Chapter 1

Introduction
Chapter - 1

Introduction

Water is a commodity which man has exploited than any other resource for the sustenance of his life. Most of the water on this planet is stored in oceans and ice caps which is difficult to be recovered. The quantity of utilizable water is limited on the earth. The unique properties of water makes it an universal solvent (Singh et al., 1988). It is a prime natural resource and a precious national asset. It is a basic human need and forms the very basis for existence of an ecosystem (Tiwari, 2000). Next to air, water is the important constituent of life support system.

It is estimated that humans use 54% accessible fresh water contained in rivers, lakes and under ground aquifers and by 2025, this will increase to 70%, This estimate reflects on the impact of population on the dwindling water resources.

Water is the general solvent in living beings. It is the most important natural resource for all economic activities ranging from agriculture to industry. We depend on water for irrigation, industry, domestic needs, shipping and disposal of wastes. These days there is a severe stress on water resources due to the exponential increase in human population. Availability of water plays a key role in the evolution of earth’s ecosystem, moderating climate and diluting pollutants. It is essential for the photosynthesis of green plants which produce food energy used by various living systems at all trophic levels.

Water is distributed in nature in different forms. The vapors in the clouds condense and precipitate in the form of either dew, rain, snow or hail on the earth.
A large part of the precipitation takes place on the oceans themselves, while the remaining precipitation is on land masses. Atmospheric water and temperature directly influence the global ecology, hydrological cycle, weather, global climate, fauna and flora.

**Distribution of water on the earth**

Water on the earth occurs in all its forms viz., liquid, solid and vapour. The world’s total quantity of water is estimated to be about $1.36 \times 10^8$ million hectare meters. About 97.2% of this water is contained in the oceans as salt water and only about 2.8% is available as fresh water on the earth. Out of the 2.8% of fresh water, around 2.2% is available as surface water and the rest (0.6%) is available as ground water. Out of the 2.2% of available fresh water, around 2.15% is in glaciers and ice caps. Out of the remaining 0.05% of fresh water, 0.01% is available in lakes and streams and the remaining 0.04% is in the other forms. In the 0.6% of stored ground water, only about 0.25% can be extracted economically with the available drilling technology and the remaining is at greater depth of the earth’s crust.

**Ground water**

Ground water volume is more than that of all fresh water lakes and streams combined. Underground water plays an important role in the overall balance of the environment. As a reservoir it has an enormous capacity to store water in rainy season which can be utilized during dry periods.

The quality of ground water depends on the quality of soil through which it percolates. Most of the bacteria, organic compounds and bioacids are filtered out during percolation (Beck, 1985).
Ground water is a primary source of fresh water in several towns and rural areas. The existing utilization of ground water in India is currently estimated at 45,000 million m$^3$. It is widely used as a source of water for irrigation and for other farm uses. The contribution of ground water to irrigation is about 40% in India.

Generally, ground water is clear and harder than the surface water of that region. The quality of ground water is uniform and it has less pathogenic bacteria than surface water. Many large public water supply systems use substantial amount of surface water, while smaller public systems and domestic systems are more dependent on ground water.

Because, ground water supplies are recharged by atmospheric precipitation, problems may result. If the amount withdrawn from the ground is greater than that which is replenished by rain fall, water table may go down substantially by over pumping at the particular point sources. Over pumping will lead to the flow of seawater into sub aquifers near the coastal areas. Recharge by forcing fresh water may provide some remedy to this. Ground water pollution is difficult to detect and it is more difficult to control and may persist for a long period of time (Singh *et al.*, 2001).

**Hydrological cycle**

“Hydrology” is the science which deals with the occurrence, distribution and circulation of water on the earth and atmosphere. Hydrology is a branch of earth science concerned with the water in the atmosphere (moisture), precipitation (rainfall and snow fall), lakes and streams, snow and ice on the land and water occurring below the earth surface i.e. ground water.
Hydrological cycle is the continuous transfer of water which occurs in the nature. The three important phases of the hydrological cycle are 1) Evaporation and evapotranspiration, 2) Precipitation and 3) Runoff.

A schematic representation of the hydrological cycle is shown (Fig-1). The planet earth has one third land and two thirds of ocean. Evaporation from the surface of ocean, lakes, ponds, reservoir, etc and vapor-transpiration from the surface vegetation (plants) takes place. The water vapor moves upwards and forms clouds. While much of the clouds condense and fall back to ocean and earth in the form of precipitation of different forms like rain, snow, mist, hail, sleet etc., a part of the precipitation may evaporate back to the atmosphere during precipitation.

A part of the precipitation flows over the ground surface called runoff and a part infiltrates in the soil and joins the ground water table. The surface runoff and a part of the ground water flows to the ocean. Again the evaporation starts from the lakes, ocean, ponds etc. and the cycle continues. Among the three phases of hydrological cycle, the runoff phase is important because it is the directly available fresh surface water for the purpose of water supply, irrigation, power generation, etc. This surface runoff can be stored in dams and reservoirs for the non-rainy season.

Water must be free from organisms and chemical constituents that may be hazardous to human health. With increase in consumption of water, not only there is an increasing concern for rapidly deteriorating supply of water, but the quality of water is also fast diminishing.
The causes of such a situation may be many, but gross pollution of water has origin mainly in urbanization, industrialization, agriculture and increase in human population (Goel, 2006).

Ground water quality

Ground water quality comprises the physical, chemical and biological qualities of groundwater. Temperature, turbidity, color, taste and odor make up the list of physical water quality parameters, since most ground water is colorless, odorless and without specific taste.

Naturally, the ground water contains mineral ions. These ions slowly dissolve from soil particles, sediments and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer. They are referred to as dissolved solids. Some dissolved solids may have originated in the precipitation water or river water that recharges the aquifer.
Ground water in the rocks such as limestone and dolomite which contains significant amount of highly soluble minerals has higher dissolved solid content than ground water in rocks such as granite and basalt which contains relatively few soluble minerals (Karanth, 1989). Ground water in an area usually has higher dissolved solid content than surface water due to long contact time with minerals surface and relatively low dissolved oxygen content (Lingmoorthi, 1995).

Ground water quality is influenced by both subsurface physical environment and by the environment where recharge takes place. The quality of ground water supply is as important as the quantity; the required quantity being dependent on geological conditions and also soil pattern. Water that is suitable for irrigation of crops, may not be suitable for human consumption or industrial use.

In brief, the quality of irrigation water should be compatible with the nature of the soil and type of the crop raised thereon. Quality criteria of water for drinking and domestic use have been prescribed by various authorities like WHO, ISI, ICMR, etc. (Rajni Kant and Keshav Kant, 2010).

Water resources of India

The quantity of water available in all forms constitutes $1.36 \times 10^{18} \text{ m}^3$ (360 billion gallons). The surface flow in our country occurs through 14 major river systems namely Ganga, Indus, Brahmaputra, Cauvery, Brahmani, Godavari, Krishna, Narmada, Periyar, Mahanadi, Mahi, Tapti, Subarnarekha and Sabarmati. These river basins account for 83% of the drainage basin and 85% of the surface flow. 80% of the population live in these basins. Apart from these rivers, there are 44 medium and 95 minor river systems.
Perennial rivers of North India receive sufficient quantity of flow throughout the year, since they receive the snow melt runoff in summer. Rivers of south India (peninsular India) receive runoff only due to rainfall and have a good flow only during the monsoon. Many of them may have negligible flow or even dry up during the remaining part of the year.

**Water resources of Karnataka**

Karnataka accounts for about 6% of the country’s surface water resources of 17 M ha-m. About 40% of this is available in the east flowing rivers and the remaining from west flowing rivers. There are seven river basins with which their tributaries drain the surface runoff of the state. The river systems include: Krishna, Cauvery, Godavari, West flowing rivers, North Pennar, South Pennar and Palar.

**Ground water source**

Ground water is contained in aquifers. An aquifer is a highly permeable layer of sediment or rock containing water. Layers of sand and gravel are good aquifers, while the clay and crystalline rocks are not good aquifers.

An aquifer is a layer of soil or rock in which ground water can move relatively freely. Porous sand and gravel aquifers yield more water than do more impermeable silt or clay deposits. Rock formations may contain enough cracks or fissures to yield significant quantities of water. Aquifers are distinguished on the basis of physical conditions under which water can exist in them: the unconfined aquifer and the confined aquifer.
Unconfined Aquifer

Unconfined aquifer is commonly called as water-table aquifer. In this type, upper surface of water or the water-table is under atmospheric pressure which may be acting through interstices in overlying rocks (Fig-2). Water occurring in the unconfined aquifer is called free ground water. When tapped through test well, the free water will rise to level in the well equivalent to the water table of the area. Water table is the zone of saturation or free ground water.

The depth to the water table varies according to factors such as the topography, geology, season, tidal effects and quantity of water being pumped from the aquifer.

Confined Aquifer

Confined aquifer (Artesian type) is a rock formation saturated with water and capable of yielding water when tapped, but unlike unconfined aquifer (Fig-2) has an overlying confining impermeable rock mass, that separates it from the influence of atmospheric pressure. Naturally, water held in this type of aquifer is not under atmospheric pressure, but under a great pressure due to the confined medium. The upper surface of the water in a confined aquifer is called piezometric surface confined aquifer may be replenished or recharged by rain or stream water infiltrating in the rock at some considerable distance away from the confined aquifer. Ground water in these aquifers can sometimes be thousands of years old.
Over use of ground water

Over use of ground water has ill effects like lowering of water table, ground water subsidence and logging. Lowering of ground water table is due to excess use of ground water for drinking, irrigation and domestic purposes which has resulted in rapid depletion of ground water in various regions leading to drying of wells.

Ground water depletion and contamination

The quality of ground water is getting affected and chances of contamination are more by industrial waste and agriculture runoff through infiltration or percolation (Rudresha et al., 2010). The extent of ground water pollution depends on rain fall pattern, depth of water table, distance from the source of contamination and soil properties such as permeability (Mohan Kumar et al., 2010).

Several organics occurring as water contaminants have been found to be highly toxic to aquatic life as well as to human beings. Water contaminants of this category include polychlorinated biphenyls, detergents, plastics, domestic, agricultural and
industrial waste discharges and pathogenic pollutants like bacteria, viruses and protozoa (Aloka and Debi, 2009).

There are areas in our country where ground water with fluoride beyond the permissible limit of 1.5 mg/l commonly exist. Though fluoride is found in many areas, its concentration is highest in the arid and semiarid regions of western India (Rao, 1979).

Ground water of some high rainfall areas is polluted naturally by excessive iron. This problem has often been observed in the ground water of Assam, West Bengal, Orissa and Kerala. Iron in toxic amounts as high as 20 ppm exists in the deep wells as ferrous iron and on taking out, immediately converts into light yellow orange color on oxidation and precipitates as ferric hydroxide.

Nitrate is one of the common pollutants of ground water. Use of commercial fertilizer is one of the source of nitrate pollution. Nitrate also occurs in substantial quantities in sewage and industrial wastes. All organic materials convert into nitrates by biological oxidation by a process called nitrification. Nitrate can easily be seeped into the soil due to its poor capacity to remain absorbed with the soil particles.

Arsenic contamination of ground water is also of concern in India. It has affected vast stretches of the state of West Bengal with nearly 13.8 million people at risk.

**Composition of ground water**

Ground water contains large amount of dissolved salts of various composition. This is due to the fact that during its downward movement it reacts with many minerals present in the earth's strata. The presence of these minerals in variable quantity limits its, use to drinking, agriculture, domestic and industrial purpose.
Ground water is composed of many inorganic and organic constituents. Compared to inorganic constituents; organic constituents are less in ground water. A fundamental property of aqueous solution is that that they are electrically neutral. So, total number of equivalents for the positive constituents must be equal to the total number of equivalents of negative constituents. A cation–anion balance will never give 100% accuracy because it is virtually impossible to analyze every single ion in the water.

The dissolved constituents are responsible for the composition of water. The most abundant cations in the ground water include calcium (Ca\(^{2+}\)), magnesium (Mg\(^{2+}\)), sodium (Na\(^+\)), potassium (K\(^+\)), iron (Fe\(^{2+}\) or Fe\(^{3+}\)) and hydrogen ion (H\(^+\)). The most abundant anions include carbonates (CO\(_3\)^{2-}\)), bicarbonates (HCO\(_3\)^{-}\)), nitrate (NO\(_3^{-}\)), sulfate (SO\(_4^{2-}\)), chlorides (Cl\(^{-}\)) and fluoride (F\(^{-}\)). Acid rain from atmospheric precipitation entering ground water lowers pH (pH 5.6), gives rise to acidic water and reduces some metals like iron from ferric (Fe\(^{3+}\)) to ferrous (Fe\(^{2+}\)) forms. The chemical composition for certain water is according to what type of rocks it was in contact with.

Analysis of ground water quality is an important factor in establishing the criteria and also for identifying the level of chemical, physical, biological and radiological constituents in ground water. However, the ground water chemistry is controlled by composition of its hydrologic variation within the aquifers (Stuytzand, 1989).

Water quality

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, fresh water (river and lakes) and ground water environment, across coastal and inland areas. Water has two
dimensions that are closely linked—quantity and quality. Water quality is commonly defined by its physical, chemical, biological and aesthetic characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Water quality in a body of water depends upon the way in which communities use the water for activities such as drinking, swimming or commercial purpose.

**Water quality Tests**

The quality of water has been classified by certain characteristics:

**Physical characteristics**

Physical characteristics relate to the quality of water for drinking and domestic purpose. Color, turbidity, pH, electrical conductivity, TDS, temperature, taste and odor are the important physical parameters.

**Chemical characteristics**

Many organic and inorganic chemicals affect the water quality. Chemical characteristics are due to the presence of dissolved gases, salts and other chemical constituents in water. Water quality varies depending on the nature and content of these constituents.

**Biological characteristics**

Microscopic plants and animals are also important in assessing the quality of water, particularly drinking water. The main focus is on a group of organisms called *coliforms* which is perhaps the most important in assessing water contamination.
Sources of ground water pollution

Ground water is usually of excellent quality. This is primarily because of natural infiltration that occurs in the layer of the soil through which water flows. Rain water flows over the surface of the earth to form lakes and ponds and a good amount of water slowly percolates into the ground layer. Ground water collects more minerals and salts. Pesticides and fertilizers from the agriculture fields, domestic and industrial waste water may join any water course. All these may pollute both surface and ground water.

Water borne diseases

Majority of diseases are directly related to poor quality of drinking water and insanitary conditions. Water borne diseases are due to the presence of pathogens and some chemical substances in water.

The first group called as the water related infections include some of the greatest cause of diseases and death in developing countries including India. The spread of major infections and parasitic diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis and guinea worm infections are due to poor drinking water quality.

The second category includes diseases such as gastro intestinal irritation as a result of TDS, methaemoglobinemia i.e., blue born baby disease as a result of high nitrate, bone fluorosis, mottle teeth due to high fluoride, decrease in haemoglobin due to high arsenic and bacteria causing odor, bad taste and undesirable color in water due to excess of iron.
World Health Organization at a regional meeting at Delhi in November 1979 called for protected water supply covering 100% of population and effective sanitation covering 80% of urban and 50% of the rural population.

A critical perusal of the available literature shows that, there was no systematic and scientific study made on the ground water quality of Tiptur town and its surrounding villages even though the residents depend on ground water for drinking purpose. Hence, immediate focus is required on the status of ground water in Tiptur town and its surrounding areas. The present investigation was carried out for a period of two years (2009-2011).