Arceivala, 1998).

The amount of calcium and magnesium in Kolleru lake water of
Andhra Pradesh has been found to be higher in summer and decreases in monsoon
and winter. The values of electrical conductivity (EC) and total dissolved solids
(TDS) have also been found to be lower in winter and monsoon seasons as
compared to summer season (Rao et al, 1999). Handa et al (1981) have worked on
the trace elements of surface waters in Uttar Pradesh and have observed that
Gomati river water is polluted at Lucknow in respect of copper and zinc while Sai
River seems to be polluted with respect to molybdenum.

The Damodar Valley Corporation has propagated industries of multiple
natures along the river Damodar, as a result, various types of pollutants are
regularly discharged in this river (Trivedi and Kulkarni, 1988). Chakraborty and
Konar (2002) have noted that the pH of river Damodar is generally alkaline in
nature. Murugesan et al (2007) have pointed out that human activities near the
aquatic systems greatly affect the physico-chemical and biological quality of the
water-system. Ram and Singh (2007) have studied the Ganga water quality at
Patna and have found that there is no harmful chemical contamination in it.
Despite the fact, that toxic metals have also been found below detection limits, however, the presence of higher population of microbial fauna indicates that the water is contaminated and is not suitable for organized bathing as well as for drinking purposes without conventional treatment.

Jeelani and Shah (2007) have reported that like other Himalayan lakes, Dal lake of Kashmir is alkaline in nature, dominated by Ca$^{2+}$, Mg$^{2+}$ and HCO$_3^-$ ions. The geochemical characteristics of the lake water are mostly influenced by the lithology of the basin and weathering of carbonate and silicate rocks and Karewa deposits of the catchment area. Sunitha et al (2005) identified that the electrical conductivity finds higher level correlation significance with many of the water quality parameters, such as total dissolved solids, total alkalinity, chlorides, sulphates, carbonates, total hardness and magnesium. Mahajan et al (2005) identified that all the parameters are more or less correlated with others in the correlation and regression study of the physico-chemical parameters of groundwater. Kalyanaraman (2005) identified that the water of groundwater can be predicted with sufficient accuracy just by the measurement of EC alone which provides a means for easier and faster monitoring of water quality in a location. Achuthan et al (2005) concluded that the correlation study and correlation coefficient values can help in selecting treatments to minimize contaminations in groundwater. Yadav et al (2007) studied on recharging of bore wells and analyzed harvested rooftop rainwater in houses of Udaipur city of Rajasthan. They concluded that rooftop rainwater harvesting system is very effective measure in increasing the quantity of water in bore wells. Dutta et al (2006) have carried out an investigation to find out the sub surface water quality at Makrana, Rajasthan. They have concluded that marble ash and slurry has its impact on the quality of groundwater, water of tube wells and hand pumps of Makrana city shows higher concentration of total dissolved solids, total hardness, total alkalinity, calcium, magnesium, chloride, nitrate and phosphate.

Singh and Lawrence (2007) have studied the groundwater quality of shallow aquifer of Chennai city using GIS. They are of the opinion that higher TDS and Cl/ HCO$_3^-$ ratio is indicative of the fact that the sea water has intruded to a considerable area adjoining the coast due to over exploitation of groundwater. The tsunami
brought large scale sea water inundation and created significant variations in the marine environment and considerable variations were observed in all the parameters (Prasath et al, 2007). Devi et al (2006) have made an attempt to classify the hydrochemical characteristics of groundwater in Kodagu district in Karnataka based on Handa, Schoeller and Stuyfzand methods and have found that the groundwater of this district is suitable for domestic as well as agricultural purposes. Sunitha and Reddy (2006) studied the correlation of physico-chemical parameters of groundwater samples with nitrate concentration and observed that 92 percent of the samples during pre-monsoon season and 88 percent of the samples during post-monsoon season were exceeding the permissible limit of nitrate concentration which might be due to excessive use of nitrogenous fertilizers in the region. Ozha et al (1993) observed that the concentration of nitrate increased with total hardness, calcium and magnesium and decreased as the depth of water table increased. Nitrate enters the human body through the use of groundwater for drinking and causes a number of health disorders namely, methemoglobinemia, gastric cancer, goiter, birth malformations, hypertension etc. when present in higher concentration (Majumdar and Gupta, 2000).

Hussain et al (2006) have worked on major ion and heavy metal chemistry of Pachin River (Itanagar) and have reported that the main chemical weathering mechanisms identified in the small watershed can be generalized for the whole Pachin river basin. Heavy metal patterns clearly reflect source input from agricultural activity and urban development. The levels of iron and cobalt are amongst the highest of any rivers of the Indian sub-continent. Chakraborty et al (2000) have analyzed water samples of Assam and reported the highest amount of fluoride to be 20.6 ppm. The highest amount of fluoride content in water samples of Guwahati is 6.8 ppm and it can be attributed to Precambrian granite which forms the basement rock of the city (Das et al, 2003). Sarmah et al (2002) have found fluoride content higher than permissible limit in Assam. The tube well water is of Na\(^+\)-HCO\(_3\)\(^-\) type with a small shift towards Ca\(^{2+}\)-HCO\(_3\)\(^-\) field in pre-monsoon period. Dug well water shifts from Na\(^+\)-Ca\(^{2+}\)-HCO\(_3\)\(^-\) field in pre-monsoon to Ca\(^{2+}\)-HCO\(_3\)\(^-\) fields in monsoon and post-monsoon, indicating a different source of recharge water for both deep and shallow aquifers (Saji, 2007).
A: Tuikhur Kawnpu, Aizawl Road

B: Tuikhur Diakkawn, Kolasib

C: Tuikhur Kolasib- Silchar Road
A: Tuikhur Kawnpuisouth

B: Tuikhur Kolasib Venglai Convent Road

C: Tuikhur Silchar Road
A: Tuikhur Kolasib- Diakkawn Field

B: Tuikhur Bilkawthlir

C: Tuikhur Police Station, Kawnpui
Rain Water Harvesting in Mizoram