INTRODUCTION

Globally one of the greatest challenges of the twenty first century is to provide an adequate quantity of good quality water for domestic consumption for every living organism including human beings. As the water demand is continuously increasing along with expanding human population and their developments in the various fields. The development of human society is one of the major reasons for deteriorating the available water resource of the planet earth. The water resources which are unequally distributed over the earth’s surface, specifically the good quality fresh water is present on the earth’s surface is available as polar ice caps and in the form of surface water resource such as lakes, rivers, ponds etc and underground water resource.

Although India occupies 2.4% of the world’s land area, i.e. only 3.29 million km$^2$ geographical area, it supports over 15% of the world’s population. The population of India as on 1 March 2001 stood at 1,027,015,247 persons. Thus, India supports about 1/6$^{th}$ of world population, 1/50$^{th}$ of world’s land and 1/25$^{th}$ of world’s water resources. India also has a livestock population of 500 million, which is about 20% of the world’s total livestock population. More than half of these are cattle, whereas, agriculture is the backbone of Indian economy. The total utilizable water resources of the country are assessed as 1086 km$^3$.

To meet the proportional demand of uncontrolled and continuously up growing human population for food and production of raw material, there has intensified pressure on natural resources such as water resources, minerals, forest resources (Smil, 1999).
Along with surface water as one of the source for water supply, the groundwater also plays an important role in the process of human development. About 1 billion people are directly dependent upon the groundwater resource from Asia for domestic use (Foster, 1995). It is estimated that approximately one third of the world’s population uses groundwater for drinking purposes (UNEP, 1999).

In recent years, due to change in monsoon in many parts of India especially in the arid and semi-arid regions, the problem of surface water scarcity becomes a serious problem and which is major reasons for over exploitation of groundwater from India. In the view of international perspective of <1,700 m$^3$/person per year as water stressed and <1,000 m$^3$/person per year as water scarce, India is water stressed today and is likely to be water scarce by 2050 (Gupta and Deshpande, 2004). It is predicted that the number of people living in water-scarce countries will increase from about 131 million to more than 800 million by 2020 (Gardner-Outlaw and Engelmann 1997). However, in developing countries many of the groundwater exploitation schemes are designed without due attention to quality issues.

During last few decades several organizations and individuals have estimated water availability for the nation. Recently, as per the survey of National Commission for Integrated Water Resources Development (NCIWRD) the basin-wise average annual flow in Indian River systems is 1953 km$^3$. Various authorities has assessed the quantity of utilizable water resource, with considering the limitations of physiographic conditions and socio-political environment, legal and constitutional constraints and the technology of development available
at present. The utilizable annual surface water of the country is about 690 km$^3$. It is stated that there is considerable scope for increasing the utilization of water in the river basins by construction of storages at suitable locations or by recharging the underground resources in the country.

According to Rakesh Kumar et al., (2005), the annual potential natural groundwater recharge from rainfall in India is about 342.43 km$^3$, which is 8.56% of total annual rainfall of the country. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46 km$^3$. Thus, total replenishable groundwater resource of the country is assessed as 431.89%. After allotting 15% of this quantity for drinking, and 6 km$^3$ for industrial purposes, the remaining can be utilized for irrigation purposes. Thus, the available groundwater resource for irrigation is 361 km$^3$, of which utilizable quantity (90%) is 325 km$^3$. The basin wise per capita water availability varies between 13,393 m$^3$ per annum for the Brahmaputra–Barak basin to about 300 m$^3$ per annum for the Sabarmati basin.

Agriculture is playing an important role in Indian economy. To increase agricultural production, the development of irrigation facilities for making the country self-sustained as food supply is concerned and for poverty alleviation has been of crucial importance for the planners and decision makers. Accordingly, the irrigation sector was assigned a very high priority in the 5-year plans. Giant schemes like the Bhakra Nangal, Hirakud, Damodar Valley, Nagarjunasagar, Rajasthan Canal project, etc. were taken up to increase irrigation potential and maximize agricultural production. Long-term planning has to account for the growth of population.
According to National Water Policy, the production of food grains has increased from around 50 million tones in the 1950 to about 203 million tones in the year 1999–2000. A number of individuals and agencies have estimated the likely population of India by the year 2025 and 2050. According to the estimates adopted by NCIWRD, by the year 2025, the population is expected to be 1333 million in high-growth scenario and 1286 million in low growth scenario. For the year 2050, high rate of population growth is likely to result in about 1581 million people while the low growth projections place the number at nearly 1346 million (Rakesh Kumar et al., 2005) Keeping in view the level of consumption, losses in storage and transport, seed requirement, and buffer stock, the projected food-grain and feed demand for 2025 would be 320 million tones (high-demand scenario) and 308 million tones (low-demand scenario). The requirement of food grains for the year 2050 would be 494 million tones (high-demand scenario) and 420 million tones (low demand scenario). The availability of water in India shows wide spatial and temporal variations. Also, there are very large inter annual variations. Hence, the general situation of availability of per capita availability is much more alarming than what is depicted by the average figures.

Along with other basic needs such as food, cloth and shelter, the water supply is a very vital factor for community growth and development. About 7 km$^3$ of surface water and 18 km$^3$ of groundwater are being used for community water supply in urban and rural areas. Rapidly increasing urbanization and increase in population are responsible for the requirement of higher rate water supply. As the higher rate of economic growth the higher would be the urbanization.
It is expected that nearly 61% of the population will be living in urban areas by the year 2050 in high-growth scenario as against 48% in low growth scenario (Rakesh Kumar et al., 2005).

Different norms have been laid by several organizations and individuals for water supply in cities and rural areas. The figure adopted by the National Commission on Integrated Water Resources Development (NCIWRD) was 220 liters per capita per day (lpcd) for class I cities. For the cities other than class I, the norms are 165 for the year 2025 and 220 lpcd for the year 2050. For rural areas, 70 lpcd and 150 lpcd have been recommended for the years 2025 and 2050. Based on these norms and projection of population, it is estimated that by 2050, water requirements per year for domestic use will be 90 km$^3$ for low demand scenario and 111 km$^3$ for high demand scenario. It is expected that about 70% of urban water requirement and 30% of rural water requirement will be met by surface water sources and the remaining from groundwater resource.

During 1950-51 the irrigated area in the country was only 22.6 million hectare (Mha). Due to much more attention was paid for expansion of agriculture the food production was much below the requirement of the country. The ultimate irrigation potential of India has been estimated as 140 Mha. Out of this, 76 Mha would come from surface water and 64 Mha from groundwater sources. The quantum of water used for irrigation by the last century was of the order of 300 km$^3$ of surface water and 128 km$^3$ of groundwater, total 428 km$^3$. The estimates indicate that by the year 2025, the water requirement for irrigation would be 561 km$^3$ for low-demand scenario and 611 km$^3$ for high-demand scenario. These requirements are likely to further
increase to 628 km\(^3\) for low-demand scenario and 807 km\(^3\) for high-demand scenario by 2050.

With the continuously increasing human population as well as rapid development in all sectors of economy in the country, the utilization of water from various resources has also been increasing at a rapid pace. In 1951, the actual utilization of surface water was about 20% and 10% in the case of underground water. The utilizable water in river basins is highly uneven. For example in the Brahmaputra basin, which contributes 629 billion m\(^3\) of surface water of the country’s total flow, only 24 billion m\(^3\) is utilizable.

Today the world’s population continues to grow annually by 77 million. The projected 1.1 billion increase in global population, from 6.1 billion in 2000 to 7.2 billion in 2015 will be in developing countries, which now account for four-fifths of the global population. Whereas, the world’s population is expected to reach 7.9 billion by 2025 and 9.3 billion in 2050 (United Nations, 2001).

Population growth rates are particularly high in the least developed countries estimated at 2.4 percent annually in the period 2000-2015, while in the developed countries this figure is estimated to be just 1.1 percent of course, global figures conceal major differences in growth rates between regions and countries. Global population is also becoming more urban, with the proportion of the world’s population living in urban areas projected to raise from 47 percent in 2000 to 53 percent in 2015; this trend being especially pronounced in the developing countries (United Nations, 2002a).

The increase in population may lead the negative impacts on the natural environment and specifically on water. Even so, in many
regions the problem of water scarcity and declining quality affect poor the most (IFAD, 2001).

The combination of rural poverty, population pressures and dwindling water supplies may lead to migration of rural population to urban area, as well as cross border movements. Rapid urbanization often leads to establishment of slums where there are serious problems such as water supply, sanitation and industrial waste (Hunter, 2001). The urbanization process may responsible for the increased consumption patterns in urban areas which may divert water from rural areas. Thus, the migration of population is also having significant effect on the water consumption patterns (Global Science Panel, 2002).

In recent decades, from developed countries the provision of water management infrastructure and services has commonly been provided by private sector specialists, with funding from international development organizations. Unfortunately, these services have often proved costly and ineffective in the long-term, driven by a supply-side, top-down approach, and led by outside experts unfamiliar with local needs and conditions. The outcome has often been a huge burden borne by the developing countries concerned without the realization of most of the economic, social and human health benefits from the investment. (INWEH, 2001).

Increase in the urban sprawl and residential development may lead to drawing off increasing quantities of water, reducing water recharge which may lead to the problem of shortage of water. Irrigation is one the important factor in the process of increasing agricultural productivity, as it allows for multiple cropping and the use of high yielding modern crop varieties while reducing risk of drought.
The main role of water basically linked with food as a basic human need but also essential as a resource with a major role in production as well as consumption is evident in any systematic appraisal of life-sustaining requirements. It was observed that with the adequate supplies of safe drinking water and better sanitation facilities, the incidence of some illness and deaths could be reduced by as much as 75 per cent (United Nations, 2002b).

Due to the frequent failures and uneven spatial and temporal distribution of rainfall in addition to the lack of sufficient surface water management technologies, the rapid developmental activities of the society are totally depending on groundwater resource. This situation is not only making more demand for groundwater but also polluting the available water resources due to improper releasing of the effluents into the natural aquatic ecosystems. This is the cause for the acute pressure of suitable quality of water for various needs of the society.

To maintain the water quality status and avoid the deterioration, the development of monitoring programs of aquatic ecosystems plays a significant role, so that the water can still be used for consumption and recreation (Feijoo et al., 1999).

Water is one of the earth’s natural resource and three quarters of the earth’s surface is covered by it (Pipkin, 1974). Fresh water plays a vital role in human development process and essential for the sustenance of life on earth as exemplified by its diversified uses (drinking, cooking, washing, irrigation, etc). The consequence of urbanization and industrialization leads to pollute the water. The maximum ground water is explored for agricultural purposes in rural areas especially in those areas where the surface water resources such
as dams, ponds, lakes, river or a canal are not available with sufficient quantity of water.

Groundwater is almost globally important for human consumption. Naturally it is of excellent quality, being naturally filtered in their passage through the ground therefore; it is usually clear, colorless, and free from microbial contamination and requires minimal treatment. Unfortunately, one can not consider it is a source of good quality water for a longer period, because humans developmental activities are deteriorating the underground water quality at a rapid rate. A threat is now posed by an ever-increasing number of soluble chemicals from urban and industrial activities and from modern agricultural practices, which contaminates the underground water resource.

The quality of groundwater is play a vital role in deciding the consumption pattern. The specific use of groundwater is depends on its quality. Therefore with considering the quality of water, it is important to monitor the water quality of resource for the better human health.

The deteriorating water quality of groundwater reflects inputs from the atmosphere, from soil and water-rock reactions (weathering), as well as from pollutant sources such as mining, leachate formation, agriculture, acid precipitation, domestic and industrial wastes.

The transport of contaminants from the point of application to the groundwater system is a function of the properties of the soil-rock strata above the aquifer and the type of pollutant (Melloul and Collin, 1994). Accordingly, the assessment of degree of vulnerability of groundwater has originated. Basically vulnerability is the property of the aquifer to receive and transmit contamination from anthropogenic
activities (Vrba and Zoporozec, 1994). There are several problems associated with aquifer vulnerability assessment due to lack of adequate baseline information and the key factors responsible for this such as soil media (Robins et al., 2002), uncertainty regarding net recharge (Rosen, 1994) and hydraulic conductivity estimates (Aller et al., 1987), lack of knowledge concerning the physical and chemical properties and attenuation processes of pollutants (Barber et al., 1993) which require all vulnerability estimates to be validated by accurate field testing.

In recent years, an increasing threat to ground water quality due to human activities has become of great importance. The man's activity at ground, surface, unintentionally by agriculture, domestic and industrial effluents, unexpectedly by sub-surface or surface disposal of sewage and industrial wastes is responsible for the adverse effects on ground water quality.

In determining the suitability of ground water for a certain use (public water supply for domestic use, irrigation, industrial applications, etc.) the study of quality of ground water is of great importance. The quality of ground water varies from place to place, with the depth of water table, and from season to season and is primarily governed by the extent and composition of dissolved solids present in it.

In general the ground water quality problems are difficult to detect and hard to solve. The solutions are usually very expensive, time consuming and not always effective. To monitor and assess the impact of contaminants on groundwater and ultimately on the users, it
is important to know the geochemistry of the chemical-soil-groundwater interactions.

In urban areas due to lack of collection and disposal system for waste generated from residential area in the form of solid and liquid waste, they are disposed directly in populated areas of the city from which it either it leached or percolate in groundwater, making water unfit for direct consumption.

The overexploitation of natural resources as raw material for the production purpose in industrial units may responsible for the generation of heaps of waste and these waste is being dumped in vicinity of factory which is subjected to reaction with percolating rain water and reaches the ground water level. The percolating water picks up a large amount of dissolved constituents and reaches the aquifer system and contaminates the ground water. During recent years the contamination of ground water by metals, heavy metals and pesticides has also considered as the major source of underground water pollution which may have toxic properties.

Mostly the drinking water supplies tend to rely on ground water resources (hand pump or tube wells etc). There is possibility of contamination of underground water resource by addition of undesirable substances from human activities. Consumption of drinking water from contaminated water sources has responsible for the various health impacts such as cancer, kidney problems, effects on central nerves system and cardiovascular diseases etc. (Fauci et al., 1998). The occurrence of harmful chemical contaminants particularly cadmium, nitrate-nitrogen, sulphate, and bacterial contaminants in drinking water sources may responsible for the diarrheal illnesses
(Fauci et al., 1998; Gupta et al., 2001). The linkage of impacts of environmental changes on health was studied by epidemiological studies.

The damage to health associated with the level of exposure of individual to the pollutants Ostro et al., (1998); Tiwari (1997), and De Motta and Mendes (1993) reported that the waterborne disease are caused due to the water pollution. The problem of water pollution contributes about 70–80% of the human health problems in most developing countries (Chabala and Mamo, 2001). The drinking water contaminated with faecal pathogens is mainly responsible for 2.5 million deaths annually of children due to diarrhoea (Kosek et al., 2003).

The main sources of nitrates in groundwater from nitrogenous fertilizers, animal wastes, municipal wastewater, landfill, septic tanks, urban runoff and soil organic matter etc. The excess use of nitrogenous fertilizers plays a vital role in the groundwater contamination. The frequency of water-related diseases is quite high in rural areas where scarcity and lack of water treatment facilities further increase the human health problems and this phenomenon becomes a severe in developing countries.

The higher concentration of nitrate in drinking water may responsible for the ‘methaemoglobinaemia,’ a cyanosis that is brought about by the reduction of nitrate to nitrite by bacteria in the digestive tract, followed by absorption of nitrite in the blood stream (Wolterink et al., 1979). The nitrite oxidizes the ferrous iron in hemoglobin to ferric iron, thereby preventing the transport of oxygen by the hemoglobin, which eventually results in a gradual suffocation.
The occurrence of higher concentration of fluoride in ground water and surface water in many parts of the world is causing the harmful impacts on human health. The main source of fluoride in ground water is fluoride-bearing rocks such as fluorspar, fluorite, cryolite, fluorapatite and Hydroxylapatite. Along with the water, food, industrial exposure, drugs, cosmetics, etc., are the main entry roots for the fluoride uptake but drinking water is the major source. Due to its strong electro negativity, fluoride is attracted to positively charged calcium in teeth and bones. Major health problems caused by fluoride are dental fluorosis, teeth mottling, skeletal fluorosis and deformation of bones in children as well as adults.

The reasons responsible for the conversion of water related diseases to epidemic proportion are depending on climate, geography, cultural habits, hygiene, quantity and quality of available water, and excreta disposal etc.

Chlorides are widely distributed in nature as salts of sodium, potassium and calcium. Chloride concentration in excess of about 250 mg/L can give rise to detectable taste in water. Sodium and potassium are the important cations occurring in nature. The major source of sodium and potassium in the natural water is the weathering of rocks. Higher concentration of sodium can results to cardiovascular diseases and in women toxemia associated with pregnancy (Trivedi and Goel, 1984).

The drinking underground water contaminated with heavy metals viz. Pb, Cd, Cr, As, Hg, Zn etc. are responsible for a large number of mortalities and is recognized as highly toxic and dangerous pollutants. Due to its bioaccumulation property, heavy metals are
accumulated in vital organs of living organisms progressively to the toxic level (Hoo et al., 2004).

Heavy metals are mobile in environment and accumulate in flora and fauna (Berggren, 1992; Edwards et. al, 1992; Eriksson, 1989, 1990a; Leita and De Nobili, 1991; Severson et. al, 1992; Obbard and Jones, 1993). The metal and heavy metals have history of occupational hazards and some of them have been linked to cancer and cardiovascular diseases (Kumaresan and Riyazuddin, 1999). Lead has recently received much attention as a major chemical pollutant in the environment (Zou et al., 2004).

Although the Copper and Zinc are essential micronutrients for humans nourishment, but are also reported as toxicants when present in higher quantities and responsible for the health hazards. Accumulation of copper in liver leads to Cirrhosis; in brain it leads to deaths of neurons resulting neurological symptoms; and in kidney leads to renal tubular damage (Matta et al., 1999). An excess of copper can cause oily skin, loss of skin tone, hair loss and hypertension. The higher concentration of Zn may lead to toxic effects. It may leads to undesirable taste to the water and also causes water to appear milky.

According to Koller (1980) the anthropogenic activities such as extensive use of pesticides which contains the concentration of lead in natural waters may responsible for the health hazards. It accumulates in the body mainly in the bones. It may cause anemia and disruption of hemoglobin synthesis, damage to nervous system and kidneys, brain damage (lead encephalopathy). It may results in delay in physical and mental development in infants and children.
The major efforts has being taken to deliver the safe, piped, community water to the world’s population over the past two decades, but due to several reasons that such supplies will not be available to all people for the foreseeable future (Mintz et al., 2001).

Water is an essential ingredient for the survival of living organism. Being a scare resource, it’s availability in our environment is limited and because of developmental activities it’s quality and quantity is declining at the alarming rate. Water as a renewable resource it’s quantity on the earth crust in the form of surface water resource is recharge by hydrological cycle.

Ground water is limited natural water resource which plays a vital role in meeting the fresh water demand of human population for various purposes. Generally the quality of ground water is considered to be superior as compared to surface water resource, as soil column purifies the contaminated water by different processes such as anaerobic decomposition, filtration, ion-exchange etc during percolation in earth crust. However over exploitation of this vital resource may leads lowering of water table. The quality of underground water resource may detioriate if recharged artificially by contaminated water or by disposing industrial effluents in it. Generally through rainfall underground water is being recharged frequently.

The groundwater level in the earth crust generally depends on physio-graphic and topographic feature of land and rainfall of that region. The rainfall activity in the region principally makes the resource available to the human society. The rainfall activities are associated with the different dependant factors such as topography and
vegetation cover of the region. Rainfall activities during monsoon make the surface water available to use to man.

Ground water, a gift of nature which generally recharged through infiltration or seepage from surface water resource. Mostly the underground water resources are used directly, because of its good quality. The underground water resources are used for irrigation, industrial activity and domestic use by man. There are some uses which require specific quality of water, in such condition assessment of quality of underground water is inherent. Ground water is valuable resource when its quality is suitable for the specific use.

The acceptability of underground water for a particular use is essentially governed by the standards of acceptable or permissible limit of different parameter adopted by institutions such as Indian Standard Institute (ISI) and World Health Organization (WHO). Today underground water resource is under the great pressure; because of it’s over exploitation, which has reduced water table drastically making water scares to human population. The disposal of sewage, industrial effluent on the earth crust or under the earth crust are responsible for the contamination of underground water resources which make water unfit for human use. Ultimately which may create a severe shortage of good quality water resource to man. Hence the assessment of underground water quality is an important aspect in the ground water investigation. Many times dissolved toxic contaminant form the earth crust may responsible for various kinds of health hazards in human society for eg.dissolved arsenic and heavy metals in ground water are responsible for different health hazards as reported by WHO. Overall
the quality of underground water is of vital concern to the mankind as it has direct link with human health and surrounding environment. Therefore problem related to groundwater pollution have attracted the attention of scientist, engineers and planers and are investigating the source and evaluating the gravity of groundwater pollution before use.

India is one of the developing countries where development in various field is being taken up at rapid rate. Most of the developmental activities are principally associated with the availability of good quality and sufficient quantity of water resource. In India most of the surface water resources are extensively used for irrigation, power generation, industrial activities and domestic purposes. The underground resources are also extensively exploited for irrigation, industrial activity and for domestic use and drinking purposes. Mostly rural part of India depends on underground water resource for the diverse use ranges from irrigation to drinking.

In Maharashtra underground water is extensively use for irrigation, domestic use and for industrial activities. Mostly in rural area underground water resources are used for irrigation and domestic purpose where as in urban areas it is being used for domestic and industrial activities.

Aurangabad is rapidly expanding metropolitan city from Marathawada region of Maharashtra. Good numbers of industries are established in the industrial areas near Aurangabad city. The water supply to the city and industrial area is from Nathsagar dam of Paithan. Because of rapid industrialization, the urbanization has been geared up at a rapid rate in last two decade and residential area is increasing day
by day. Many of the people depend on underground water resource for their domestic water need and even too the industrial water need. The sewage and industrial effluent from residential and industrial areas respectively may responsible for contamination of underground water resource. At present detailed quality of underground water resource was not studied extensively, the incidences of disease and epidemic out break related to the water are frequently observed in the city area. Hence present work has been undertaken to monitor and asses the underground water quality of Aurangabad city. The main objectives of the present works were:

- Survey of underground water resources – The wells and bore wells from Aurangabad city were surveyed for the selection of representative sampling sites and 30 sampling sites were selected for monitoring of underground water quality for deciding its potability. Along with the physico-chemical parameters, metals and heavy metal study, the microbial parameter i.e. Most Probable Number (MPN) of E.coli was also monitored.

- The water quality index of underground water resources of Aurangabad city were determined to decide its specific use. The water quality index of underground water resource is being helpful for deciding its quality as well as potability.

Customarily, the potability of water is being assessed through the study of physicochemical and microbiological parameter study. For the specific quality of water resource, the physico-chemical parameter must be within a specific limit i.e., minimum and maximum
permissible limit as prescribed various agencies such as WHO, ISI, Central Pollution Control Board (CPCB), Maharashtra Pollution Control Board (MPCB) etc.

1.1 Physical Parameters:

For assessment of quality of water resources, determination of different physical parameters such as temperature, total dissolved solids and electrical conductivity is having great importance.

1.1.1 Temperature:

Temperature is one of the important physical parameter which governs the various chemical reactions in the surrounding environment as well as in the body of living organisms. The optimum temperature is required for the maximum efficiency of chemical reactions in the living organisms body and in the aquatic ecosystem. The monitoring of temperature gives an idea about the self purification of water resource. Temperature is significant factor for determining the solubility of oxygen and carbon dioxide, bicarbonate etc. The temperature affects the taste of drinking water by removing dissolved gases from it and by converting the nutrient into the other form by promoting the reactions. Increase in water temperature may leads to the acceleration of the rate of chemical reactions in water, which may reduces the solubility of gases and affect the odour and taste. In the temperate regions the temperature of water range between 7°C to 11°C and imparts pleasant taste.

The concentration of dissolved oxygen is inversely proportional to the temperature. Increasing temperatures tends to reduce the dissolved oxygen quantity by increasing the molecular motions of
water and dissolved gases, which decrease the solubility of the dissolved oxygen (Black, 1977).

1.1.2 Total Dissolved Solids:

The concentration of dissolved solids is an important parameter in drinking water and other water quality standards. Total dissolved solids give a particular taste to the water and at higher concentration it also reduces its taste. However, in case of drinking water along with the concentrations of each physical and chemical parameter is also more important. A high content of dissolve solids raise the density of water reduces solubility of gases like oxygen, influences osmoregulation of fresh water organism and reduces the convenience of water for drinking, domestic, industrial and agricultural use. The concentration of total dissolved solids of water beyond 500 mg/liter reduces potability of water and also it may cause gastrointestinal irritation.

Water, the universal solvent has a large number of salts dissolved in it which largely govern its physico-chemical characteristics and alternation in it is having the indirect effect on the organisms. In natural waters, dissolved solids are mainly contains of carbonates, bicarbonates, chlorides, sulphates, phosphates, and nitrates of calcium, magnesium, sodium, potassium, iron and manganese, etc. The concentration of dissolved solids in groundwater varies both qualitatively and quantitatively with the season, location, geological strata, rainfall leachates percolation etc. (Adoni et al., 1985).

1.1.3 Electrical Conductivity:

Conductivity is capacity of water to carry an electrical current and varies both with number and types of ion the solution contains.
Conductivity is related to concentration of ionized substances in the water. This ability depends upon presence of ions, their total concentration, mobility valence, relative concentrations and temperature measurements. In water most dissolved inorganic substances in ionized form contributes to conductivity.

Electrical conductivity or specific conductance is usually expressed as micromhos/cm. It is the reciprocal of resistance for which the standard unit is an ohm. Since, conductance is the inverse of resistance, the unit of conductance is the micromhos. Specific conductance is generally reported as micromhos per centimeter. Because the measurement is made using two electrodes placed 1 cm apart. The electrical conductivity measurement is affected by the nature of various ions, their relative concentration and the ionic strength of water where dissolved carbon dioxide, turbidity and temperature may also play an important role. Pure water is a poor conductor of electricity. In water dissolve acids, bases and salts make it relatively good conductor of electricity. Conductivity is used for quantitative measurement of ionic constituents dissolved in water which are important for cooling water and boiler feed water etc.

Temperature plays a vital role in measurement of electrical conductivity as it affects the ionic velocity of solution and thus, the specific conductance. In unpolluted water, conductance increases from 2% to 3% per degree centigrade, and generally a correction of 2.5% is usable. Since temperature is an integral part of these data, it must always be reported along with the specific conductance. For convenience, most literature values are found corrected to one standard temperature. Sanitary engineers and geochemists have long used 25°C
as a standard temperature. Conductivity is used for detection of impurities in water. There is distinct relationship between conductivity and total dissolve solids.

1.2 Chemical Parameters:

The important chemical parameters such as pH, total alkalinity, dissolved oxygen; biochemical oxygen demand (BOD), chlorides, calcium, total hardness, nitrate, sulphate, and fluoride were selected for the quality study of underground water resources.

1.2.1 pH:

The majority of waters are slightly basic i.e. the pH of water is above 7, and that is because of the presence of carbonate and bicarbonates. Being a dynamic parameter the pH of water changes continuously because of chemical reactions. The pH water is acidic during day time and it may be due to photosynthesis in producers and alkaline at night due to respiratory activity of living organisms. The pH is important in all most every environmental analytical practice such as water supply, waste water treatment, water softening and corrosion control etc. Due to low pH there is cause of corrosion, high pH causes taste. The pH of natural water usually lies in the range of 4.4 to 8.5 In drinking water pH value must be in the range of 6.5 to 8.5 (WHO, 1993).

1.2.2 Total Alkalinity:

The alkalinity of water is a measurement of its capacity to neutralize acids. The alkalinity of natural waters is due to salts of carbonates, bicarbonates, silicates and phosphates along with the hydroxyl ions in the free state. However the major portion of alkalinity in natural water is caused by hydroxide, carbonate and bicarbonates.
which may be rank in order of their association with high pH values. Alkalinity values provide guidance in applying proper doses of chemicals in water and waste water treatment process particularly in coagulation softening and operational control of anaerobic digestion. Alkalinity in itself not harmful to human beings still the water supplies with less than 100 mg/liter are desirable for domestic use in excess quantities alkalinity imparts bitter test of water. Ray et al., (2000) studied the quality of drinking water in Rohtas District of Bihar and observed the alkalinity range from 40-820 mg/L$^{-1}$ with the mean value 33.

1.2.3 Dissolved Oxygen (DO):

One of the most important water quality parameter is the amount of dissolve oxygen present in natural and waste water DO levels depend on physical chemical and biological activities in that water body. Generally oxygen is considered as poorly soluble in water. The solubility of oxygen in any water body is related to pressure and temperature. Oxygen depleting substances reduces the available dissolve oxygen. During summer months the rate of biological oxidation is highly increased, while unfortunately the DO concentration is at its due to higher temperature. Dissolve oxygen is use to evaluate the pollution strength of domestic and industrial effluents. DO measure are vital for maintaining aerobic conditions in natural waters that receive polluted matter. DO is also responsible for undesirable odour and taste because of its level decreases.

The sources for the dissolved oxygen in water bodies are oxygen balance in water bodies are input due to atmospheric diffusion, photosynthesis and decrease its quantity in water due to respiration,
decomposition and mineralization of organic matter as well as losses to atmosphere. The elevated temperature of water body may also affects the dissolved oxygen concentration which further decreases in the solubility of oxygen and intensification of biochemical oxygen demand (Cairns et. al., 1975). The decrease in values of dissolved oxygen affect the potability of water and can causes mortality in aquatic animals (Kudesia, 1985).

1.2.4 Biochemical Oxygen Demand (BOD):

Biochemical oxygen demand is defined as the amount of oxygen required by bacteria to decomposing organic material in a sample under aerobic conditions at 20°C over a period of 5 days or 27°C over 3 days. Biochemical Oxygen Demand is widely used in determining the polluted lode of waste water.

BOD test is mainly a bioassay procedure, involving measurement of O₂ consumed by bacteria while stabilizing organic matter under aerobic condition, it is consumed by bacterial while stabilizing organic matter under aerobic condition, it necessary to provided standard conditions of nutrient supply.

Kalyankar et.al., (2004) studied the groundwater characteristics of industrial zone of Aurangabad and observed minimum BOD value i.e. 0.05 mg/L. It was also observed that during Aug.’ 05 to Jun.’ 06 periods the lower BOD values were recorded, while during July’ 06 to Jun.’ 07 higher values were noticed.

1.2.5 Chlorides:
Chloride as an anion is generally present in natural water can be attributed to dissolution of salts deposits discharges of effluents from chemical industries, sewage discharges, contamination from refuse leachates. Each of these sources may result in local contamination of both surface water and ground water. The salty taste produce by chloride depends on chemical composition of water. A concentration of 250 mg/L may be detectable in some waters containing sodium ions. High chloride content also has deleterious effect on metallic pipes and structures as well as on agricultural plants.

Ekbal & Hussain (2004) assessed the drinking water of Rajasthan’s village area and reported the chloride range from 685-3560 mg/lit.

1.2.6 Calcium:

Calcium is common constituent of natural water and important contributor to the hardness of water. The concentration of calcium in water is depend on source and treatment. In number of studies death rates from cardiovascular disease are inversely related with the hardness of water but involvement of calcium is not directly proved. Subramani et al., (2005) studied the ground water quality in chithar river basin, Tamilnadu, India and reported the calcium range from 10-176 mg/l in (July 2001) and 16-880 mg/l (July 2002)

1.2.7 Total Hardness (as CaCO₃):

Hardness is defined as the concentration of multivalent metallic citations in solution. Hard water are generally considered to be those water that requires considerable amount of soap to produce a foam that also produce scale in hot water pipes, boilers and other units in which temperature of water increase. The hardness of water varies
from place to place. Generally in surface water hardness is softer than ground water. Due to high value of hardness soap consumption by hard water cause economic loss to water consumer precipitated foam by hard water adheres to surfaces of tubes, sinks etc. and it may stain clothing, dishes and other items.

Public acceptability of degree of hardness may vary considerably from community to community depending on local conditions and the associated anion the taste threshold for the magnesium is probably less than that for calcium.

The summation of calcium hardness and magnesium hardness is regarded as the total hardness of water. Mishra and Bhatt(2008)studied under ground water in V.V Nagar and near by places of Anand district, Gujarat, India, in the present investigation it has been reported that the calcium concentration is at least two folds greater than that of magnesium.

Each of the samples has registered a high value of calcium hardness (30-200 mg/L), magnesium hardness (15-120 mg/L) and in turn the total hardness (45-320 mg/L).The limiting value prescribed by ISI are much less than reported.

**1.2.8 Nitrate:**

Nitrate is the highest oxidisable form of nitrogen. availability of nitrate is in trace quantities in surface water and it attain high level in ground water nitrate is the product of aerobic decomposition of organic nitrogenous matter important sources of nitrate are domestic effluent, disposal of sewage sludge to land discharge from industries and leachates from dump depending on various conditions these
sources may contaminate rivers, lakes and ground water especially wells.

High concentration of nitrate in drinking water (> 40mg/liter) may cause Blue baby disease. Certain bacteria generally found in the intestinal tract of infants can convert nitrates to highly toxic nitrites. Nitrites have a greater affinity for hemoglobin in the blood stream than oxygen. They replace that oxygen this phenomenon is known methamoglobinemia. This resulting oxygen starvation causes bluish discoloration of newborn and known as blue baby syndrome

Satyanarayan *et al.*, (2007) studied geochemical study of ground water from a structurally deformed granitic terrain near Hyderabad, India and observed the nitrate content range from 1-20 mg/L in dug well and 3-9 mg/L in bore well.

### 1.2.9 Sulphate :

Sulphate ions are usually present in natural water. It is of important public water supplies because of its cathartic effect upon humans when present in excessive amounts many sulphate compounds are readily soluble in water most of them originate from oxidation of sulphate ores, the solution of gypsum and anhydrite, the presence of shales, particularly rich in organic compound and existence of industrial wastes. Atmospheric sulphur dioxide formed by combustion of fossil fuels may also contribute to sulphate compounds of water.

Sulphate is one of the least toxic anions however catharsis, dehydration and gastrointestinal irritation have been observed at the high concentration in drinking water and WHO therefore suggests that the health authorities should be notified when concentration of sulphate in drinking water exceeds 500 mg/L.
Ingestion of water containing high concentration of sulphate can have a laxative effect this effect is enhance when sulphate is consumed in combination with magnesium. The water containing magnesium sulphate at levels about 1000 mg/liter acts as a purgative in human adults, lower concentration may still affect new users and children. Waters with about 300 to 400 mg/L sulphate have bitter taste and with the concentration more than 1000 mg/L may cause intestinal disorders.

Singh *et al.*, (2006) studied the ground water quality in northern indo-gangetic alluvium region and observed sulphate content in the range of BDL-377.2 mg/L.

1.2.10 Fluoride:

The presence of fluoride in ground water may be attributed to the localized effects of natural sources. The fluoride is present in soil strata due to the presence of geological formations like fluorspar, fluorapatite, and amphiaboles such as hornblinde, trimolite and mica. Weathering of alkali, silicate, igneous and sedimentary rocks especially shales contribute a major portion of fluorides to ground waters. In addition to natural sources, considerable amount of fluorides may be contributed due to human activities. Fluoride salts are commonly used in steel, aluminum, bricks and tile-industries. The insecticides and herbicides which contain fluoride may contribute through agricultural runoff. The accumulation of fluoride in soil eventually results in its leaching due to percolating water, thus increase fluoride concentration in ground water (CPCB, 2008).

The excess concentration of fluoride affects bone development and leads to dental or in extreme form, skeletal fluorosis. The latter is a
painful debilitating disease that causes physical impairment (WHO, 2004b). Drinking-water is the principal route of exposure to fluoride in most settings, although burning of high fluoride coal is a significant route of exposure in parts of China (Gu et al., 1990).

High concentrations of fluoride also occur in some metamorphic and sedimentary rocks that contain significant amounts of fluoride-bearing minerals such as fluorite and apatite. Fluoride in water supply based on groundwater is a problem in a number of countries and over 70 million people worldwide are believed to be at risk of adverse health effects from consumption of water containing high levels of fluoride. The geological, chemical and physical characteristics of the aquifer, the porosity and acidity of the soil and rocks, the temperature, the action of other chemical elements, and the depth of wells may responsible for the concentration of fluoride in ground water. The aqueous ionic concentrations of ground water may influence the fluoride solubility behavior in the presence of excessive sodium bicarbonates and the dissociation activity of fluoride will be high (Tirumalesh et al., 2007).

In groundwater with a high concentration of calcium ions, fluoride concentrations rarely exceed 1 mg/L. substantially higher fluoride concentrations in groundwater are usually caused by a lack of calcium.

1.3 Metal and Heavy Metals Study:

The natural levels of heavy metals occurrence in water basically due to the weathering process of rocks during the course of evolution the organisms have adapted themselves to the background concentration of these metals. Metals cycle in the environment through
the biogeochemical cycles and are redistributed in various compartments of the ecosphere. The natural levels of these elements are usually harmless to the organisms but the pollution by way of mining activities, agricultural chemicals, industrial effluents and fossil fuels has considerably increased their global levels. Anthropogenic sources of several metals like lead, mercury, cadmium and zinc have been reported to exceed the natural fluxes which has resulted its continuous buildup of these metals in different components of the environment. Many of these are essential for the growth of organisms at lower concentrations.

1.3.1 Iron:

In most of element in earth crust fourth most is iron by weight. In water it occurs mainly in the divalent and trivalent state i.e ferrous and ferric the concentration of iron in well aerated water is rarely high but under reducing conditions which also exist in ground water lakes or reservoirs and in absence of sulphate and carbonate high concentration of soluble ferrous iron may found. The presence of iron in natural water can be due to dissolution of rocks and minerals, landfill leachates sewage.

The presence of iron in drinking water supplies is objectionable for number of reasons iron promotes the growth of iron bacteria these microorganism derive their energy from the oxidation of ferrous to ferric and in process deposit a slimy coating on piping. In human nutrition iron is an essential element but ingestion in large quantities results in haemochromatosis and damage of tissue due to iron accumulation.
Rim-Rukeh et al., (2007) studied the physical-chemical characteristics of river and hand-dug well waters in the oil rich Niger Delta area of Nigeria and observed the value of Fe (6.07 – 15.71 mg/l) in river water and (13.17 – 16.31 mg/l) in hand dug-well.

1.3.2 Lead:

Lead concentration in surface and ground water range from traces to 0.04 mg/liter averaging about 0.01 mg/liter. Industrial and mining sources may contribute some localized lead pollution. The health effects of lead are neurotoxic. Three human systems are most affected i.e. blood forming system, nervous system and renal system. Such a toxic level is reached when the blood level exceeds 100 to 120 µg/L.

Lead is a natural constituent of the earth’s crust at an average concentration of about 16 mg/kg. It is present in number of minerals, the principle ore being galena. Lead in the environment exist almost entirely in the inorganic form but small amount of organic lead result from the use of leaded gasoline and from natural alkylation’s process that produce metal lead including the manufacturer of acid ammunition, alkyl lead compounds for gasoline, solder, pigments, ammunition, cable shooting etc.

The natural lead content of lake and river water worldwide has been esteemed to be 1-10 µg/l. Although higher values have been recorded where contamination has occurred particularly from industrial sources, such situations are relatively rare, since there are number of natural mechanisms that control the levels. The concentration in finished water prior to its distribution are generally lower than in source waters since lead is particularly remove by most
conventional water treatment processes. The lead services pipes running from the street to dwelling, from lead plumbing and or lead lined storage tank. Particularly high lead levels can result when the water is aggressive, soft or has a low pH.

Lead in high doses has been recognized for centuries, as cumulative metabolic poison. Some of the symptoms of acute poisoning are tiredness, lassitude, slight abdominal discomforts, irritability, anemia, and children’s behavioral changes. Such symptoms are difficult to quantify and currently there is considerable interest in various possible subtle effects, including neurophysiological ones, caused perhaps by exposure to low level of lead.

Kumar et al., (2006) studied drinking water samples collected from Bathinda district of Punjab and reported variation in lead content in the groundwater resources. In human body lead accumulates primarily in bones. Excess concentration of lead may cause anemia and disruption of hemoglobin synthesis, damage to nervous system and kidneys, brain damage (lead encephalopathy). Delay in physical and mental growth in infants and children may be due to excess concentration of lead.

1.3.3 Copper :

Copper salts are used in water supply systems to control biological growth in reservoirs and distribution pipes and to catalyze oxidation of manganese. The nature of copper in water depends on the pH and carbonate concentration and other anions in solution. In a small amount it is not detrimental to health but it will impart an undesirable taste to water it causes Wilson’s disease. Copper is essential to human the adult daily requirement has been estimated at 2
Copper is mainly absorbed from duodenum in man and chicks. Copper absorption and retention depends on factors such as the chemical form in which metal is ingested by the directory levels of other minerals and organic substances and the acidity of intestinal contains in the absorptive area. Many copper protein compounds were isolated from living tissues most of which were found to be oxidative functions this copper enzymes help in catalyzing the reduction of molecular oxygen to water. Whenever the tissue concentration of these enzymes is low, it is a sign of copper deficiency and thus revealing the basic biochemical defects.

1.3.4 Chromium (Cr):

Most rocks and soil contains small amount of Chromium concentration. The commonest ore is chromate in which the metal exists in the trivalent form hexavalent chromium also exists naturally. Frequently chromium in its naturally occurring state is highly insoluble. But can be converted in to more soluble form by the action of weathering, oxidation and bacteria. Chromium is absorbed to both gastrointestinal and respiratory tracks. Trivalent is essential form of chromium for human beings. Hexavalant chromium is toxic, hexavalent chromium if distributed in human tissue in variable and low concentration. The presence of chromium in man is skin, muscle, and fat. Chronic exposure to chromate dust has been correlated with increase incidence of lung cancer. Oral administration of excessive levels i.e. above 50 ppm has been associated with a liver and kidney damage. Exposure to hexavalnat chromium causes allergic skin irritations, dermatitis, irritation to mucus membrane, gastrointestinal
ulcers; chrome holes i.e. penetrating ulcers which occur around the finger nails. Chromium concentration in potable water supplies varies from 0.002 to 0.1 ppm. The United States Environmental Protection Agency (USEPA) suggest 0.05 ppm as the chromium limit for domestic water supply. The environmental standards are usually set on the basis of hexavalent chromium because of its toxic nature. The daily intake of person averages in the range of 150 µg to 280 µg in different countries.

Different water bodied like river and sea waters are about 0.04 ppm and .00005 ppm respectively chromium concentration in potable water varies from 0.002 to 0.1 ppm. The USEPA suggests 0.05 ppm as the chromium limit for domestic water supply.

The concentration of chromium in environmental standards set on the basis of hexavalent chromium which is more toxic. The daily intake of Cr per person averages in the range of 150 µg and 280 µg in different countries (Dara, 2002). Most of rocks and soils contain minute amount of chromium.

Chromium metal exists in the trivalent form in chromites ore. Hexavalent chromium exist naturally Chromium in its natural form occurs in insoluble but converted into more soluble form by action of weathering, oxidation and bacteria. Because of chromium’s low solubility the level of chromium found in water are usually low. In human being it is absorbed through both gastro-intestinal and respiratory tracts in its two form trivalent is an essential form of element for human beings hexavalent chromium is toxic. It is distributed in human tissue in variable and low concentration. The largest form of chromium in man are present in skin, muscle and fat.
Chromium appears to be necessary for glucose and lipid metabolism and for utilization of amino acids in several systems. Chromium is also important in prevention of mild diabetes and atherosclerosis in humans. Hexavalent chromium in high doses has responsible for digestive tract cancer in man. Metal pickling and plating operations uses hexavalent chromium. Hexavalent chromium used in leather industry as a tanning agent also in manufacturing of paints, dyes, explosives, ceramics, and paper, etc. Trivalent chromium salts on the other side used in less extensive manner and employed as mordant in textile dyeing in ceramics and glass industry and in photography.

Ong et al., (2007) studied the tap water quality in Kuala Lumpur and observed that the concentration of chromium in tap water ranged from 0.036 mg/l to 3.57 mg/l with an average concentration of 1.24 mg/l. The concentration of chromium for all the 20 samples complied with the current provisional guideline of 50 mg/l for total chromium.

1.3.5 Zinc:

Zinc is an abundant element and comprises 0.04 g/kg of earth crust approximately the most common zinc mineral is sphalerite (ZnS). The concentration of zinc in water is generally low. Zinc is essential element for both animals and human. Zinc may be considered non toxic, the low toxicity of zinc and efficient homeostatic control and mechanism make chronic toxicity from drinking water. Symptoms of zinc toxicity in human include vomiting, dehydration, electrolyte imbalance and abdominal pain. Zinc imparts an undesirable astringent taste. Zinc at concentration to excess of 5.0 mg/L may appear opalescent to develop a greasy film on boiling.
The role of zinc as an essential nutrient is a well-established now. A number of enzyme including aldolase, alkaline phosphatase, carboxy peptidase, lactic acid dehydrogenase are dependant of zinc. Zinc is also present in co-factor of other enzymes such as arginase and diaminase. Thus, it takes part in the synthesis of protein and insulin. Hence, zinc is essential for the normal functioning of the cells including protein synthesis, carbohydrate metabolism, cell growth and cell division. Zinc is an essential and beneficial element for human bodies. However, above 5 mg/l causes bitter taste and opalescence in alkaline waters.

Zinc influences growth rate and bone development. The integrity of the skin the development and function of the reproductive organs. It is also helps in wound healing. The zinc deficiency syndrome manifests itself by retardation of growth, anorexia, lesions of skin and appendices, impaired development and function of reproductive organs.

Ong et al., (2007) studied the tap water quality in Kuala Lumpur and observed that the concentration of zinc in tap water of the selected areas varied from 2.2 mg/l to 453.0 mg/l with an average of 130.2 mg/l. The presence of a trace element such as zinc is good as it is essential for human nutrition. The concentrations of zinc in tap water of these areas were much lower than the guideline value of 5 mg/l.

1.4 Microbiological Parameters:

The microbiological examination of water is important parameter in determining pollution status of water as this directly measure the harmful effect of pollution on human health. To ensure
the safety of potable water, monitor the water quality for domestic, industrial and agricultural uses and also to evaluate prospective water resources for drinking purposes. The detection and estimation of pathogenic bacteria is a tedious work because of the presence of very small numbers. Different types of bacteria are routinely monitored to indicate the presence of pathogenic organisms in water for deciding the potability of underground water.

1.4.1 Most Probable Number (MPN)

The micro-organism in water include several types of bacteria which may useful to human societies and others may harmful to man and living organisms. The contaminated water may contain several disease causing bacteria capable of causing diseases such as typhoid, fever, dysentery and cholera. Such organisms are called pathogenic organisms. The pathogenic organisms present in surface and underground water resources may contributed by anthropogenic activities or by natural phenomenon.

The coliform bacteria indicate the presence of pathogenic organism in water, these pathogenic bacteria discharged from human intestine. The coliform bacteria include genera *Escherichia*, *Citrobactor*, *Enterobacter* and *Klebsiella*. The *Escherichia coli* are entirely of human origin but their exclusive estimation is difficult and hence entire coliform are used as an indicator of pollution. In routine the actual number of coliform is not reported but they are reported as a most probable number.

1.4 Water Quality Index (WQI)
Water quality index indicates a single number (like a grade) that expresses the overall water quality at certain location and time based on several water quality parameters, it is also defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water.

The concept of water quality indices was first proposed by Horton, (1965) the use of index based water grade system is controversial among water quality scientists.

The main objective of water quality index is to turn complex water quality data into that information that is understandable and usable by public water quality index gives the public a general idea of possible problems with water in a particular region the indices among the most effective ways to communicate the information on water quality trends to the public or the policy makers and water quality management.

Prior to construction of Jaikwadi dam the water supplies to Aurangabad city was from Harsul dam, which was built in 1954 on the Kham River. But, due to the increasing human population the demand of water supply was also increased. In 1975 the water was supplied to Aurangabad city from Jaikwadi at a rate of about 28 MLD per day. After 1984 the capacity of water supply increased by Buster system and 50 MLD water was supplied every day. Presently, the water supplies to Aurangabad city at a rate of about 135 MLD per day

Aurangabad is one of the fastly growing townships from Asia. The industrialization and urbanization has been geared up at a rapid rate in last two decades. Due to availability of sufficient water resources in the form of Nathsagar at Paithan, there is increase in
numbers of industries at Aurangabad. The water supply to the city and industrial area is from Nathsagar dam of Paithan constructed on the Godavari River. The industrial development has positive impact on the growth of city.

Due to rapidly expanding population and industrialization the residential area is increasing day by day. Along with the expanding population and city area peoples are depending on underground water resource for their domestic water needs.

The groundwater quality was monitored with the measurement of physical, chemical, microbiological parameters and metallic constituent from Aurangabad city. The study was conducted during the February 2007 to January 2009.

Whether the sewage and industrial effluent from residential and industrial areas respectively are responsible for contamination of underground water resource of Aurangabad city was to be assed. The incidences of disease and epidemic and out breaks diseases related to the water quality. As quality of water decides its suitability for its specific use, hence monitoring of water quality in the form of physico–chemical and microbial parameters of available resources in the city area is an integral part of the present study.