CHAPTER – 2

REVIEW OF LITERATURE
Hydrochemical studies are concerned with the chemical nature of ground water, which can be interpreted, to identify processes in both past and present periods, that are responsible for the evolution of ground water bodies. There is a considerable progress in the application of hydrochemistry in hydrogeological investigations during the last decade. The hydro-chemical parameters such as physical, chemical and bacteriological characteristics of water, determine its usefulness for domestic, agricultural and industrial activities. It can also be used to interpret rate of ground water flow, flow direction and aquifer boundary conditions.

Chemical analysis of water has been routine, for more than a century. However, the successful correlation of water chemistry with hydrologic and geologic environments, is a more recent development. Lersch of Germany in 1864 and Hunt of Canada made early studies of water chemistry in 1865 as reported by Davis and De Weist (1966). The hydro-geochemical work of Clarke in North America, between 1910 and 1925 highlighted the chemical analysis with geochemical interpretations (Davis and De Weist, 1966).

Subramanium et.al., (1971) have carried out geological and geophysical investigations in Pondicherry region, to understand the geology and structure of the region, pertaining to groundwater. Zoetman (1985) of National Institute for public Health and Environmental protection of Netherland while working on the problems of soil, has described the details of contaminants in ground water systems. The increased anthropogenic activities, urbanization, industrialization etc., were the prominent sources for causing pollution in underground water by various chemicals produced due to the activities mentioned above. For this purpose, a better insight, into the
possible affect of soil contamination on the soil ecosystem and on the public health has to be developed in conjunction with the methods, to predict the transport and behavior of ground water contaminants. Many symposia papers were discussed in detail, the analytical aspects of detecting contaminants in ground water and their behavior in the soil as well as their effect on soil ecology and health. Finally, indications for future research needs are delineated. The work of Zoeteman (1985) highlights the types and quantities of contaminants, which may be inorganic or organic and pathogenic organisms polluting ground water systems.

Migration of ionic substances and contamination of ground water and use of ion activity in the geochemical classification of water has been discussed in detail by Mathess (1982) and Hem (1985).

Native and Smith (1987) have conducted geochemical studies of the Ogallal aquifer, south high plains of Texas and New Mexico. The study revealed that the geochemistry of aquifer is controlled by surface topography of the underlying formations, the thickness and permeability of alluvial deposits. The geochemistry of ground water is largely is a function of mineral composition of aquifer, through which the water flows. Thus, differences in aquifer compositions are reflected as differences in the ground water chemistry (Rogers, 1989). Native and Smith (1987) have also expressed that the ground water being affected by contamination by evaporating saline lakes, agricultural chemicals, fertilizers and oilfield brines.

Studies conducted on the chemical ground water quality of Mangalore City in Karnataka (India) by Narayana and Suresh (1989) also indicated that ground water quality deteriorates due to urbanization, industrialization and anthropogenic activities.
Therefore, ground water is a vital source of water supply for domestic, agricultural and industrial purposes. Even though there are two sources of water namely, surface and ground, which seem to be independent of each other but are definitely interrelated and use of one may effect the water available from other source of recharge for ground water quality by Ramesh et.al., (1995) of Chennai, Tamilnadu (India) indicated that ground water quality has been deteriorated due to over exploitation, anthropogenic activities and improper management of natural resources. These lead to the unequal distribution of major and trace elements in nature (Ramesh et.al., 1995).

Baruni (1995) conducted a study in Tripoli, Libya, and noted that over exploitation of ground water of the Miocene- Quaternary aquifer to meet the Tripoli water supplies, invited the problem of chemical contamination and thereby the TDS content has increased to about 10,000 ppm.

Studies on the quality water supplied by the municipality of Kakinada and ground water of Kakinada Town was studied by Kaza Somasekhara Rao et.al., (1994). They reported that physico-chemical characters of ground water are suitable for drinking & domestic purpose. But the ground water contains less amount of fluoride. Therefore, the people use fluoride-containing toothpaste. However, studies on the quality of bore water of Nazvid studied by Rambabu et.al., (1996), revealed that the water quality was good for drinking purpose but the water was very hard.

Tripathy and Panigrahy (1998) have carried out chemical analysis for salts, in ground water samples, in and around the salt pan, situated on the adjacent part of Chilka Lake in Orissa (India). The study showed that the ground water has been polluted due to increase in the salt concentration, which flows through the soil by
percolation and reaches the aquifers from the surrounding salt pan regions. Adhikari *et al.*, (1997) of West Bengal (India), have studied the raw sewage effluent discharge from Dhapa chemical plant, with respect to its long-term effect on application on the composition of ground water. The study revealed the effect of raw sewage fed in this area has little impact on the chemical composition of ground water. Janardhana Raju *et al.*, (1998) have also conducted study on chemical quality and ecological aspects of ground water in Nandyal taluk of Andra Pradesh. The investigation made indicated that the chemical quality is characterized by high salinity with non-carbonate alkalinity.

Further, Davina V. Gonsalves and Joe D'Souza (1999) have conducted a study on the ground water in Goa city in order to assess the impact of tourism industry on the quality of ground water with respect to physico-chemical and microbial parameters. Shubha Srivastava *et al.*, (1997) investigated the status of water pollution in and around Hazaribagh town ship in south Bihar region. The analytical work was made during the pre and post-monsoon seasons. The report obtained during the study revealed the presence of high levels of hardness, iron and biological oxygen demand content than the standard limits of drinking water. Therefore, the treatment of water prior to use for domestic purpose from the pollution control point of view was suggested.

Dubey *et al.*, (1997) conducted a pilot study on the ground water quality, in core zone of Malanpur industrial complex near Gwalior of Madhya Pradesh (India) in order to ascertain the current status of ground water quality in the industrial region. The study indicated that, the values obtained for various chemical parameters for
drinking purposes were satisfactory, as per standards except sodium, turbidity and microbial quantity since they have exceeded the standard limits. As the study has reported on ground water quality in an adjoining industrial area, the data generated would help in assessing the impact of industrialization on the environment, through regular monitoring process in the future.

Babar and Kaplay (1999) carried out analysis on ground water quality around Pingalgad Nala in Parbhani district of Maharashtra (India), in order to predict the quality of water for domestic needs. The analytical report obtained indicated that the problem of health in urban and rural areas needs detailed chemical analysis of water of the wells located near streams, rivers, nalas where drainage outlets are made. The preventive measures are necessary to save the people from the danger of health hazards in these areas.

The chemistry of ground water in Sangamner area of Maharashtra (India) was carried out by Deshmukh and Pawar (1999), with regard to determination of the suitability of water for domestic and irrigation purposes. The analytical data obtained, showed that the quality of ground water in irrigated land region was unsatisfactory. However, the quality of ground water from non-irrigated land (area with out drainage), was fit for domestic as well as agricultural purposes.

Raymahashay (1999) of civil engineering Dept, IIT Kanpur has emphasized the need for geochemical approach and for the evolution of ground water quality, to predict the major and minor elemental pollutants that percolates into the ground water reservoirs and their interactions with soil water and rock water. These interactions start with the desolutions of atmospheric gasses in the rain water and continue with
carbonate and silicate mineral equilibrium, redox reactions, ion exchange and adsorption process. Surface active colloids and organic matters present in the aquifer, play an important role in attenuation of pollutants. In conclusion, the author has stressed the relevance of geological expertise in protection and monitoring of our environment.

A case study on ground water pollution due to improper treatment and disposal arrangement by Maharastra distilleries was conducted by Biradar et al., (1999). They have arrived at the conclusion that, among the various physico-chemical parameters analyzed, few parameters namely DO, Alkalinity, BOD were affected by percolation of distillery effluent stored in Katcha lagoon and thereby the water quality was made unsuitable for drinking, domestic and irrigation purposes.

Krishna Rao, et al., (1999) have carried out analytical work on the influence of tank irrigation on ground water quality in the Vizianagaram district of Andrapradesh. The results obtained revealed that, the ground waters quality deteriorates due to leaching of agro-chemicals in ayacut area by registering very high concentrations of salinity, sodium, potassium and sulfates.

Chandrashekar et al., (2000) have succeeded in assessing the ground water pollution potential, through remote sensing and GIS techniques for Anekal taluk of Bangalore urban district of Karnataka. The main objective of remote sensing technique used was to protect ground water quality from every activity of the society, which causes pollution and to determine ground water pollution potential.

Joseph (2001) conducted detailed investigation on ground water chemistry in the valley De Yabucoa alluvial aquifer South Eastern Puerto Rico of U.S.A.
valley is surrounded by the hills of Son Lorenz Batholith on three sides and by Caribbean Sea on the fourth side. The study area has tropical marine climate and the valley is the major source of water for public and industrial supplies in the area. The water samples collected from public supplies, industrial, abandoned wells and observation wells were analyzed for important physico-chemical parameters as well as metal nutrients like ferrous and manganese constituents. The investigation revealed that the aquifer system in the valley De Yabucoa region indicated high level of iron and manganese concentration, as high as 28 and 36 ppm respectively. The investigator predicted from the report that, the longest contributor of ferrous iron to the ground water, appears to be an iron oxide phase. Illuminite is probably the sole significant source of manganese. In addition to iron and manganese, the ground water in the aquifer locally contains high total dissolved solids (TDS) content that exceeds the drinking water standard. The high concentrations of TDS have caused some water supply wells to be taken out of service. Further, the author identified high levels of calcium, magnesium and bicarbonate. As water moves through the aquifer and approaches the ocean, it becomes rich in sodium, potassium and chloride.

Physico-chemical characteristics of ground water in eastern part of Hissar city was studied by Garg et.al. (2000) and they reported that almost all the parameters were beyond WHO permissible limit. However, Dasgupta (2000) carried out work on physicochemical parameters of Rajgangpur municipal area & he concentrated on the water quality index & correlation co-efficient and he reported that all waters are suitable for drinking purpose except pond water.
Among the major nutrients, nitrogen, phosphorous and potassium application through agricultural activities caused high level nitrate contamination in altering the quality of ground water (Meisinger, 1976). Higher level nitrate concentration have been reported in dug wells and shallow tube wells, penetrating the alluvial aquifers of the Indo-Gangetic plain, which is intensively cropped and irrigated area (Handa, 1983). Study by Cain et.al., (1989) depicts that the frequencies of detection of volatile organic compounds and some trace elements, which were larger in ground water underlying urban or industrial areas in comparison to undeveloped areas.

The relationship between infant methaemoglobinaemia disease and nitrate content in drinking water in Germany was first published by Schoceller (1962) and then by Kolaja et.al., (1986). Also, a cancer risk in human cannot be excluded (Sander et.al., 1981). Health risks can also arise when high nitrate contents are combined with pesticides (Kolaja et.al., 1986).

Lakshmanan et.al., (1986), have made an investigation on drinking waters of twin cities of Hyderabad and Secunderabad with respect to nitrate and fluoride levels, in dug and tube wells. Along with these, pH, TDS and chloride were detected, in order to correlate the nitrate and fluoride levels. The analytical report revealed that the mean nitrate concentration of 118.7 ppm and 35.3 ppm were observed in the dug wells and tube wells respectively, about 50 % of wells, fluoride levels are above 1.0 ppm and nitrate content in about 58 % of the wells exceeds 45 ppm.

The leaching of nitrogen fertilizers through agricultural soils and the impact on ground water quality is of great concern (Scalon, 1990). For example, the leaching of nitrogen fertilizers pollutes the ground water and represents a considerable waste of
valuable plant nutrients to the farmer. An indiscriminate use of nitrogen fertilizers leads to increase levels of nitrate concentration in ground water and food chain (April et.al., 1992). While primary effects of nitrate on human are very trifling, secondary effects of the metabolism of nitrate to nitrite imposes considerable risk. Nitrite blocks haemoglobin in the red blood cells and inhibits oxygen transport (Lal et.al., 1983). Adverse health effects (gastric cancer, birth defects, cardio vascular diseases, effects on the thyroid gland) will result as a consequence of long term consumption of water with high nitrate content (Ramachandran et.al., 1991)

Nitrate (NO$_3$-N) status of ground water in tribal belt of Satpura valley was studied by Nemode et.al., (1997). They concluded that, in the industrial area the nitrate concentration is very high, compared to WHO Standards. So the grovindwater is not suitable for drinking purpose.

Phosphate is slightly soluble and strongly adsorbed in most of the soil systems (Linsley, 1992). Generally, it does not infiltrate except under abnormal circumstances. High Phosphate concentrations in subsurface water under cropland were observed in Florida (Lawrence and Upchurch, 1982), Nebraska (Exner and Spalding, 1979; Alkinson 1984) Long Island,, Arkansas (Wagner et.al., 1976) and England (Edmonds et.al., 1987). The concentration of Phosphate –Phosphorous in contaminated ground water generally ranged from 0.05 ppm to 0.17 ppm depending on specific sites.

Contradictory to phosphate, potassium is highly soluble, but absorbed by negatively charged colloids in soils and geologic systems. As with phosphorous, appearance of potassium in ground water is not normally expected. Wagner et.al., (1976) associated potassium and sodium concentrations observed in shallow wells of
a limestone formation in Arkansas with fertilizer and biological waste contamination. Exner and Spalding (1979) noted a very high concentration of potassium, reaching the ground water. Edmonds *et al.*, (1973) showed that the phosphate and nitrate are enriched in recent waters and depleted in the oldest. However, the potassium patterns were reversed, increasing in concentration with increasing ground water age.

It is interesting to note that, the results of Madhu and Smith (1995) from Potan and Bhaktapur (Urban areas) and agricultural villages of Nepal, indicated that the concentration of nitrate is higher in urban areas than in the agricultural regions. But, Shivasankaran (1997) have expressed that the anthropogenic and agricultural activities are the main causes for worldwide increase in the concentration of nitrate and phosphate in ground waters of the study area. It is further noted that, the guideline values are not set for phosphate and potassium.

Dubey *et al.*, (1999) made a pilot survey and carried out physico-chemical and bacteriological analysis so as to ascertain the status of ground water quality in Malanpur industrial complex zone near Gwalior of Madya Pradesh. The study reports that along with the major physico-chemical parameters, is also involves phosphate and microbial parameters. Further, it was reported that the investigation was made for three seasons of the year viz. pre, rainy and post-monsoon seasons. The phosphate concentration in an appreciable quantity was noticed in rainy and post-monsoon seasons. However, zero concentration was reported in pre-monsoon season.

Fluoride is considered as a mineral-nutrient. The farmers in Andhra Pradesh state, first detected fluorosis in India among the cattle, during early 1930’s. Among the Indian Union states, a high level of fluoride of 5.2 ppm in Medak district of
Andhra Pradesh (Srikanth et. al., 1994), 15 ppm in Nawabganj block of Uttar Pradesh (Mukherjee et. al., 1995) and 18 ppm in Jaipur of Rajasthan (Agarwal et. al., 1991) has been reported as against its critical limit of 1.5 ppm in drinking water (BIS 1991). The fluoride levels mentioned above by various regions pose serious health hazards to humans and irreversible damage to plants. High profile of Fluoride in shallow zone ground water is due to geochemical disposition in the vicinity of ground water extraction structures. High ambient temperature, alkalinity, calcium and magnesium contents in the drinking water, influences toxicity of fluoride (Singh et. al., 1993)

Das et. al., (1998) of Central ground water board, Bhubaneswar (Orissa) have conducted hydro-geological investigations on the source of high fluoride concentration in ground water around Anugal, Dhenkenal district, in order to evaluate the sources of high fluoride content. The study area was surrounded by a number of industrial sectors namely NALCO (National Aluminum Company) Smelter, NALCO power plant, Talcher thermal power stations and Fertilizer corporation of India. These industries discharge significant load of effluent wastes even though suitably treated, there were reports of high fluoride content in the ground water of the area. As high fluoride content in drinking water causes health hazards, a study was under taken to evaluate water quality, occurrence and distribution of fluoride in ground water as well as the possible sources for high fluoride in the above mentioned study area. The study revealed the occurrence of high fluoride in pockets scattered all over the area without any pattern. Although the water in the NALCO disposal pond and other industrial discharge contains high fluoride, the fluoride content of ground water in the vicinity of study area was well within the permissible limits.
Garg *et al.*, (1998) of Guru Jambeshwar University, Hisar (Haryana) have carried out analytical work for the fluoride content of underground drinking water along with other major physico-chemical parameters. The report obtained indicates that underground water in the study locality has been found to be hard having high fluoride concentration than permissible limit at many places. Attempts were also made to correlate the fluoride content with various physico-chemical parameters and correlation matrix (*Garg et al.*, 1997) so emerged was also discussed. Fluoride content was found to be positively correlated with calcium content but with very low degree of validity. This observation was supported by Somani *et al.*, (1972) but not in agreement to that reported by Guptha *et al.*, (1984).

High profile of fluoride in ground water has been observed in 4.6 % of geographical area in Karnataka (*Sumalatha, et al.*, 1999). Sporadic incidence of high fluoride content in ground water has been reported from India, China, Srilanka, West Indies, Spain, Holland, Italy, Mexico, North and South American Countries. In India, its occurrence in top aquifer system is endemic to many places in Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Rajasthan, Punjab, Haryana, Bihar and Kerala (*Sumalatha and Ambica, 1999*).

Recently, Pushpa Bharathi and Meera Rao (2000) have made investigation pertaining to fluoride content of ground water and its diets on adults from fluorotic villages in Mandaragi taluk of Gadag district. Further, they focussed on the content of fluoride in ground water diets of adults from six fluorotic villages and one non-fluorotic village of Mandaragi taluk of the study area. The report indicated that a maximum of 13.5 ppm fluoride in the fluorotic villages and a minimum of 0.8 ppm
from non fluorotic village. They have also conducted a study on preventive measures of fluorotic villages in Mandaragi taluk of Gadag district in order to get information on the existing measures for prevention of fluorosis through personnel interview. Even though some practicing methods such as consumption of milk, green leaf vegetable, use of plastic and soil pots for storage of eatables the authors failed to remove excess fluoride from drinking waters in the study locality. Pushpa Bharathi et.al., (2000) suggested a chemical treatment for defluoridation for using alum as a defluoridator at domestic level. The experiment conducted revealed that, alum at a concentration of 2.5 ppm for the contact of 18 hours reduces the fluoride to permissible limit of 1.5 ppm.

**Heavy metal distribution**

Investigations on heavy metals in ground water system have been carried out by many investigators including those of Burkitt et.al., (1972) and Satyanarayana et.al., (1992). High level of Iron and zinc portions may be because of the rock unit and soil nature of the area. The dumping of the solid waste in the open landfill in low-lying areas creates a major source of ground water pollution through leaching process of materials. Generally, among the trace metals, iron and zinc were detected in considerable quantities. The heavy metals chelated with organic compounds and invisibly greater redox potentials might be aided in easy transportation of the heavy metals (Warrin et.al., 1971; Rao and Shantaram, 1995).

The behaviour of trace elements in ground water is complicated because it is related to source of ground water (rain, river and seawater). Further, it is also related to many bio-geochemical processes that control macro chemical and trace elemental
conditions (Edmonds, 1973; Edmonds et.al., 1982; Drevir, 1988 and Stuyfzand, 1992).

Iron in surface water is generally present in ferric state. Concentrations of ferric greater than 1 ppm have been reported in ground waters (Dart, 1974). The average daily requirement of iron is considered to be 10 mg. Manganese plays a key role in the proper functioning of flavoproteins and in the synthesis of sulfated mucopolysaccharides, cholesterol haemoglobin and in many other metabolic processes (National research Council, (NRC) 1973). Copper in public water supplies enhances corrosion of aluminum and zinc utensils and fittings even when concentration in water exceeds 1 ppm. The concentration of zinc in ground water is usually higher than that in the surface water owing to the leaching of zinc containing particles. Many nickel salts are water soluble and therefore contamination of ground water can take place. The levels of nickel generally found in food and water are considered to be a serious health hazard (Underwood, 1997). Because of low solubility of chromium the levels found in water are usually low. The concentration of lead in fresh water is generally lower than water source since lead is partially removed by conventional water treatment process. The levels of lead in drinking water, however can be much higher, owing to the use of lead services, pipes and lead lined storage tanks (NRC, 1977). The sources for accumulation of cadmium in drinking water are fishes (Kataria, 1995) hence generally cadmium is not found in ground waters. It has been particularly prevalent among children in slum areas. (Patri and Pande, 1987; Sharma et.al., 1998; Singh et.al., 1994; Sawanth et.al., 2000 and Mohan et.al., 1998).
Mercury is rather a scarce element in the earth’s crust but its industrial use is wide spread and it is easily found in the aquatic environment around most of the big cities. All forms of mercury are not equally toxic and in nature, they change their form, due to different kinds of reactions. Methyl mercury is worst toxic form, which is soluble in nature. The ‘minimata’ disease was found to be due to the consumption of fishes containing methyl mercury (Sawant et.al., 2000).

Hexavalent form of Chromium (Cr$^{6+}$) is more toxic than trivalent (Cr$^{3+}$) form. The Cr$^{6+}$ causes bronchial cancer in humans (Adrino, 1986). The maximum permissible limit of chromium in drinking water as recommended by WHO and ISI is 0.05 ppm.

Trace metals are added to aquifer systems, both from natural and man made sources. Soluble materials chemically weathered from soil and rock due to geochemical alterations may contribute them. Trace metals, which are selectively concentrated by vegetation, find their way to surface and ground waters following decay, runoff and infiltration. Industrial sources especially those devoted to mining, alloying, cleaning and plating of metals also add significant amount of trace metals to aquatic systems. Municipal sewage also adds trace metals to surface and ground waters (Robards et.al., 1994).

Stuyfzand (1992) published a general study made on the concentration ranges, and possible mobilization process in many ground water types. Shivakumar and Biksham (1995) have reported that elements such as copper, arsenic, selenium iron and lead are present in ground waters of Patenchoru village in Medak district of Andhra Pradesh. About 5 to 10 times more than permissible limits due to the
increased industrial growth and inefficient waste management have also been found. On critical examination of the data of ground water analysis in Madras city by Ramesh et.al., (1995) indicated that, the major and trace metal concentration in ground water have increased several folds. Further, it has denoted that the polluted overlying water influences the quality of ground water.

The recent study on pollution on heavy metals in Mehadrigedda stream of Vishakapatnam in Andhra Pradesh was conducted by Rao et.al., (1998) to monitor the levels of zinc, lead and cadmium from the local stream in order to assess the impact of urbanization and industrialization. The industries located around this study area include various industries located on the bank of the stream. The industrial wastes containing toxic chemicals were released into the natural bodies caused severe water pollution (Dagan, 1972). Therefore, much attention had been focussed on heavy metals, as they cause environmental pollution since the occurrence of ‘itai-itai’ caused by cadmium poisoning and ‘minamata’ disease caused by methyl mercury poisoning.

Further, Mohaputra and Singh (1999) of Utkal University of Orissa have said that, the trace metals such as iron, manganese, copper, zinc, cobalt and nickel are very important for the proper functioning of biological system. Sushil Tiwari (2001) has expressed that study of dissolved iron in some ground water samples have indicated some undesirable effects, if present beyond the prescribed standards. Excessive concentration of iron (ICMR, 1975 and Rao et.al., 1998) causes astringent taste, discoloration, turbidity, sedimentation and growth of iron bacteria. High concentration of iron also strains cloth, Joseph (2001).
Some of the research works similar to the present investigation undertaken in the state include the following:

- Studies on the quality of ground water in Mangalore city (Narayan and Suresh, 1989).
- Sub surface water quality in and around Mysore city (Ansari and Ramesh, 1989).
- Ground water quality in Hubli city, Karnataka University (Chandankeri, 1989).
- Studies on ground water quality of Bangalore rural areas of Anekal, Bangalore University (Chandrashekar et al., 2000).
- Drinking water quality in Mandaragi Taluk of Gadag district, Gulbarga University (Pushpa Bharathi, 2000).
- Studies on the impact of environmental pollution on ground water quality in and around Davanagere (Basavarajappa, 2001).

Some of the research works similar to the present investigation undertaken in other state include the following:

- Studies on ground water quality in and around Jaipur city (Sharma, 1998).
- Studies on ground water quality of Madras City (Ramesh and Purvaja, 1995)
- Studies on ground water quality of twin cities of Hyderabad and Secundarabad in Andra Pradesh (Rao, 1995 and Lakshmanan et al., 1996)
- Studies on ground water quality of Hazaribagh township of Bihar (Shubha, 1997).
- Studies on ground water quality of Pondicherry region (Shivasankaran, 1997).
- Studies on ground water quality of Goa city (Devina et al., 1999)
- Studies on ground water quality of Pingalgad nala in Prabhabhani district in Maharastra (Babar et al., 1999).

- Studies on ground water quality of Haryana and Punjab (Garg et al., 1998 and Anubha Kaushik, 2000)