CHAPTER-2

REVIEW OF LITERATURE

Water is fundamental to a life of human dignity, and is prerequisite to the realization of all other human rights (WHO, 2011). It is not only that water problems are precarious in the population sector but, as a whole, the country has been facing a water crisis both for agriculture as well as for basic needs. Water, both for survival and in utilizing its resources, has been a major factor in economic development. It is well known that it is only paucity of water which has altered civilization since ancient times. Even the dislodging of areas of civilization has occurred due to shift in water availability. Gradually, technology brought global culture to a crossroads and as the population started increasing due to manifold factors of economic development and inventions, humans started tapping the water sources, both rivers and underground, for survival. It is the modernization of cultures which increased water utilization. This utilization became so intense and wasteful that the consciousness of water, its conservation and new exploration became most crucial and important initiatives, leading to development in some and disparity in other regions (Roy, 1991). It is therefore, necessary that quality of water should be maintained at regular intervals by monitoring water supply and proper water management. Various attempts made by different researchers in this direction.

2.1 Physico-chemical assessment of ground water and surface water

Ground water quality assessment of Kaithal City (Haryana) was done by Gupta et al. (2009) and reported that some of the water samples were unsuitable for consumption due to high concentration of some of the parameters. Likewise, suitability of ground water in Ambala was checked by Rout and Sharma (2011) and reported water is of good quality.

Seasonal variation of ground water quality was studied by Ganiyu et al. (2018) using multivariate statistical analysis in Ajakanga area, Ibadan, Nigeria for its suitability for drinking and irrigational purposes. The analysed parameters were pH, TDS, EC, Na+, K+, Ca2+, Mg2+, Cl−, SO42−, NO3−. It was found that there were very strong associations between EC and TDS, HCO3− and CO32− in wet and dry seasons and most of the water samples were suitable for drinking and irrigational purposes except for few sites. Likewise, Adimalla and Venkatayogi (2018) studied geochemical characteristics of
ground water of Telangana state of South India. The physico-chemical parameters studied were Na\(^+\), K\(^+\), Ca\(^{2+}\), HCO\(^3\), Cl\(^-\), NO\(_3\)\(^-\), CO\(_3\)\(^-\), SO\(_4\)\(^{2-}\) and F\(^-\). It was found that NO\(_3\)\(^-\) and F\(^-\) concentrations were above the maximum permissible limit, while Na\(^+\), K\(^+\), Ca\(^{2+}\) and Cl\(^-\) were found below the desirable limits in most of the groundwater samples. As per the findings of Wilcox diagram, 59% of the samples belong to excellent to good category.

Suitability of ground water in villages of southwestern Haryana, India for drinking purposes was checked by Garg et al. (2009). The physico-chemical parameters such as pH, total dissolved solids (TDS), total hardness (TH), total alkalinity (TA), calcium, magnesium, carbonate, bicarbonate, sulphate, chloride and fluoride were studied and results were compared with BIS and WHO water standards. The values of parameters such as TDS, total alkalinity and bicarbonate were higher than maximum permissible limit at some sites. According to this study, it was found that fluoride appeared as a major problem of safe drinking water in this region. Kumari and Kumar (2013) monitored ground water quality in five blocks (Sabji Mandi, Bus Stand, Govt. Hospital, Railway Station, Anaj Mandi) of Mahendera Garh district. According to this study, the results of the physico-chemical parameters were showed considerable variation. Likewise, Ground water quality parameters and statistical analyses of the selected 41 different locations in Panipat city (Haryana) were done by Bishnoi and Malik (2008). The physico-chemical parameters such as pH, EC, TDS, TA, TH, Na\(^+\), K\(^+\), Ca\(^{2+}\), HCO\(^3\), Cl\(^-\), SO\(_4\)\(^{2-}\) and F\(^-\) were studied. According to this study, all samples were reported with high concentration of dissolved salts and fluoride was found to be higher than permissible limits in most of the samples.

A study has been carried out for quantification and possible causes for occurrence of high fluoride concentration in water samples representing ground water of Faridabad (Haryana) India by Singh and Garg (2012). Various physico-chemical parameters such as pH, electrical conductivity, total dissolved salts, total hardness, total alkalinity, sodium, potassium, calcium, magnesium, carbonate, bicarbonate, chloride, phosphate, nitrate-nitrogen and sulphate were studied. The results were compared with the BIS and WHO standards of water quality. The correlation matrix was also calculated for different water quality parameters. According to this study, it was found that most of the water samples were above the prescribed limits as prescribed by BIS and WHO standards. The fluoride concentration in the ground water of study area varied from 1.0
to 40.0 mg/l. They concluded that weathering of rocks and anthropogenic activities were responsible for high fluoride concentration in groundwater of this area.

Shalu et al. (2015) studied ground water of district Bhiwani, Haryana, India to assess its quality and suitability for both drinking as well irrigation purpose. The physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, hardness, alkalinity, sodium, potassium, calcium, magnesium, chloride, phosphate, nitrate and fluoride were studied. Water quality index (WQI) was calculated to find suitability of groundwater for drinking and irrigation purpose. According to this study, it was observed that about 78% of ground water samples were affected with salts. Residual sodium carbonate and sodium absorption ratio indices indicated that most of the water samples were suitable for irrigation. The correlation coefficient was also calculated among different quality parameters. According to the results, it was found that all the water samples were in excellent and good category as per WQI rating and were absolutely fit for drinking and irrigation purposes except few samples.

A study has been carried out for determination of fluoride in ground water of seven villages of Tosham sub-division, Bhiwani district, Haryana by Dahiya et al. (2000) and results were compared with WHO water quality standards. According to this study, it was found that fluoride content in 56% of ground water samples were more than permissible limit. Assessment of ground water quality of Nimna Terna project of Makni district, Osmanabad (M.S.), India was carried out by Ustad (2015) for drinking and irrigation purpose. pH, total dissolved solids, total hardness, turbidity, iron (Fe), fluoride (F⁻), chloride (Cl⁻), sodium (Na⁺), magnesium (Mg²⁺), potassium (K⁺), sulphate (SO₄²⁻) and nitrate (NO₃⁻), calcium (Ca²⁺) etc. were determined. The results were compared with the ISI and WHO standards of water quality. It was found that the ground water of some villages was fit for drinking and irrigation purposes.

Ground water quality assessment of Safidon and Julana blocks of Jind district, Haryana, India and comparison with drinking water quality standards laid by World Health Organization (WHO), Bureau of Indian Standard (BIS) and Indian Council of Medical Research (ICMR) was assessed by Singh et al. (2012). The physico-chemical parameters such as pH, electrical conductivity, total dissolved solids (TDS), total hardness (TH), calcium, magnesium, total alkalinity (TA), carbonate, bicarbonate, sodium, potassium, chloride, sulphate and fluoride were studied. The correlation
coefficient was also calculated for different parameters of drinking water and t-test was applied for checking the significance.

Ground water quality parameters and statistical analyses of the selected villages near by Sagar city, Madhay Pradesh was assessed by Pathak and Limaye (2012) during different months of the pre monsoon, monsoon and post monsoon seasons in Oct. 2007 to July 2011. It was found that pH values of all samples were between 5.5-8.5 limits. Conductivity of all the samples was below WHO water standards. A study was done on the nitrate pollution in ground water of Sulaimaniyah city by Mustafa and Ahmad (2008). They collected samples from different aquifers (Quaternary sediments and Kometan and Tanjero formations) and from different depths. Majority of the water wells (63% of the ground water in Sulaimaniyah city) was polluted with NO₃. The main sources of this pollution by NO₃ in the ground water came from sewages. Waters of polluted wells were not suitable for drinking purposes. Assessment of ground water quality parameters of Sambhar lake, Jaipur district, Rajasthan, India was carried out by Joshi and Seth (2008). Physico-chemical parameters such as total dissolved solids, EC and major ions e.g., Ca²⁺, Mg²⁺, NO₃⁻, F⁻, Na⁺ and K⁺ were studied. It was found that most of the water samples were non-potable for consumption due to high concentration of various parameters.

Dhankar et al. (2008) studied ground water quality for irrigation and drinking purposes in the villages of Sirsa district, Haryana. The study reported that parameters in majority of water samples were within permissible limits except magnesium and bicarbonates. They also determined correlation coefficients for various physico-chemical parameters of ground water samples. Bundela et al. (2012) analysed physico-chemical characteristics of ground water near municipal solid waste dumping sites in Jabalpur during the rainy season 2011 for various physical and chemical properties. Total Dissolved Solids varied from 546 mg/L to 907 mg/L and compared with permissible limits. It was found the best accepted option was to avoid the possibility of polluting the groundwater resources.

Jain and Agarwal (2012) studied the ground water quality of 24 villages around Raisar of district Bikaner in Rajasthan. The physico-chemical parameters like colour, odour, pH, TDS, TH, EC, major ions like F⁻, NO₃⁻, Cl⁻, SO₄²⁻, Ca²⁺ and Mg²⁺ were studied. It was found that some water samples were non potable for drinking purpose due to high concentration. Similarly Dhale et al. (2012) studied the ground water quality of
Parbhani district (M.S., India). The physico-chemical parameters such as Temperature, colour, odour, pH, EC, TDS, turbidity, TH, Ca$^{2+}$, Mg$^{2+}$, total alkalinity, bicarbonate, sodium, potassium, chloride, fluoride, nitrate and sulphate were studied. In this study, few samples showed high total hardness content indicating the need of some treatment for minimization of the parameters.

Palanisamy et al. (2007) monitored ground water quality of Gobichettipalayam town, Tamil Nadu and reported the suitability of drinking water. Seasonal variation of physico-chemical quality of ground water of Mysore city, (Karnataka) India was determined by Nirmala et al. (2012) and compared the results with water quality standards (WHO).

A study was carried out for determination of fluoride in ground water of some villages of Rohtak district, Haryana by Bishnoi and Arora (2007) and results were compared with Indian and WHO standards. Various physico-chemical parameters were studied. Water was found to be unsuitable from drinking point of view, they also concluded high fluoride content in half of the samples.

Dash et al. (2012) carried out a study to assess the physico-chemical parameters in ground water of Balasore area, Odisha, India. The parameters used were pH, turbidity, total dissolved solids, total hardness, alkalinity, nitrate, fluoride, sulfate and iron. It was found that drinking water quality in the study area was reasonably good. It was found that some sort of treatment was needed before consumption. Similarly, assessment of drinking water quality of Rimuli village, district Keonjhar, Orissa was done by Pradhan et al. (2003). Five wells and five tube wells were chosen for water sampling during the period of Mar 1999-Feb 2000. Seventeen essential parameters such as temperature, pH, turbidity, EC, TDS, TS, TH, Cl$^-$, SO$_4^{2-}$, calcium, magnesium, total alkalinity, acidity etc. were studied and discussed.

Kalra et al. (2012) monitored seasonal variation of water quality parameters in Ara block, Bhojpur district, Bihar. Parameters i.e temperature, turbidity, pH, EC, TA, Ca$^{2+}$, Mg$^{2+}$, Cl$^-$, NO$_3^-$, SO$_4^{2-}$, Fe, As, F$^-$ were studied. In this study maximum value of parameters in all three seasons were compared with EOROPEAN, USPH, ICMR standards to investigate quality of water for drinking purpose.

Water quality index and statistical assessment of ground water quality at Hasanpur in J.P. Nagar, Uttar Pradesh, India was done by Sinha and Saxena (2006). Samples were collected during monsoon and pre monsoon and after the onset of monsoon in 2005.
According to this study, it was found that almost all the sites were highly contaminated. It was monitored that water quality parameters showed deterioration after onset of monsoon. Similarly, Kupwade and Langade (2013) studied ground water quality in region near Kupwad MIDC, Sangli, Maharashtra to know its suitability for domestic and irrigation purpose. Various physico-chemical parameters such as pH, EC, TDS, total hardness, Ca and Mg hardness, Na\(^+\), K\(^+\), total alkalinity, chlorides, free CO\(_2\), DO, sulphate, nitrate and phosphate were estimated. According to this study, it was found that parameters like TDS, total hardness, chloride, sodium, total alkalinity and sulphate were high in some samples. Some samples were extremely hard and highly saline and absolutely unfit for consumption, domestic use and irrigation.

Naik and Purohit (1998) carried out a work on assessment of water quality parameters of Bondamunda for two years. The parameters were compared with standards prescribed by Bureau of Indian standards (BIS), Indian Council of Medical Research (ICMR) and World Health Organization (WHO). According to this study, it was found that water was suitable for drinking and other domestic uses.

Analysis of ground water quality of areas adjacent to Loco and carriage workshops, Ajmer, Rajasthan was done by Dutta et al. (2009). Physico-chemical parameters were studied including pH, EC, TDS, TH, Cl\(^-\), SO\(_4\)\(^{2-}\), NO\(_3\)\(^-\), Na\(^+\) and F\(^-\) and statistical analysis was also done for the different parameters. The study indicated slight alkaline nature of ground water samples. TDS and TH values were observed higher than permissible limits. A similar type of study on physico-chemical analysis of ground water of Ambala, Haryana was done by Singh et al. (2010). To assess the quality of ground water comparison was made as per standards prescribed by World Health Organization (WHO), Bureau of Indian standards (BIS) and Indian Council of Medical Research (ICMR).

A study on Ground water quality using WQI and GIS in Jada was carried out by Ishaku et al. (2012). WQI values ranged from 15 to 43, and thus indicated well to very good ground water quality status. Similarly, suitability of ground water quality as per WQI in Orissa, India was assessed by Reza and Singh (2010). The values of water quality index was found to be affected by the concentration of dissolved ions (F\(^-\), NO\(_3\)\(^-\), Ca\(^{2+}\) and Mg\(^{2+}\)) in ground water.

Ramakrishnaiah (2009) calculated WQI for ground water in Tumukur Taluk, Karnataka, India. The WQI for these samples ranged from 89.21 to 660.56. High values
of WQI was reported due to the higher concentrations of nitrate, TDS, hardness, fluoride, bicarbonate iron and manganese in the ground water. Physico-chemical parameters and correlation coefficients of ground waters of north-east Libya was assessed by Nair et al. (2005). The mean value of each parameter together with its standard deviation (SD), standard error (SE) and coefficient of variation (CV) were calculated. Correlation coefficient was calculated among different parameters.

Varughese and Prasad (2012) carried out ground water quality in the varahanadi basin. In this area, ground water was the main source of irrigation. Groundwater samples were analysed for various physico-chemical parameters and compared with the standard desirable limits of water quality parameters prescribed by Bureau of Indian Standards and World Health Organisation. It was observed that the bed rock of the study area influenced the groundwater quality resulting in higher concentrations of calcium, potassium and phosphates in the ground water samples.

Sleema and Babu (2009) studied ground water quality of Vadakkekara Panchayath, Ernakulam district, Kerala during Sep-Dec 2009 for its suitability for drinking purpose. The water quality parameters were colour, odour, turbidity, temperature, pH, electrical conductivity, total dissolved solids, acidity, alkalinity, total hardness, chloride, free CO₂, dissolved oxygen, biological oxygen demand, chemical oxygen demand, calcium, magnesium, iron, sodium, potassium. Umadevi et al. (2010) carried out a study on ground water quality at Eloor in Ernakulum District of Kerala, India and results were compared with limits prescribed by BIS. Correlation analysis was carried out amongst the measured parameters. It was found that in some area pH values were lower than the prescribed limit and magnesium and chloride exceeded the desirable limit in some areas.

Lohani et al. (2011) studied drinking water quality parameters in Bhubaneswar city of Odisha, India during post-monsoon period. Different parameters of groundwater samples were examined using WHO and Indian Standards to find their suitability for drinking and domestic purposes. Similarly, Harish et al. (2006) analyzed physico-chemical parameters including fluoride from hand pumps of Tarikere Taluk for drinking purpose. The fluoride concentration ranged was 0.45 mg/l to 1.98 mg/l and reported that ground water was not suitable with respect to high concentration of fluoride. Nagarnaik and Patil (2012) studied different physico-chemical parameters and
MPN which were according to the suitability for drinking and domestic purposes in case of ground water.

Hand pump’s water quality and statistical analysis in Banda, Uttar Pradesh was evaluated by Gupta et al. (2014). The physico-chemical parameters studied were colour, temperature, turbidity, EC, pH, D.O, TDS, total solids, alkalinity, sodium, potassium, total hardness, calcium, magnesium, phosphate, total nitrogen, chloride, sulphate, nitrate, fluoride and iron. The results were compared as prescribed by WHO. Alkalinity and hardness values were more than their permissible level. Similarly, Sharma et al. (2014) carried out a research work on ground water quality assessment from the Nalgonda district of Andhra Pradesh, India. Various physical and chemical characteristics like pH, temperature, alkalinity, acidity, hardness, chorine, phosphate, nitrate, nitrite, arsenic and fluoride were studied to know suitability of water for use.

Physico-chemical parameters and correlation coefficients of ground water of Manendragarh, Chhattisgarh, India was assessed by Dwivedi and Augur (2014). The physico-chemical parameters like pH, alkalinity, total hardness, iron, chlorides, dissolved solid, calcium, nitrate, fluoride, sulphate and DO. The analysis of various parameters using standard methods (APHA/NEERI) and their comparison with WHO and BIS standard values, suggested that nearly all the parameters were according permissible limit. Pond and ground water quality of Tiruchirapalli city of Tamil Nadu, India was assessed by Prasath et al. (2013). The groundwater quality viz., pH, electrical conductivity, total hardness, calcium ion, magnesium ion, chloride, carbonate, bicarbonate, inorganic nitrate, nitrite, phosphate, ammonia and reactive silicate were analysed with respect to various seasons. According to this study, it was found that the quality of ground waters was suitable for human consumption. But the pond water available in and around Tiruchirappalli city was not fit for human usage, agricultural or industrial purposes.

Seasonal variation in ground water quality of Tirunelveli District, Tamil Nadu, India was assessed by Subramanian et al. (2011) for determining its suitability for drinking and agricultural proposes. It was found that water was neutral to alkaline having pH ranged from 7.1 to 8.6 with an average of 7.8 pre monsoon and 7.7 post monsoon. The abundance of major ions in the groundwater was in the order of Na Ca > Mg > Na+ K > Cl > SO4 > TDS > TH. As per the classification of water for irrigation purpose, water was fit for domestic and agricultural purposes with
minor exceptions irrespective of seasons. Ground water quality analysis in Pilani, Jhunjhunu district, Rajasthan was evaluated by Mitharwal et al. (2009) for drinking purpose. The different parameters determined were pH, TDS, fluoride, chloride, nitrate, sulphate, total alkalinity and total hardness. It was found that nitrate values were high compared to ICMR standards. Other parameters were found within desirable limits. According to this result, it was found that nitrate alone was making ground water unfit for drinking.

Seasonal status of ground water quality in Shivpuri district, Madhya Pradesh, India was assessed by Jain et al. (2013) during May 2011 to November 2011. The physico-chemical properties such as pH, total dissolved solid, electrical conductivity, acidity, alkalinity; chloride, iron, total hardness, calcium and magnesium hardness, and fluoride concentration were studied and analyzed. The results obtained were compared with permissible limits of the drinking water set by Bureau of Indian Standards (BIS). Water quality in post monsoon was better than the pre monsoon season. The physico-chemical characteristics of different water samples showed that pH, EC, alkalinity and iron content were higher in post-monsoon. Results indicated that fluoride content was very low in the samples and all the water samples were suitable for drinking purpose. Likewise, assessment of groundwater quality by multivariate analysis in villages of Sagar City, MP, India was carried out by Pathak (2012) for their suitability for human consumption during different months of the pre monsoon, monsoon and post monsoon seasons in Oct. 2007–July 2011. pH values of all samples were between 5.5-8.5 limits. Conductivity of all samples was below WHO water standards. The statistical analysis such as range, mean, standard deviation, co-efficient of variation, correlation analysis was done.

Seasonal variation in ground water quality of Mindi industrial area, Visakhapatnam, India was assessed by Yashoda et al. (2014) during the year 2012 to know the potability of the ground water. The parameters i.e pH, electrical conductivity, total hardness, total alkalinity, chloride, sulphate, phosphate, fluoride and nitrate were analyzed. It was found that better water quality was found in pre-monsoon season than that of post-monsoon season. Extent of pollution occurred may be due to over exploitation of ground water, urbanization and anthropogenic activities. Assessment of ground water quality and its impact on resident’s health in Bahawalpur city, Pakistan was assessed by Mohsin et al. (2013) and compared the ground water quality with WHO standards and its related diseases in Bahawalpur city. Data collection was based
on the questionnaire and laboratory analysis of water samples. The physico-chemical parameters like total dissolved solids (TDS), electrical conductivity (EC), pH, hardness, alkalinity etc. were examined. It was reported that groundwater quality was deteriorating. High EC, TDS, hardness, pH etc. were reported after comparison from WHO permissible limits.

Ground water quality assessment in Aligarh city, Uttar Pradesh was carried out by Perween and Fatima (2015). The samples showed a mean of pH 7.8, total acidity 46.5 mg/l, phenolphthalein alkalinity 52.25 mg/l, total alkalinity 528.8 mg/l, total hardness 303 mg/l, calcium 155 mg/l, magnesium 148 mg/l, dissolved oxygen 13.1 mg/l, chemical oxygen demand 4.64 mg/l, turbidity 0.5 NTU, conductivity 1565.67 µS/cm, total solids 1428.8 mg/l, total dissolved solid 1175 mg/l and chloride 168.073mg/l. The analysis revealed that drinking water quality in the study area was reasonably good and did not show any alarming level of pollutants. However it needs some degree of treatment before consumption as the concentration of the parameters such as dissolved oxygen, total alkalinity, magnesium hardness, calcium hardness, total hardness, total solids and chemical oxygen demand exceeded the permissible limits for drinking water.

Assessment of municipal water quality in Gwalior city, Madhya Pradesh, India was done by Sharma and Rather (2013) and reported that most of the water samples were showing bacteriological contamination. According to questionnaire survey, diarrhoea was most of the prevalent health problem in the study area followed by Typhoid.

The hydro-geochemical quality of surface water of Pratapgarh district, Uttar Pradesh, India was assessed by Tiwari et al. (2017) for drinking and domestic purposes. They reported the HCO$_3^-$ and Cl$^-$ were the dominant anions, while cations were dominated by Na$^+$ and Ca$^{2+}$. Based on statistical analysis and Piper diagram, they also reported that the surface water chemistry was mainly controlled by rock weathering with secondary contributions from agriculture and man made sources.

Seasonal variation on physico-chemical characteristics of z-miner canal in Sriganganagar, Rajasthan, India were determined by Manjeet and Kumar (2015). Likewise, Jhansilakshmi and Reddi (2014) carried out a study on physico-chemical characteristics of Gostanadi Velpur canal for the suitability for drinking purposes in Bhimavaram town, Andhra Pradesh, India. It was found that canal water was polluted with turbidity and BOD. They also reported the parameters such as nitrate, phosphate, potassium and sulphate were low in the summer season while high in rainy season.
Seasonal variations in physico-chemical parameters of Sirhind canal passing through Moga, Punjab, India was studied by Kaur and Kaur (2014) during summer, monsoon and winter seasons in 2012. It was observed that most of the parameters showed increased concentration during summer in comparison to monsoon and winter except nitrate & phosphate that showed maximum concentration during monsoon.

Saxena et al. (2014) carried out a study on seasonal variation and evaluation of water quality index (WQI) of different types of raw water sources such as Yamuna river from Delhi, Ganga water from Uttar Pradesh, Bhakra through Haryana, rainy wells and tube wells during 2011-2012 and reported excellent water quality in monsoon and very poor in winter seasons.

Kerketta et al. (2013) carried out a study in Ranchi, Jharkhand, India to assess the physico-chemical parameters and heavy metals in drinking water from various sources i.e taps, river, pond, hand pumps and wells. It was reported from this study that samples from ponds and rivers were highly contaminated than other water samples. According to this study, some water samples showed pH more than prescribed level and lead and cadmium was more than the permissible limits. Similarly, Mohemmad et al. (2011) carried out a study on chemical analysis of drinking water from neighboring villages of Nandyal region of Kurnool district, Andhra Pradesh, India and reported that the concentrations of majority of the studied parameters existed within limits as per WHO drinking water standards.

Werkneh et al. (2015) assessed physico-chemical quality of tap water samples from Jigjiga city, Ethiopia. Studied parameters i.e temperature, pH, EC, TDS, TH were compared with international drinking water standards set by WHO. It was found that except total hardness and electrical conductivity all the parameters fulfill the minimum and maximum permissible limit of drinking water standards. Likewise, Tella et al. (2014) studied water quality of municipal water from Machilipatnam, Krishna district, Andhra Pradesh, India and reported that some of the water quality parameters were above the permissible limit and some were below the limits.

Singh and Sahu (2004) studied drinking water quality parameters in Rourkela, Orissa. It was found that most of the parameters fall within limits as per standards except few samples.

Physico-chemical parameters and correlation coefficients of some water sources were assessed by Kumar and Babu (2013) during Jan-May 2013 at Patiala and it was found
that correlation coefficients showed positive correlation between conductivity and dissolved solids and alkalinity and hardness. Similarly, Sundari et al. (2004) carried out a seasonal study on assessment of drinking water quality in Chidambaram, in Cuddalore district of Tamil Nadu during pre monsoon, post monsoon and summer and reported that water was not suitable for drinking purpose.

Surface water quality parameters in Akot city was assessed by Murhekar (2011) for drinking purpose. It was found that quality of water was not suitable for drinking purpose except for some sites. Similarly, Simpi et al. (2011) studied water quality parameters of Hosahalli Water Tank in Shimoga District, Karnataka for a period of one year. According to this study, monthly changes in parameters such as temperature, turbidity, TDS, pH, dissolved oxygen, free carbon dioxide, total hardness, chlorides, alkalinity, phosphate and nitrates were found within the permissible limits.

Physico-chemical analysis of drinking water of Yavatmal district, Maharashtra, India was studied by Chandne (2014). The physico-chemical parameters like, temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), sulphate (SO₄), iron (Fe), chloride (Cl⁻), fluoride (F⁻), nitrate (NO₃⁻) were studied. It was reported that the water samples were found affected by some parameters and the quality of water was very bad at some places and it was unfit for drinking purpose. Similarly, physico-chemical analysis of tap water of Chandigarh (UT), India was assessed by Sharma (2015). Physico-chemical parameters i.e colour, odour temperature, pH, turbidity, EC, TDS, DO and salinity were studied. It was concluded that the quality of water samples studied were in acceptable limit for various physicochemical parameters. Water quality assessment from various sources was carried out by Shukla et al. (2013) in Ahmedabad city. Physicochemical and microbial quality of water was investigated the quality of water. During the study it was found that maximum number of physical and chemical parameters were within the desirable limits as suggested by WHO and BIS.

Municipal water assessment of Makronia sub-urban area of Bundelkhand, India was done by Pathak (2012) during different months of the pre monsoon, monsoon and post monsoon seasons in Sep. 2007 to Sep. 2011. Results showed that all the samples were under Indian standard limit for drinking purpose. The statistical analysis of the collected samples yielded the range of the variation, mean, standard deviation and coefficient of variation. Water quality analysis of Tamirabarani river water in South India
was assessed by Arasu et al. (2007) for suitability of drinking water and other purpose. Physico-chemical parameters was measured at sixteen locations of the river body revealed that the riparian water samples were in desirable limit of the standards.

Assessment of water quality parameters of ancient lakes of Udaipur city, Tripura, India was carried out by Lodh et al. (2014) during the month of April, 2014. Collected water samples were analyzed according to APHA for different physicochemical parameters and the results were examined according to WHO and BIS. Average BOD as well as the value of ammonical nitrogen (NH\textsubscript{3}-N) was found high which conveyed high bacteriological load, organic matter disposal and animal waste contamination into the lakes. Drinking water sources assessment in Chawmanu R.D. block of Dhalai district, Tripura, India was assessed by Das et al. (2014) in March, 2014. Almost in all of the locations, Turbidity (TU), BOD, COD and iron value was found above the standard limit according to BIS. They also reported that the water sources were very much polluted and were not suitable for drinking.

A study on water quality assessment of Narmada river was carried out by Malviya and Dwivedi (2015). The water samples collected were analyzed for pH, EC etc. High values of physico-chemical parameters indicated that the river water was polluted due to domestic wastes, municipal sewage, industrial effluent and agricultural run-off.

Variability study of water quality parameters of Ramkund pond of Raipur Chhattishgarh, India was assessed by Uzma et al. (2015) during 2013-2014. Parameters analyzed were temperature, pH, conductivity, total hardness, total dissolved solids, dissolved oxygen, BOD, COD, total alkalinity, chloride, sulphate, nitrate, nitrite, orthophosphate. The data obtained from these analyses were statistically analyzed to determine the correlation between various water quality parameters. Investigation of quality of water and WQI in Bhima River of Gulbarga District, Karnataka State, India was carried out by Shivashranappa and Yalakpalli (2012). The parameters such as pH, total dissolved solids, total hardness, calcium, magnesium, chloride, nitrate, sulphate, DO, BOD, alkalinity, sodium, potassium and fluoride were studied. It was found that the high value of WQI was mainly due to higher values of TDS, hardness, BOD and nitrate.

2.2 Microbiological assessment of ground water and surface water

Chemical and microbial quality of ground water was studied by Al-Barakah et al. (2017) and found that 94% of the samples were in excellent category for drinking
purpose. Assessment of physico-chemical and microbiological parameters in ground water of Gwalior city, MP, India was done by Parihar et al. (2012) and it was reported that electrical conductivity, total dissolved solids, total aerobic microbial count and most probable number were maximum in some of the samples. They also reported the presence of Enteric pathogen *E. coli* and Enterobacter in some water samples. Similarly, Salgado *et al.* (2003) studied water quality along the road to Santiago for its suitability for drinking purpose and reported only 19% of the water samples were drinkable. Likewise, Giglio *et al.* (2016) reported *Salmonella* sp., *Pseudomonas aeruginosa*, *E.coli*, *Enterococci* and total coliforms in study of well water of Italy.

Pavendan *et al.* (2011) studied physico-chemical and microbial parameters of drinking water in Tiruchirappalli district, Tamil Nadu, India and reported wells samples were highly polluted with total dissolved solids, total alkalinity and total hardness and fluoride content. They also reported the presence of microbial contamination in water samples. Similarly, bacteriological analysis of well water samples of Karumalloor panchayat in Paravoor Taluk, Ernakulam district, Kerala was carried out by Thomas *et al.* (2015). Sehar *et al.* (2011) studied the physico-chemical and microbiological analysis of ground and municipal water in Kallar Syedan and reported the presence of microbial contamination in some water samples.

Shivaraju (2012) assessed physico-chemical and bacteriological parameters of potable water in Mysore city, India and reported all the water samples were crossed their permissible limits. They also reported drinking water in the city was seriously polluted by harmful bacteria and unfit for drinking purposes. Similarly, physico-chemical and microbial analysis of drinking water in Rajkot district, Gujarat (India) was assessed by Kumar and Parita (2014) and reported that some of the parameters such as BOD and COD values were high in the water, indicating high pollution load. It was also reported that almost all the water samples were found positive for TC and *Salmonella* sp. Ground water in Mohanpur village of North Bihar was evaluated by Priyanka *et al.* (2014) for its suitability for drinking purpose and reported the contamination of water samples due to sewage and agricultural waste.

A microbiological study has been carried out on bore well water in Bengaluru city, India by Thirumalesh and Fathima (2015) for drinking purpose and statistical analysis of the results was performed using SPSS. Based on obtained results, it was reported that water samples were contaminated with coliform and fecal coliform bacteria. Similarly,
physicochemical and bacteriological analysis of ground water in Bhavnagar, Gujarat, India was evaluated by Patel et al. (2014) and reported the contamination of water by *Aeromonas* and *Acinetobacter*, *Citrobacter* and *Serratia* and *Pseudomonas* sp. Similarly, ground water quality in Belgaum district, Karnataka, India was assessed by Sunkad (2013) for drinking purpose.

Seasonal variation in microbial contamination of ground water in Bilaspur city, Chhattisgarh was assessed by Shrivastava et al. (2014) and reported the drinking water of the Bilaspur city was not safe for drinking due to bacterial contamination.

Prasai et al. (2007) studied microbial water quality of Kathmandu valley and reported the presence of enteric bacteria such as *E*-coli, *Enterobacter* sp, *Citrobacter* sp, *Pseudomonas* sp, *Klebsiella* sp, *Serratia* sp, *Shigella* sp, *Proteus vulgaris*, *V. cholera* and *Salmonella typhi* in the water samples.

Ground water quality in Bareilly (U.P.), India was assessed by Khanna et al. (2011) by estimating physicochemical parameters and calculating Water Quality Index (WQI). The WQI of different sites showed that drinking water was of good quality. They also reported the presence of Enteric pathogen *E. coli* and total aerobic microbial count in the water sample of one site.

Ground water quality near municipal dump site was assessed by Satyavani et al. (2013) during pre and post seasons for drinking purpose and reported the presence of bacterial contamination. Hence, they reported unsuitability of water for drinking as well as for domestic purposes. Ground water quality in adjoining area of Omti Nallah, Jabalpur (M.P.), India was studied by Srivastava and Pandey (2012) for drinking purpose. Similarly, Kumar and Priyadharshini (2014) analyzed ground water samples in Madurai and Virudhunagar Districts, Tamil Nadu, India and reported the presence of microbial contamination in water.

Physico-chemical and microbial analysis for drinking, borewell and sewage water in streets of Sivakasi was studied by Radhakrishnan et al. (2007) and reported the presence of bacterial count in drinking and borewell water samples. Estimation of drinking water quality parameters was evaluated at Bilagi, Bagalkot and Mudhol taluka of Bagalkot district by Kasturi et al. (2014). They reported 30% samples were contaminated with microbes and other parameters.
Seasonal variations of groundwater quality parameters in Ruiru, Kiambu, Kenya was assessed by Olonga et al. (2015) and reported significant difference between seasons for all the studied parameters, except for sodium and magnesium. Similarly, ground water quality assessment near Mehmood Bot landfill, Lahore, Pakistan was carried out by Ibisisam and Abdul (2012) and reported the non-potability of the ground water as per WHO standards.

Physico-chemical and microbial parameters of Narmada river water was assessed by Gupta et al. (2017) in Madhya Pradesh and reported excellent water quality in the summer and winter seasons and poor to unfit in the monsoon season.

Physico-chemical parameters and presence of indicator bacteria in river Gomti was assessed by Anukool and Shivani (2011) and reported that drains and industrial discharge was mainly responsible for pollution in river Gomti. Similarly, Smruti and Sanjeeda (2012) carried out a study on water borne pathogens in surface water in Indore, India and reported the presence of gram negative, non spore forming and rod shaped bacteria. The isolated strains were characterized and identified as E.coli, Enterobacter, Klebsilla, salmonella and Shigell in this study.

Antony and Renuga (2012) carried out bacteriological analysis of Ananthanar channel of Kanyakumari district, Tamil Nadu and reported the presence of Pseudomonas aeruginosa, Shewanella putrefaciens, Klebsiella pneumoniae, Citrobacter freundii and Proteus mirabilis. Similarly, a microbiological study was carried out by Acharjee et al. (2011) on supplied and treated water for drinking purposes in Dhaka city, Bangladesh.

Choudhury et al. (2016) studied physico-chemical and microbiological quality of Bahini River to check the suitability for drinking purpose and reported high TSS, total alkalinity, total acidity and BOD and high TPC. They also reported the presence of E. coli, Bacillus sp., Enterobacter sp., Klebsiella sp. and Pseudomonas sp in the water samples.

Okonko et al. (2008) analyzed physico-chemical and microbiological parameters collected from Abeokuta and Ojota, Nigeria state and reported water samples contaminated by coliforms organisms and high TPC for all the water samples. As per the results, the isolated organisms were Staphylococcus aureus, Salmonella species, Escherchia coli, Pseudomonas aerugionosa, Enterobacter aerogenes, Bacillus species, Proteus species, Klebsiella species, Flavobacterium species and Acinetobacter species.
Shittu et al. (2008) carried out physicochemical and bacteriological analysis of drinking water in Abeokuta, Nigeria and reported all physico-chemical parameters within limit while water was reported to be contaminated with TC and Salmonella, Shigella and V. cholera. Srivastava and Shivani (2011) monitored seasonal variation in physico-chemical and microbiological parameters in river Gomti for drinking and other domestic uses.

The physico-chemical, bacterial contamination and pesticides estimation in tap water samples in Gurgaon city was done by Nishta et al. (2012). Likewise, Battu and Reddy (2009) studied MPN test to detect the coliform in water samples of mobile vendors, well and municipal supplied water from Jeedimetla municipality and reported coliforms in few samples. The bacteria identified were Escherichia coli, Pseudomonas aeruginosa and Staphylococcus aureus in this study.

Rajiv et al. (2012) carried out physico-chemical and microbial analysis of different river waters in Western Tamil Nadu India. Similarly, a research has been carried out to study indicator organisms in water samples from mobile vendors, sweet shops and municipal supplied water by Chatterjee et al. (2007) and reported high coliforms mobile vendors. They also reported Escherichia coli in some water samples.

Potable water in Mysore city was assessed by Sunitha et al. (2013) and reported most of the water samples showed fecal contamination, TC (MPN/100 ml). Raw water of the river showed fecal contamination of Escherichia coli, Klebsiella pneumoniae, processed water with Salmonella typhi and sewage mixed water with Salmonella typhi, Klebsiella pneumoniae and Citrobacter freundii.

Physicochemical and microbiological quality of the household water and the prevalence of diarrhoea in Kumasi, Ghana were done by Boamah et al. (2015). They reported some of the physico-chemical parameters above permissible limit and water was contaminated by Faecal coliforms and faecal streptococci. Similarly, Bacteriological and physico-chemical analysis of drinking water supply of the Mahabubnagar district in Andhra Pradesh, India was assessed by Pindi et al. (2012).

Physico-chemical and microbiological analysis of water samples in Anakapalli municipal corporation (India) was assessed by Geetha et al. (2014) and reported physico-chemical characteristics of all water samples were within the permissible limit of WHO while TPC was above the limit. Tristaru (2011) studied the microbiological quality of water from water cooler dispenser and tap in Cyprus and
reported the dispenser water was comparatively polluted than the water samples from the tap.

Water quality of Ganga and Yamuna in Allahabad was assessed by Kaur and Verma (2014) before and after the Magh Mela and reported the physico-chemical parameters above permissible limits. Various pathogenic microorganisms were also isolated from the rivers water. Water quality of Shivnath river in Durg district was monitored by Belorkar (2010) and reported the presence of *E. coli* 0157 (Thermo tolerant strain) and *Salmonella* species. Microbiological analysis of packaged bottled water in Jaipur was assessed by (Gangil *et al.* 2013) and reported 50% samples unfit in SPC and on the basis of overall microbiological assessment 55% of samples proved to be unfit for consumption.

Seasonal variations of quality of utility water in Andhra University, Visakhapatnam was assessed by Jyothi *et al.* (2015) and reported TPC above the WHO permissible values. They also reported the presence of six isolates of bacteria namely *Escherichia coli*, *Enterobacteriaceae*, *Staphylococcus*, *Klebsiella*, *Salmonella* and *Shigella* families. Assessment of water quality parameters of Sukhna Lake in Chandigarh was carried out by Dadwal *et al.* (2012) and reported the values within the limit of CPCB and BIS range while TVC and TC values confirmed presence of coliforms in the lake water.

River water quality analysis in Nagapattinam district, Tamil Nadu, India was assessed by Sumathi and Manonmani (2016) and reported various pathogenic bacteria in river water. A study on water quality parameters of river Cauvery was carried out by Venkatesharaaju *et al.* (2010) for a period of two years and concluded that river water was not polluted with any of the parameters.

Adejuwon and Adelakun (2012) studied surface water quality parameters of Lala, Yobo and Agodo rivers in Ewekoro local Government area of Ogun state, Nigeria for drinking purpose and reported total alkalinity, total hardness, calcium, nitrate and calcium carbonate were above maximum permissible limit. And in bacteriological study, *Escherichia coli* were reported in river water. Giannoulis *et al.* 2004 reported the occurrence of total coliforms, faecal coliform and *Faecal streptococci* in drinking water samples of North Western Greece. According to them 1/3rd of the studied water samples were found not potable as per guidelines. They also reported the municipal load in ground water samples. Mostafa *et al.* (2013) discussed the unsuitability of well
water samples due to the presence of total coliforms, faecal coliforms and *faecal streptococci*. (Hassan and Nawaj, 2014) reported the occurrence of total coliforms, faecal coliforms, *E.coli, Salmonella* sp. and *Pseudomonas* sp. from ground water of different locations of Punjab in Pakistan. (Bisi-Johnson *et al.* 2017) recovered *E. coli, Pseudomonas* sp., *Klebsiella* sp., *Enterobacter* sp. bacterial diversity in the studied water samples of Nigeria and also reported occurrence of these organisms due to unhygienic and dirty condition of water storage. Edberg *et al.* 1996 conducted microbial analysis of drinking water and reported the presence of *Bacillus megaterium, Bacillus polymyxa, Bacillus firmus, Pseudomonas aeruginosa, Staphylococcus* sp., *Comamonas* sp. in bottled water, tap water and cooler water.

### 2.3 Hydro-geochemical characteristics in water

To explore the suitability of ground water for domestic purpose i.e drinking, geochemical characteristics were studied by (Madhav *et al.* 2018) in rural area of Sant Ravidas nagar (UP). Geochemical parameters studied were pH, total dissolved solids (TDS), total hardness, cations and anions. Based on piper’s diagram, it was showed that most of the samples belong to CaMgHCO$_3$ hydrochemical facies. Based on TDS, it was found that all the samples were within the range of desirable to permissible for drinking and agriculture purpose. Forty percent samples were reported nitrate content more than permissible limit. Ground water quality assessment of Madanpur Khadar, Delhi, India was assessed by (Kaur *et al.* 2015) and they reported about one fourth of the water samples were contaminated with coliforms. They also reported the water type of the samples as very hard on the basis of their CaCO$_3$ content. (Didar-Ul Islam *et al.* 2017) investigated the hydro geochemical characteristics of water samples and its potability. The physico-chemical parameters such as TDS, temperature, pH, EC, and major ions i.e., Na$^+$, K$^+$, Ca$^{2+}$, Mg$^{2+}$, Cl$^-$, SO$_4^{2-}$, NO$_3^-$, HCO$_3^-$ were studied. As per the findings of piper diagram and Wilcox plots, results showed that groundwater were not suitable for drinking and irrigational use. Likewise, suitability of ground water for drinking purpose in Pratapgarh district, India was assessed by (Tiwari *et al.* 2017). Physico-chemical parameters studied were pH, TDS, TH, Na$^+$, K$^+$, Ca$^{2+}$, Mg$^{2+}$, Cl$^-$, SO$_4^{2-}$, NO$_3^-$, HCO$_3^-$, F$^-$ and Cl$^-$. As per the results, it was found that HCO$_3^-$ and Cl$^-$ were the dominant anions, while cation chemistry was dominated by Mg$^{2+}$ and Na$^+$. As per the WQI range of 52 to 345, it was concluded that groundwater quality varied from good to unsuitable
for drinking. Likewise, seasonal variation of physico-chemical parameters and trace metals in ground water were determined by Ravichandran and Jayaprakash (2011). During hydrochemical investigation, it was reported that effect of seasonal variation does not change the order of abundance of cations and anions but it does change the concentration of various ions that are present in the ground water. Ground water in the study area was reported to generally hard, fresh to brackish and low alkaline nature. The unsuitability of ground water for drinking was identified in few places due to high total hardness and TDS. Hydro geochemical quality of ground water in Vedaranniyam town, Tamil Nadu was studied by Ramkumar et al. (2009) various hydro-geochemical plots such as Piper plot and USSL classification diagram.

2.4 Irrigational aspects of plant study

Anuradha and Rao (2007) studied the effect of cadmium toxicity on seed germination and seedling growth of radish (Raphanus sativus L.) and reported that seed germination was affected due to cadmium toxicity. Plant length, fresh weight and dry weight were also affected and induction of proline and peroxidase (POD) were enhanced which signifies the test plants are experiencing oxidative stress. Similarly, Beevi et al. 2012 studied the antioxidant properties of radish (Raphanus sativus L.) and reported the presence of polyphenolics and antioxidants in radish plant. Pell et al. 1993 reported the effect of ozone inducing stress on radish and suggested the influence of seasons and genotype of the plants to mitigate different stresses whereas Muthukumarasamy et al. 2000 studied the stress due to NaCl and reported the oxidative damage in radish plants due to NaCl induced stress.

Panuccio et al. 2014 concluded that saline water adversely affected seed germination followed by other growth parameters which include root length, shoot length, plant length and plant weight. They also reported the high antioxidant capacity of plants under salt stress. Further they also concluded the induction in total phenolic content in treated plants having NaCl and KCl salt based treatments.

Coleman et al. 1989 study the effect of stress on radish plant and concluded the induction of abiotic stress on radish growth parameters due to SO₂ exposure. Similarly, Begum et al. 2013 studied the abiotic stress of salts on plant growth and reported that crop production may be limited due to various environmental factors. They also reported that stress induced due to presence of salts affect different growth stages of the plants. Poor germination ultimately result into low desired yield and concluded that the
alteration in osmotic potential of plants due to presence of high sodium and chloride ions. Similarly, Jha et al. 2017 reported plant length of potato was decreased due to saline water whereas Stagnari et al. 2018 studied the response of radish against stress induced due to drought conditions and reported stress reduced root and leaves dry weight. Pandey et al. 2017 studied the effect of biotic and abiotic stress on plant growth and reported the adverse effect of various abiotic and biotic stress factors adversely affecting the growth and yield parameters.

Mondal and Gupta, 2015 studied the effect of fluoride and reported the reduction of chlorophyll and sugar in crops irrigated with water having high fluoride content. Biczak et al. 2017 studied on barley and radish and concluded the resistance of radish against 3 ionic liquids having variety of cations but reported the reduction of chlorophyll-a, chlorophyll-b and increase in chlorophyll-a/chlorophyll-b ratio due to increase in concentration of ionic liquids having fluoride. They also reported the induction in antioxidant enzymes due to occurrence of oxidative stress in both the test plants.