2. REVIEW OF LITERATURE

Western Uttar Pradesh characterized by fertile soils, medium rainfall and surface water resources. Irrigation is a pre requisite to meet the crop water demand. This requirement is to meet either from surface or under ground water. Most extensive use of ground water in the world is for irrigation of crops. The ground water in such area is mostly encountered with either in sufficient discharge and charged with excessive heavy metal varying proportion of cations waters leads good health of crop and yield and also deteriorate the chemical and physical properties of soils. The degree of adverse affect on soil properties and crop yields is the result of interaction of soil and under ground irrigation water quality.

It is rather difficult to monitor all the chemical processes in a complex system such as water soil plant system, while crops irrigating with poor quality water. The scope of this review therefore is to examine quality parameters of under ground irrigation water and their effect on physico chmical properties of the soil. Crop yield tend to become low and unprofitable, if proper quality of water is not used for irrigation, as excessive use of saline/sodic/specific ion toxicity water seriously deteriorate the crop growth and soil health.

In present chapter an attempt has been made to review the research work carried out by various workers on quality parameter in relation to salinity/sodicity, specific ion toxicity metal ion accumulation and ionic imbalance in under ground irrigation water and their effect on physico chemical properties of the soil.

I. Salinity/sodicity/specific ion toxicity

II. Toxic ion content

III. Metal ion accumulation

IV. Ionic imbalance

V. Pesticides accumulation
I. Salinity/sodicity/specific ion toxicity

Different sources of irrigation water in central western portion of Gangetic alluvial region of Uttar Pradesh were examined by Agrwal and Ganawar. The proposed scale was based on the EC and SAR value. Average chemical compositions of underground water were of medium salinity and low sodium hazard.

Hoon (1962) revealed that before introduction of canal irrigation in Kali east river ground water quality was poor and water table varied from 20 to 90 meters. Kanwar and Kanwar, 1968 concluded that increase in EC of irrigation water lowered the pH of saturation extract of the irrigated soil.

Singh and Bhumla (1968) worked on the effect of quality of irrigation water on soil properties and observed that the salinity of soil solution increased with the clay content of soil. The soils irrigated with waters of high salinity and SAR at Udaipur gave positive/additive trend in salinity and SAR exchangeable sodium percentage increased with increase of SAR. Paliwal and Maliwal,(1971) and Paliwal, (1972). Similarly, Lal and Singh, (1973) worked on various irrigation waters and found that an increase in pH of soil under high SAR or RSC was mainly due to sufficient increase in exchangeable sodium or excessive bicarbonate causing more hydrolysis effect.

Sharma (1980) studied the quality of ground water in Jind district of Haryana where nitrate content ranged from nil to 10.7 mg L. Deo and Lal, 1982 found relationship between different water parameters and reported that an increase in pH value with increase in SAR of irrigation water and decrease in pH value with an increase in salt concentration of irrigation water.

Maggar and Patel (1980) studied on saline water irrigation and its effection soil properties and found that at harvest stage of crop the SAR increased with increase in saline water irrigation in all three depths (0-15, 15-30 and 30-60cm) of soil due to higher amount of Na+ concentration than Ca++ and Mg++ (Gupta (1984) in Bikaner district found that the nitrate concentration was 37 per cent higher as compared with WHO standard for drinking water.
Investigation on the appraisal of the quality of underground water particularly with regard to soluble silica content was carried out by Goyal (1985) in Pali district of western Rajasthan. He reported that the dissolved silica was adsorbed almost instantaneously on fine and coarse texture used soil and adsorption. Increased strength of soil crust was found to be interrelated with higher amount of silica deposition from irrigation water. Very high degree of correlation ($r=0.983$ to $0.991$) was found between concentration of silicon in irrigation water and the soil crust force.

Rajpal et al. (1985) prepared a model to predict leaching and accumulation of total soluble salts in a sandy loam soil profile on redistribution as well as evaporation. A cycle of three irrigations with water of high salinity and sodium adsorption ratio (SAR) was used. There was a fair agreement between the predicted and observed values of EC, in various soil layers. Gupta (1987) analysed 43 ground water samples from Udaipur, Dungarpur, Banswara, Chittorgarh, Bhilwara and Bundi district of Rajasthan and found significant amount of nitrate content. The variation in nitrate content was found to be from 0 to 30 mg/l and average value was 1.12 mg/l.

The saline water with salinity higher than EC 8 dSm$^{-1}$ reduced the germination of wheat markedly which ultimately had its impact on crop production. The high salinity effect may be minimized by making favourable conditions for germination by controlling the salinity build up in seed zone (Chauhan and Singh (1987)). Gupta (1987) found that in case of high EC, SAR water, SAR of the irrigated soils depends primarily upon the ratio of EC/ SAR. He further reported that the values of EC and SAR of saline irrigation waters as well as saline water irrigated soils remain nearly the same year after year.

Effect of quality of infiltrating water on transient infiltration and soil water diffusivity was studied by Verma et al. (1987) in columns packed with a sodic black clay soil. Wetting front position and cumulative infiltration increased with increasing concentration of salts in infiltrating solution and decreased with increasing soil ESP. Soil water diffusivity ($D$) in the range of 0.15 to 0.35 g g$^{-1}$ moister content increased exponentially with salt concentration in the influent water at low ESP level. But linearly at high ESP levels water defucivity decreased with increase in ESP of soil.
Chauhan et al. (1988) worked on underground water of Mathura district and observed the worked out multiple correlations between water quality parameters and soil characteristics. They reported that salinity buildup in soil was positively correlated with salinity of water, while pH was influenced by EGW and RSC, and SAR in and RSC below and above 18 SAR of water respectively. Similarly Khandelwal et al. (1990) observed that salinity of irrigation water had positive effect of soil salinity while pH of saturation paste decreased significantly with an increase in E.C of irrigation water.

The soil electrical conductivity (ECs) and SAR increased after three years with the increasing SAR levels of irrigation water. The SAR decreased significantly with the application of gypsum at 100% requirement level but soil pH remained unchanged (Ali et al. (1991) and Abbas et al. (1991) Singh and Anand) (1991) reported that in general, ground water of Jhunjhunu district was suitable for drinking purpose, although samples from some location had content of nitrate fluoride and total dissolved solids excluding 100, 30, and 3000 mg. respectively Ground water quality did not appear to be affected by effluent from local copper mines.

Barambe et al. (1992) observed that SAR of ground water decreased during rainy and winter seasons and increased during summer, whereas salt concentration (EC) and Chloride (CL) remained unchanged. SAR, EC and pH values were higher in command area as compared to unirrigated area throughout the year. Sulphates and carbonates were highest in June and decreased in rainy and winter seasons while bicarbonate followed reverse trend.

Studies on use of saline water (6 dSm\(^{-1}\)) in conjunction with good water on vertisols showed that with the increase in saline water irrigation increased the EC\(_2\), Na+ K+ and SAR of the soil, whereas pH and Mg++ contents was unaffected and Ca++ content of soil decreased (Patil et al. (1992)). It was also observed that the yield of green gram was significantly and negatively correlated with EC Na and SAR, whereas, Ca++ was significantly positively correlated at harvest.
Singh et al. (1992) found that increasing levels of adj. SAR of irrigation water increased significantly the EC, SAR, ESP and pH of the soil, while decreased plant height, effective tillars and grain and straw yields of wheat.

In Saudi Arabia, Al Jaloud and Hussain (1993) used chemical composition data to clarify the ground waters. The mean water composition for different water quality parameters ranges were EC, 1.56-8.24 dSm\(^{-1}\), TDS 1200-4860 mg L\(^{-1}\), SAR 310-1253; Ca\(^+\), Mg\(^{2+}\) ratio, 0.80-3.15; and Cl: SO\(_4^{2-}\) ratio, 0.49-3.68. Sodium was found to be the most abundant cation followed by Ca\(^+\), Cl, and SO\(_4^{2-}\) were present in a balanced proportion, followed by HCO. The water was classified as C\(_3\) S\(_1\) to C\(_u\) S\(_u\), i.e. a category of high to very high salinity and low to very high sodicity problem water.

Patel et al. (1993) worked on poor quality well waters (EC 4.4 to 6.9 dSm at shil farm and 4.49 to 6.4 dSm at Metra farm) at Junagarh with and without FYM. The results showed that frequent irrigation (8 days interval) of more depth (6 cm) in the presence of FYM significantly increased grain and straw yield of wheat and fodder yield of many over less frequent irrigation and without. FYM. The more depth of irrigation significantly reduced the EC of the sub soil layers. However, application of FYM significantly increased ESP of surface layer after monsoon.

Singh and Bishnoe (1993) conducted a survey of the quality of underground irrigation water from 11 villages in Barnala Tehsil of Sangrur district of Punjab. Soluble carbonates, bicarbonates and RSC were 3.6-9, 1.2-12.9 and 0-16.6 ml/l respectively and results indicated that continued use of at least 68% of underground water was expected to build up excessive sodium saturation. Soluble sodium ranged from 0.1 to 18.7 me L and it was the dominant cation and SAR ranged 0.1-23.5 with 95% of samples having low alkali hazard, contradicting results from RSC. Based on both EC and RSC 32, 38 and for irrigation, respectively. EC was significantly correlated with RSC for all blocks.

Two hundred twenty water samples were collected from running tube wells from 5 villages viz Tihara, Shahpur, Asalwas, Karnawas and Bawal in Mahendragarh district of Haryana State. Each water sample was analysed for electrolyte conductivity, cations (Na\(^+\), Cu\(^+\), Mg\(^+\)) and also anions (Cl, HCO\(_3\) and CO\(_3\)) RSC and SAR were also
calculated. On the basis of results, the water samples were clarified into 5 categories viz. good, normal, sodic, marginally saline and saline sodic. The water sample percentage of Tihara, Shahpur, Bawal and Asalwas was found suitable (Good and Normal) for most of the crops were 100, 57, 54 and 38 respectively. In contrast, 100 per cent of water samples from Karnawas village belonged to marginally saline and saline sodic categories of ground water quality. As regard the distribution of sodic waters, about 52% belonged to this category in Asalws village followed by Shahpur (43%) and Bawal (27%). The proportion of saline and or sodic waters was maximum in village Karnawas (100%) , followed by Bawal (19.4%) and Asalwas (9.5%) Tekchand et al. (1993) Quality criteria, for various uses of water established on the basis of field experience and experiments were compiled by Tondon (1993) and U. S. Salinity Laboratory.

At Central Soil Salinity Research Institute Karnal, Gupta et al. (1994) compiled the ground water quality survey work conducted by various centers of the All India Coordinated Research Project on “Management of salt affected soils and saline water”. Based on the characteristics features of ground water in use with the farmers in different agro- ecological regions and the indices which describe their salinity, irrigation waters can be broadly grouped into (i) Eciw>2 and SAR<10 (iii) High SAR saline Eciw>4.0 and SAR >10 and (iv) alkali waters, EC in variable, SAR variable and RSC>2.5.

A study was conducted in a sewage farm of the Madurai Corporation by Mathan (1994) to compare the effects of sewage- effluents and well water irrigation on physical properties of soil. The soil was sandy loam and had been irrigated from 10-15 years. Results indicated that soil irrigated by well water had significantly highest bulk density 32-1.58 mg/m$^3$ and compared with sewage effluent whereas, hydraulic conductivity which was 9.1 cm/hr in well water irrigated soils, increased to 13.5-16.5 cm/hr. in sewage effluent irrigated soils.

Palaniswani and Sheeramulu (1994) worked on use of paper factory effluent pH 8.3, EC 1.9 dSM$^{-1}$ and SAR 7.6 as irrigation in sugarcane crop and effect on soil properties. It was noticed that pH and EC of soil available micronutrients and enzymatic activities in the soil increased slightly. This was possible because of nature of soil as well
as high yields of sugarcane, which resulted in heavy removal of most of the elements from the soils.

Twenty six synthetic water samples containing various proportions of Ca$^2+$ and HCO$_3^-$ ions (prepared using salts of NaHCO$_3$, NaCl and CaCl$_2$) and four natural water samples were analysed by Sharma et al. (1994) for their ionic composition and ionic strength before and after saturation with CaCO$_3$. Twenty three water samples resulted in positive values of saturation index, leading to increase in their SAR after equilibration with CaCO$_3$. The effect of ion complexation on SAR was negligible. Singh and Bhargarva (1994), while working water transmission function in soils observed that soil water diffusivity increased with increasing salinity of water. Difference in soil water diffusivity brought about by different salinity levels of water was greater in clay than in sandy loam soil and near saturation; highest soil water diffusivity was observed in sandy loam and the lowest in clay soil.

Yaduvanshi (1994) reported that EC and concentration of cations and anions and ESP values in soil increased progressively from the end of the rainy season till the summer season. ESP value of the surface soils did not exceed the safe limit of 15. The salt balance of total added salt increased with an increase in the salinity of irrigation waters which ranged within an average EC value of 8.37 µs/cm$^{-1}$.

Gupta and Jain (1995) reported that nitrate content in most of the underground water was more than permissible limit of 45 mg/l. Nitrate content of more than 20 mg/l in drinking water or in food material of childrens gave ill effects on health by reducing the oxygen absorption capacity of red blood caruples. High nitrate content in drinking water also gave bad effects on stomach. They reported that 40-60 per cent water samples contain nitrate more than 50 mg/l. In Nagaur district, 32 per cent water samples comes under the category of more than 250 mg/l followed by Bikaner and badmer (23%). The man causes of increasing nitrate content in underground water are increasing doses of nitrogenous fertilizers and atmospheric nitrogen through rains Gupta et al. (1995) worked on conjunctive use of 1000 quality ground water with fresh water and found that a decrease in the pH, EC, CO$_3^-$+HCO$_3^-$ soluble Na$^+$ and SAR value and increase in the Ca$^2+$ +Mg$^2+$ and Cl content in the surface soil as compared to initial soil properties. The yield
data showed that 2 canal water and 1 tubewell water irrigation treatment was as good as canal water only.

Padole *et al.* (1995) noticed that grain yield of wheat decreased when crop was irrigated with highly saline or sodic water (4.0-4.2 dSm$^{-1}$ and SAR 1.7-8.6). Uptake of sodium was increased up to a medium salinity or sodicity of soil or irrigation water.

Purushothaman *et al.* (1995) concluded that various agronomic and irrigation management practices are necessary to minimize the poor water quality hazard for sustained crop production.

Brar and Bajwa (1996) reported that increase in rations of HCO$_3}$/Ca$^{2+}$, HCO$_3}$/Mg$^2+$ and HCO$_3}$/Ca$^{++}$+ Mg$^{++}$ and salt concentration in irrigation water increased the SAR, ESP and value of different selectivity coefficient ($K_gK_v$ and $K_{KDG}$). The increase in SAR and ESP was more under HCO3/Ca2+ system followed by HCO3/Ca2++Mg2+ and HCO3/Mg2+. Increase in total electrolyte concentration increased the ARNa. ESR, ESP and decreased the values of different selectivity coefficients.

Mnihas (1996) worked on saline water management and reported its benefits with frequent irrigations, the amount of water applied per irrigation needs to be reduced. Tolerance limits of crops to be use for saline water should be followed strictly. Additional doses of P$_2$O$_5$ to evaluate the effects of chloride toxicity and the use of organic materials to enhance the efficiency of applied nitrogen are recommended under saline irrigated conditions. Gypsum is needed for soils when these were irrigated with saline water with an Mg:Ca ratio 73 and rich in silica.

Palamiaphom and Yerrswamy (1996) observed that salinity of irrigation water had some adverse effect on yield of Robusta banana. Reduction in yield was attributed to decreased girth, number of leaves and also due to imbalance in nutrient of N.P.K. and Ca. Nutrient concentrations of N, K, Ca, Na, Mn, Fe and Cl in the leaves significantly varied due to use of saline water. Salinity threshold value of irrigation water at which 25 and 50 per cent yield decrease was found to be 3, 4 and 5.7 dSm1 respectively.
Abdel-Aal *et al.* (1997) Studies 217 representative underground water samples in central Saudi Arabia. The water quality parameters showed (i) water salinity ranged from 210-8200 ppm with an average of 2375 ppm [i.e. 16.6 and 83 + salt/ha deposited in soil per season for wheat and Lucerne (medicago sativa) cultivation] (ii) Extensive water extraction caused a significant increment in $SO_4^{2-}: Cl.$ ratio.

A detailed survey of underground irrigation water of 61 villages 484 samples was carried out by Bishnoi *et al.* (1997) soluble sodium varied from 0.21 to 11.4 MeL with a mean value of 4.67 on the basis of residual sodium carbonate (R.S.C.) 50, 31 and 19 per cent of samples were graded in fit, marginal and unfit categories, respectively, Saluble carbonates and bicarbonates in there water varied from nil to 5.6 and 1.2 to 14.0 me L1 with mean values of 1.52 and 5.87, respectively. The potassium and sulphate content varied 0.08 to 2.08 and 0.02 to 2.96 mg/l, respectively.

Kaur and Thukral (1997) worked on physico chemical study of water of water logged area of Rawatsar ( Hanumangarh) and found that due to high concentration of salt of Na$^+\text{Mg}^2+\text{Ca}^{2+}\text{Cl, SO}_4^{2-}\text{CO}_3^3\text{HCO}_3^3$ reduced the permeability of soil by reducing the pore size, decrease the in infiltration rate of water and hydraulic conductivity at surface. Kumar and Bajwa (1997) studied on conjucutive use of different saline irrigation water (EC 3 and 6 dSm1 and SAR 5 and 30) and good quality canal water (EC 0.4 dSm1). It was reported that use of saline water alone significantly increased salt buildup in soil and decreased growth of crop. Use of canal water in conjuction with saline waters resulted in appreciably lower buildup of ESP in soil. Similarly, Al-Habulsi (1998) also reported that salinity of the soil extract and SAR increased noticeably as irrigation water salinity increased. The distribution of salts through the soil profile was highly positively correlated with the applied amount and salinity of irrigation water.

In Yugoslavia, Dragovic *et al.* (1998) observed increased salt concentrations in heavy soil with a irrigation water of 3 dSm1 Ec. Significant increase was also found in SAR, Cl and $SO_4$ content.
The effects of waste water irrigation on groundwater quality in Mexico were studied by Gallegos et al. (1998). The samples of underground water were analysed for a range of physic-chemical and microbiological parameter. It was reported that waste water irrigation has had a negative impact on ground water quality.

Water samples from different sources (rivers, streams, nallah, tubewells and hand pumps) in Jammu region were collected and analysed by Guptal et al. (1998) for quality parameters. The majority of water samples were suitable for irrigation purposes. However, the tubewell and hand pump water samples showed high values of RSC and were not suitable for irrigation.

Lal et al. (1999) worked on underground irrigation water of Bikaner district and found that 81.3 per cent water samples showed RSC less than 2.5 mmol/L, whereas 16.3 and 2.4 percent water had RSC between 2.5-5.0 and 75.0 mmol/L, respectively. On an average 32.6 per cent water samples fell under the category good, whereas 16.3, 12.8,17.4,4.1,9.3,4.1 and 3.4 percent samples were under marginally saline, high SAR saline, high SAR non saline, marginally alkali, and highly alkali, respectively. Regarding EC, 11.0,43.0, 29.7 and 16.3 per cent samples were found to have EC <1.0, 1.2, 2.4 and >4 dSm^{-1} respectively. Salinity and SAR of tubewell water were positively correlated with EC and SAR of soil.

Sood et al. (1998) worked in underground water of Bhatinda (Punjab) and found that EC of underground water varied 0.55 to 3.71 dSm, soluble carbonate nil to 3.2 bicarbonate 2.0 to 17.7 and RSC nil to 14.6 meq/L, respectively. Soluble sodium (3.0 to 90.1 meq/L) was the predominant cation and sodium adsorption ratio (SAR) ranged from 2.3 to 31.3. Based on EC and RSC of the waters 15, 38, 12, and 35 per cent samples were good (low EC and RSC), marginal saline, marginal sodic and poor (high EC and RSC), for irrigation purposes, respectively.

Chemical parameters of water for public health point of view includes pH, electrical conductivity 9EC, total dissolved solids (TDS), chlorides, fluorides and nitrates. These parameters studied were by Saxena and Chhabra (1998) at Bikaner Rajasthan. It was found that pH of groundwater ranged from 8.174 to 9.91 indicating alkaline in
nature. Moreover, a strong positive correlation was evident among EC, TDS, Chloride and nitrate and between TDFS and Fluoride. Fluoride concentration was greater than maximum permissible limit of 1.5 mg/L in more than 50% water samples of Barmer and Jalore districts.

Xiao-Zhen Hua et al. (1998) studied the effect of irrigation water quality on soil hydraulic conductivity. Results showed that the higher the mineralization of irrigation water, the greater the soil hydraulic conductivity become. A high SAR value of irrigation water would have an unfavourable effect on soil hydraulic conductivity.

Quality parameter of 211 and tubewell water samples of Sriganganagar and Haumangarh districts of Rajasthan were studied by Yadav et al. (1998) and concluded that 26.2 per cent under ground water samples were found unsuitable for irrigation being highly saline (12.9%) and highly alkaline (13.3%). Whereas marginally saline, saline and marginally alkaline water were 21.9, 12.4 and 5.2 per cent, respectively.

The quality parameters of underground water of Faisalabad, (Pakistan) were studied by Khurshid et al. (1999). It was found that water from all the localities had high chemical oxygen demand (COD), sodium and potassium. Most of the other parameters were with in the permissible limit with a few exceptions.

Subba Rao (1999) reported very high nitrate concentration in ground water of Churu and Jaipur districts of Rajasthan whose were 530 and 180 mg L\(^{-1}\), respectively. Tripathi and Kumar (1999) found that soil salinity was a major agriculture problem in arid and semi arid region where water salinity decreased the survival percentage of seedling after the salinity level of EC 4.3 dSm and plant height after 8.9 dSm\(^{-1}\).

A study was carried out by Chaudhary and Somawanshi (2000) to quantity the effect of SAR and total electrolyte concentration (TEC) of equilibrating solution on water retention characteristics and water constants of clay, clay loam and silt loam soils of Maharashtra. Water constants were studied as drainable water (DW), available water (AW) and residual water (RW). A spectacular rise in AW was recorded with increase in SAR and decrease in TEC. Such increase in AW was associated with sharp decline in
However, influence of water quality on RW was marginal. SAR of equilibrating solution was found to be highly effective as compared to TEC.

Majumdar and Balai (2000) recorded that EC and soil pH increased, while exchangeable K content of the soil decreased, with increasing SAR of irrigation water. Plant height and grain and straw yield of wheat decreased with increasing SAR levels of irrigation water. Similarly, Raghuwanshi et al. (2000) found that grain and straw yield of wheat decreased with the increase in EC of irrigation water. An increase in EC in from 4 to 6 dS/m increased the EC of saturation extract, water soluble cations and anions, SAR and ESP. The Ece, water soluble cations and anions, SAR and ESP of the soil also increased with increasing SAR of irrigation water.

Integrated geological, hydrological (surface and ground water) and geochemical studies were conducted by Reddy et al. (2000) for the development and management of water resources in Cuddapah district of Andhra Pradesh. Ground water assessment studies show that 584 million m3 of groundwater was available for future irrigation. From the chemical analysis, the quality of ground water was with in the permissible limits for irrigation and domestic purposes, but at a few places chloride and fluoride contents were high.

Singh et al. (2000) collected underground water and soil samples for qualitative studies in Jhunghunu district of Rajasthan. Irrigated soils showed slightly higher EC and pH than unirrigated due to continuous irrigation with saline sodic water. The EC of irrigation water had significant positive correlation (r=0.885) with EC of irrigated soils.

A study was conducted with fine loamy mixed calcareous soil to determine the effect of combinations of chemical amendments. Crop species and irrigation water quality on Na+ and salt leaching from salt affected soils (Baudor and Brock) (2001) was concluded that irrigation with high SAR high TDS water increased the soil solution EC to approximately 5.5 dSm but did not decreased crop yields relative to irrigation water having SAR and TDS of 0.37 and 747 mg kg-1 respectively mg+ displaced Na+ on the exchange complex, but the effects were short term compared to casoucer P-CaSO4, Bharambe et al. (2001) worked on water fluctuations, quality of groundwater and the
changes in physico chemical character of soil. They concluded that groundwater was
deep during June and canal water closer periods and rose during rainy season (July-
October) and canal opening periods. EC and SAR value were higher in command than
the non command area. However, the difference in EC and SAR were non significant.

Das and Maji (2001) worked on seasonal fluctuation in salinization of soil and
groundwater quality at CSSRI coming town. West Bengal and found that ground water
depth varied from 0 (at surface) to 1.58 m and salinity decreased from June
onwards attaining minimum (0.65-4.26 dSm-1), during July August increasing from
November onwards and reaching maximum during March-May. During May the EC of
ground water varied from 1.87-26.90 dSm from one location to another. The SAR of the
fround water also showed the trend as observed in Ecw. Presence of Mg2 in excess and
its subsequent enrichment during March to May consequently reduced SAR.

Longterm experiment conducted by Phogat et al. (2001) at Rohtak (Haryana) on
conjunctive use of sodic under ground and canal water in rice wheat system, to safe use
of pre dominantly sodic ground water for sustainalble crop production. The quality of the
canal water was EC 0.35 to 0.65 dSm1 and RSC 0.3 to 1.5 meL-1. For the sodic water, it
was EC 1.00 to 1.35 dSm-1 and RSC 8.9 to 11.8 meL-1. There was a varied fall in the
productivity of the system (1.3 to 84.5%) over a spell of 4 years due to the use of sodic
water alone as well as in conjuction with canal water. The adverse effect on wheat was
not a cut as compared to its effect on Rice crop.

Interactive effects of irrigation water salinity and soil fertility on the salinity and
sodicy buildup in soils was studied by Prasad et al. (2001). It was concluded that the
sustained use of slaine water increased the pH, Ece and SARe of irrigated soils. The
lower value of Ece and SARe and higher value of soil pH in the root zone of irrigated
soils was recoreded at the end of monsoon season than at the onset of monsoon.

Nayak et al. (2001) worked on conjuctive use of saline groundwater with best
available water in mustard crop at Anand (Gujrat). They found that seed yield of mustard
decreased by out 15, 35, and 62 per cent, respectively, at EC 4, 8 and 12 dSm-1 levels of
salinity as compared to best available water and one irrigation with saline water. With the
application of irrigations with saline water the reduction of seed yield was 58, 79 and 82 per cent respectively at 4, 8 and 12 dSm-1 water salinity as compared to best available water. The maximum salinity (0.8 dSm-1) and SAR (29.5) of soil were found at the time of harvest with the increase in frequency of saline water irrigation.

A detailed village-wise survey of Ludhiana district (Punjab) was carried out by Singh and Bishnoi (2001) for assessing the contribution of nitrogen and sulphur from underground irrigation waters. For this purpose 3897 random water samples were collected from 736 villages from covering tubewells in a way that almost all the area of the district was covered. It was found that sulphate concentration varied from 0 to 7.58 meL with a mean value of 1.02 Distribution of water samples in different categories according to sulphate concentration shows that 33, 40, 19 and 8 per cent samples contain <0.5, 0.5-1.0, 1.0-2.0 and 72.0 meL-1 SO42-, respectively. This means that use of such waters will add <24, 24-48, 48-96 and >96 kg S per hectare foot of irrigation. Nitrate nitrogen concentration of there water samples ranged from 0 to 25.45 mg L-1 with a mean value of 5.10. The data show that about 26, 36, 24 and 14 per cent water samples contained nitrate nitrogen less than 1-5, 5-10 and more than 10 mgL-1 and there will add less than 3, 3-15, 15-30 and than 30 kg nitrate nitrogen per hectare, foot of irrigation water.

Somasundaram et al. (2001) worked on quality management of irrigation water through native tree materials and observed that a treatment of alkali (High RSC) water with amla tree dried lopping improved the quality of irrigation water Na and K concentrations increased leading to slight increase in electrical conductivity.

Bulk density of soil marginally decreased but saturated hydraulic conductivity increased substantially with an increase in salinity of irrigation water (Agrawal et al. (2001) ). Increase in salt was observed due to an increase in salinity of irrigation water and frequency of irrigation.

Kaushik et al. (2002) studied the ground water quality in Hissar and Panipat (Haryana) for drinking purpose based on water quality parameters like pH, EC, turbidity, TDS, alkalinity, total hardness, calcium, magnesium, sodium, potassium chloride, nitrate,
phosphate, sulphate and fluoride with respect to different landuse are viz residential, industrial, commercial and agricultural. Water quality index based on 9 parameters showed that at Panipat underground water in all the land use zones was fit for consumption (water quality index <50), whereas at Hisar, water in agricultural areas good in quality, but that in other areas varied in magnitude of pollution (water quality index >50 to 100).

A total of 133 ground water samples collected by Latha et al. (2002) from different places of coimbatore district (Tamil nadu) and analysed for water quality parameters. The EC of water sampler ranged from 0.54-4.50, 2.27-9.95 and 0.2-2.7 dSm-1 of Avinashi, Pollachi and Palladam places respectively. The highest SAR of 34.20 was observed in Pollandam samples water samples with RSC ranging from 5.0-7.5 meL-1 and EC>3 dSm-1 were unsuitable for irrigation.

The intrusion of sea water into ground water was estimated by Mahendran and Chalan (2002) in costal belt of Radhapuram taluk (Tiruneveli distridt Tamil nadu) in Tamil nadu. The pH of the well waters ranged from 7.5 to 7.9. conspicuous increase in SAR of well water was observed during summer months (April to June) and it decreased thereafter. The well waters were affected by sea water intrusion as evidenced by the cation sequence following the order Na+>Mg2>Ca2>K+ and the anion sequence Cl>SO\textsubscript{4}>HCO\textsubscript{3}. Therefore there water unsuitable for irrigation purposes.

Mamedov et al. (2002) conducted three interrelated experiments in order to evaluate the effect of waste water (WW) and fresh ground water (FW) on infiltration runoff and soil loss. Results showed that efficiency of irrigation with FW and WW in changing hydraulic properties and erosion rigidly depends on rain intensity. Irrigation with WW decreased infiltration rate and increased soil susceptibility to realing processes compared with FW irrigation. Soils irrigated with WW found to be more sensitive to rain energy and waiting rate.

Ninety five water samples were collected from dug wells motor pumps, water works department, canal and Tanks by Mehruinsa et al. (2002) in Tharparkar (Pakistan) district to investigate the quality parameters. It was found that most of the samples were
contaminated with coliform bacteria had higher TDS, pH, EC hardness, alkalinity, iron and manganese and phosphate concentrations compared to the standard permissible limits.

Pannu and Swami (2002) worked on distillery effluents at Sriganganagar and reported that treated effluents improve the micronutrient status in soils but on the other hand they also deteriorate. The physical and chemical properties of irrigated soil, by increasing the concentrations of organic pollutants and high BOD and COD values.

Singh et al. (2002) studied the effect of canal and sodic irrigation water on quality of potato and found that N, P, and K contents in tubers were highest in canal water and lowest in sodic water irrigation. Srudevi, 2001, found that groundwater levels water from wells for irrigation and domestic uses. Ninety nine ground water samples were analysed and found that all major chemical constituents, such as Ca, Mg, Na, K etc. are significantly increased after post monsoon recharge.

Groundwater samples in and around Tiruchiraphalli city (Tamil Nadu) were analysed for drinking purpose by Jameel. Most of the water bodies were found to contain high level of inorganic salts and total hardness with high electrical conductance resulted in unsuitable for drinking purpose. The high level contents of the parameter observed may be minimized, if the ground water is recharged with available storm water in rainy season.

Kumar and Sharma (2002) while working in All India Coordinated Research Project on saline water collected the underground water samples in Uttar Pradesh with special reference to districts like Fatehpur, Unnao and Kanpur. The result revealed that 75.8% water samples were of good quality, 8.6% marginally saline, 2.4% saline, 13% marginally alkali and 0.2% samples were alkali in nature. it was also found that if salt concentration increased, there was relatively higher increase in Na+ as compared to Ca^2+ and Mg^2+ concentration.

Dhillon and Dhillon (2003) worked on quality parameters of under ground water and reported that with respect to RSC ratings, 86% of samples were marginally fit and 12% of the samples were unfit for irrigation purposes. Whereas, on the basis of TDS, all
the water samples were found to be suitable for irrigation. Selenium content of tubewell water at or near the toxic soils ranged between 0.25 and 69.5 µg/L with an average value of 4.7µg/L.

Mishra et al. (2003) studies the quality parameter of underground water in Keonjhar district of Orissa. It was concluded that the water samples well within the prescribed limit. PH and EC values ranges from 6.5 to 7.67 and 138.4 to 326 mmhos/cm respectively. The prescribed limit for EC, 300 µs/cm in as prescribed by USPH, for drinking water. Total solids (TS) range from 111 to 2001 mg/L, Total hardness of water ranges from 56 to 93 mg/l. The ICMR standards recommended a permissible limit of 300 mg/L. Chloride, which have been associated with pollution as an index is found below the permissible value at 250 mg/L. Fluoride content varied from 1.89 to 3.12 mg/L, while permissible value is only 1.5 mg/L.

Ground water of Churu district was evaluated by Verma et al. (2003) Five hundred fifty six groundwater samples were collected and analysed various quality parameters. The EC pH, SAR and RSC of water samples ranged from 0.4 to 19.7 dSm-1, 7.2 to 9.3, 2.2 to 33.5 (mmolL-1) and nil to 13.1 miL-1 respectively on an average 26.6 percent samples were categorized as good, whereas 15.3, 4.9, 28.7, 4.3, 0.2 and 20.0 percent samples were marginally alkaline, alkaline and high alkaline, respectively.

Sharma and Minhas (2004) evaluated the long term effects of irrigation with water varying in residual alkalinity (RSC 5 and 10 meL-1) salinity (Eciw 2 and 4 dSm-1), sodicity (SAR 10, 20 and 30 mmolL-1/2) and ionic composition (HCO₃ vs Cl-SO₄) in lysimeter filled with loam soil. The crop rotation was cotton wheat for initial 4 years followed by pearl millet wheat for another 7 years. Build up of sodicity (SARe) in soil in general was more where water of high salinity but of similar SAR were used. Sodicity was more with HCO₃ type water as compared with Cl vs SO₄ ones. Increase in soil pH was related to RSC rather than to SAR. Progressive buildup in salts Ece 1.25-5.8 dSm sodicity, SAR 5.6-38.5 and soil pH (8.10-8.66) monitored during cotton wheat rotations were either curtailed or even got reduced as a consequence of shifting to pearl millet wheat rotation. Sodicity build up was also related to duration of irrigation both in cotton and wheat.
II. Toxic ion content

Fluoride and boron are most common toxic ions of ground waters. Fluoride occurrence in groundwater is a natural phenomenon influenced by the local and regional geological setting and hydro-geological condition of the region. This problem is very serious in India and other such developing countries because major portion of population living in rural areas have to depend on available ground water sources for their day to day water requirement. Modern agricultural practices, which involve the application of fertilizers coupled with pesticides, which contain about 1-3% of fluoride, also contributes the fluoride to the groundwater (Anonymous, 2000). Boron is the most toxic ion and least toxic ion like fluoride. Groundwater arsenic (As) contamination in West Bengal was first reported in December 1983. The discharge of untreated industrial effluents is one of the most significant polluting agents for cadmium, chromium and arsenic in aquatic ecosystem and irrigated lands. There toxic ion reached in human stomach through water, plant, cattle and human pathway. Rao and Bhaskaran (1964) observed fluoride containing water in Kurnoral district of Andhra Pradesh. The reported 0.1 to 6.00 mgL-1 fluoride in waters and no correlation between the fluoride content and depth of wells Kanwar and Mehta (1968) reported toxic concentration of Fluoride in 91 per cent samples of Punjab and 10 per cent samples of Haryana. The results of groundwater samples of Bhilwara (Rajasthan) analysed by Paliwal et al. (1970) revealed that irrigation water contained a range of 2.1 to 24.0 mg L-1 fluoride. Fluoride content in soil was significantly correlated with EC, SAR and boron content of well waters. Paliwal (1972) has reported higher concentration of B in irrigation water of several districts of Rajasthan. Somani et al. (1972) observed that well water of Nagaur and Jaipur districts of Rajasthan contained 4.5 to 28.1 mg/L. fluoride with a mean of 5.5 mg/l. In Udaipur district of Rajasthan, the ground water contained the fluoride in the range of 0.15 to 21.6 mg L. with a mean value of 4.5 mg L. It was also noted that fluoride content of well water increased with the depth of well (Somani, (1974)). Singh and Sinsinwar (1975) observed positives correlation of fluoride with depth of water table. EC and sodium content in water. Somani (1977) found that there was no significant effect of fluoride on the growth of wheat up to a concentration 10 mgL-1. Mishra et al. (2006) reported a higher F content in shallow (0.6 to 2.5 mg/L) and deep (0.1 to 1.5 mg/L) aquifers of gangetic alluvial plams in India,
enrichment of F in ground water due to dissololation of acid volcanic rocks. Singh and Randhawa (1978) studied fifteen soil profiles in Maler Kotla black of Sangrur district of Punjab for ascertaining the distribution on water soluble fluoride in surface and sub surface soil layers. Seventeen underground water samples from these soil series were also examined for fluoride content. The mean value of water soluble fluoride for saline sodic, sodic and normal soils was found 2.81, 1.67 and 1.30 mg kg\(^{-1}\) respectively. The water soluble fluoride was positively correlated with pH, EC CaCO\(_3\) and silt clay but negatively correlated with sand. Singh et al. (1979) reported that the dry matter yield of rice decreased significantly with increasing levels of fluoride in the soil and decrease was more in high ESP soils. They also observed that fluoride content in wheat straw increased with increasing levels of fluoride in soil. Chhabra et al. (1980) found that water extractable fluoride increases with increase in soil ESP and pH. Sinsinwar et al. (1981) collected 134 ground water and soil samples from Sriganganagar district North West desert belt of Rajasthan and analyzed for their fluoride content. Fluoride content in water and soil samples ranged from 0.10 to 28.2 mgL\(^{-1}\) and 2.02 to 4.48 mgkg\(^{-1}\), respectively, water soluble fluoride with fluoride content of water. Malik et al. (1987) found that absorption of fluoride in a Ca\(^++\) saturated round increased with increasing level of CaCO\(_3\) at all equilibrium fluoride concentrations.

Khandelwal and Lal (1990) found that Ece of loamy sand and sandy soilam soils were less than EC of corresponding irrigation water. On an average, the Ece of loamy sand soil was 75.17 and 69.92 per cent of EC of water having EC 3 and 6 dSm\(^{-1}\), respectively. The corresponding figure for sandy loam was 104.17 and 94.17 per cent, respectively. Values increased with increase of clay content of soils. It was also reported that grain and straw yield of wheat increased with and increase in the boron content of irrigation water up to 2.5 ppm, but beyond 15 ppm, a significant reduction in yield was observed. This increase took place due to the fact that application of water containing 2.5 place due to the fact that application of water containing 2.5 ppm boron raised the boron content of saturation extract to a level of about 1.5 ppm (favourable limit). Singh and Bishnoe (1993) analysed the underground water samples of Sangrur district (Punjab) and found that soluble boron ranged from 0-2.5 ppm They found only 2.7% samples unfit for irrigation and drinking purpose due to high boron content. Fluoride ranged from 0.1-3.8
ppm with 69% samples having >1 ppm fluoride which is the critical limit for drinking water. Levels of potassium (0.1-1.6 mgL\textsuperscript{-1}) and sulphate (0-4.5 mgL\textsuperscript{-1}) were recorded, which were considered beneficial for plant growth.

Totamat (1993) collected the under ground water samples from wells scattered around the effluent stream of zinc smiltor at Udaipur to evaluate the effect of the effluent on ground water quality. He reported that the EC of well waters adjoining the effluent stream/river was high ranging 3.15 to 5.60 dSm\textsuperscript{-1} for used situated for off from stream/river. The under samples contain much higher level of cadmium (0.039 to 0.091 mg L\textsuperscript{-1}) than the permissible limit for irrigation water (0.01 mgL\textsuperscript{-1}) and for drinking (0.005 mg L\textsuperscript{-1}) in pre-monsoon samples above the permissible limits for irrigation. Fe content of well water drawn prior to monsoon revealed that almost all the wells situated with in 255 m vicinity of stream/river contained purposes (0.3 mgL\textsuperscript{-1}). Chloride of sulphate contents of almost all the well water amplremained above the limit permissible for drinking, while fluoride remained higher not only for drinking but irrigation as well.

Vegetables irrigated with water of high fluoride content (0.13, 10.0 or 15.0 mgL\textsuperscript{-1}) showed F- concentration in plant tissue. F- Accumulated more in leaves than fruits (Kabasaklis and Trolaki,1994). Detailed studies on fluoride concentration in ground water were conducted by Rao (1964) and reported that high fluoride concentrations in the ground water reaching a maximum of 3.4 mgL\textsuperscript{-1} were associated with weathered formations of pyroxene amphibolites and pegmatites. The ground water in the clay soils contained less fluoride compared to the sandy soils. The contribtion of fluoride from geological formation was greater than that from agriculture. The maximum increase in fluoride content by super phosphate fertilizer to irrigation water was 0.34 mgL\textsuperscript{-1}. An inverse relationship between F and Ca and positive relationships of F with Na, HCO\textsubscript{3} PO\textsubscript{4} and Ec were observed. Best relationships were obtained in the fluoride range of 1.0-3.4 mgL\textsuperscript{-1}.

Sharma \textit{et al.} (1980) pointed out that fluorosis buffalow and cows was associated with toxic fluoride level (3.14±0.42 ppm) in underground water of Bhatinda, Sangrur and Ferozepur districts. The diseases were more common in buffaloes (9.75%) Than cows (2.5%) Dental mottling, lameness and high respiration and heart rates were more
common symptoms in buffaloes and cows in such areas. Akhter (1998) found that fluoride concentration in underground waters of Bahrain varied from 0.50 to 1.46 mgL$^{-1}$ and 38% of the water contained harmful concentrations of fluoride for drinking. However, there water were not harmful for most crop with respect to fluoride concentration. No significant correlation between fluoride and EC and SAR was found.

Singh et al. (2001) analysed the ground water and soil samples collected from the location with in one km from the carpet industries Chromium content of water samples ranged from 0.110 to 0.323 mg L$^{-1}$ and thus very high than permissible limit of Cr (0.05 mgL$^{-1}$- WHO 1984) High level of Cr in ground water samples indicate the leaching of the metal released from the industry. The Cr. Content in ground water sample reduced with increase the distance of sampling site.

Chakraborti et al. (2002) reported ground water arsenic (As) contamination in west Bengal in December 1983, when 63 people from 3 villages of 2 districts were identified by health officials as suffering from arsenic toxicity. Then 10500 water samples were analysed. The results showed that most of the water samples contain As up to 50 mg L$^{-1}$. The present situation is that in 2000 villages in 50 out of 64 districts of Bangladesh, ground water contains as above 50 mgL$^{-1}$ and more than 25 million people are drinking water having arsenic above 50 gL$^{-1}$ Proper watershed management and participation by villagers are needed for the proper utilization of water resources and to combat the as calamity. As in groundwater may just be nature initial warning about more dangerous toxins yet to come. Ghose et al. (2002) also studied the arsenic status in underground water and soil of Nadia district of west Bengal. Results showed that the arsenic level ranged from trace to 8.80 mgL$^{-1}$.

Gupta (2002) while working on quality of underground irrigation water and found that boron, lithium and fluorine are some of the toxic ions tending to occur more so in saline water. Boron could occure in soils and waters up to 10.0 mgL$^{-1}$ but only 1% water contained more than 3.0 mgL$^{-1}$ Due to adsorption of boron on clay particles the water containing 10.0 mgL could be used successfully in heavy textured soils, where as this limit reduced to 5.0 mgL in course texured soils. Lithium occurred in concentration of in saline ground water. Fluoride occurred generally up to but only water contained higher
than 10.0 Bron was the most toxic and fluoride the least. The tolerance limits of boron, Lithium and fluoride could be considered as 5, 10 and 20 mg L\(^{-1}\) respectively for tolerant crops in semiarid zone.

Mohammed et al. (2002) worked in on the Bangladesh effect of arsenic (As) contaminated groundwater irrigation on paddy yield and quality. Increasing the concentrations of arsenic in irrigation water significantly, decreased plant height, grains yield and number of filled grains in root. Straw and rice husk increased significantly Rice straw is used as cattle feed in many countries including Bangladesh. In this area arsenic toxicity, rushes in humans beings the plant, animal in human pathway.

Status of fluoride in underground irrigation water of Jayal tehsil (Nagaur) was studied by Yadav and Verma (2003) The study have been that fluoride content of underground water ranged 0.2 to 12.0 mgL\(^{-1}\) with mean value of 3.5 mgL\(^{-1}\). Fluoride content of irrigation water showed positive correlation with pH and SAR.

As defined in the medical dictionary, fluorosis in a hazardous condition resulting from ingestion of excessive amounts of fluorine. Rajasthan is one of the highest endemic state suffering from the presence of high fluoride contents in the ground water in most of the districts. A study was undertaken by Dadhich and Sharma (1997) to assess the success of the antitoxicity prevention programme of Center for Community Economics and Development Consultants Society (CCEDCS) initiated in rural area of Jaipur district. The programme focussed on capacity building among villagers to create awareness about fluorosis and used Nalgonda technique for removal of excess fluorides from ground water. The analysis of collected data revealed that level of awareness was highest (68%) among the respondents of Barkheda and Yarlipura villages of Jaipur district where the project was with drawn in 1998. It was observed that the level of awareness decreased over time and it was found lowest in the villages where project was with drawn in 1996.

EC and ESP in saturation extract of the soils increased significantly with an increase in EC from 4 dSm\(^{-1}\) to 12 dSm\(^{-1}\) while pH of soil decreased significantly with increasing levels of boron in irrigation water. The fodder yield decreased significantly with increasing levels of Eciw and Biw. The fodder yield decreased significantly when
irrigation water having EC and boron content more than 4 dSm$^{-1}$ and 2 ppm respectively (Kumar and Singh) (2003).

Kausar et al. (2003) determined the fluoride contents of underground water used for drinking in Faisalabad city (Pakistan). The results revealed that the underground water listed in 3 categories i.e. fluoride free water, fluoride up to 0.5 ppm and more than 0.5 ppm. The total soluble soils and pH values of drinking water varied from 310 to 2330 ppm and 7.46 to 8.13, respectively.

The environmental impact of tannery effluents wastes in Walajah (T.N.) was studied by Thanguvel et al. (2003). It was observed that 30% underground water samples had on EC>3 dSm$^{-1}$. A significant negative correlation between the distance from the point of disposal of tannery effluents and EC was observed. There was no definite pattern of decreasing in the content of Cr with increasing in distance from the point of discharge of effluents.

Ojha and Golani (2003) described that of ground water should be free from toxic ion i.e. nitrate, fluoride and arsenic and EC SAR and RSC should remain with in the tolerable limits. Fresh water for all” and “Health for all” should be available for all in 21st century.

According to Heath organization the nitrate content in drinking water should be 45 mgL$^{-1}$. The groundwater of Rajasthan contained, highest figure of 4750 mgL$^{-1}$ of nitrate and stand first in the country followed by Haryana (1800 mgL$^{-1}$) and Tamil Nadu (1030 mgL$^{-1}$). High nitrate content of water reduced nil permeability of soil. Fluoride content in drinking water should not be more than 1.5 mgL$^{-1}$. In Rajasthan highest fluoride content in ground water was 90 mgL$^{-1}$ in Nagaur district followed by Hanumangarh (35 mgL$^{-1}$) and Churu district (30 mgL$^{-1}$). The ground water of 8 districts of West Bengal namely Malda, Murshidabad, North and South 24 Pargana Nadia Vardwan, Hawrah and Hugali was reported contamination with arsenic toxicants. According to health organization the arsenic content in drinking water should not be more than 1.5 mg/l.

Gautam et al. (2003) studied the underground water of Maharaj Ganj district of Uttar Pradesh for existence of arsenic. The use of arsenic contaminated groundwater for
Irrigation of crops resulted in elevated concentrations of arsenic in soils, food and fodder. The arsenic III is more dangerous to humans and cattle as compared to arsenic (V) and organic arsenic. It was found that as the content in underground water of all blocks of Maharajganj district was below the IS permissible limit to 0.05 mgL\(^{-1}\). The upper limit of arsenic concentration 0.024, 0.020, 0.017 and 0.016 mgL\(^{-1}\) in ground water were recorded, respectively in Ghugholi, Nautanwa, Brajmangang and Siswa Bajar blocks.

Beinner et al. (2005) studied the effect of iron forhsed drinking water on the hemoglobin status of young children in this study 43.2% (69) of children evaluated as being anemic decreased to 21% (37) at end of the study. The data indicated that after iron fortification, total number of children suffering from moderate and severe anemia had decreased to 32 (20.7%) and 5 (3%).

Montenegro and Mejia (2001) found that when irrigation waters contained the highest concentration of Cd as yields of paddy were significantly reduced and the maximum yield were obtained when Cd and As were absent from the irrigation water. Accumulation of Cd and As in rice grains increased with gradual increment in concentration of both elements in the irrigation waters. The amounts of Cd and As accumulated in the rice grains were 50 and 150 times, higher than the maximum critical levels, respectively.

Mehrotra et al. (1995) studied 39 underground water samples collected from Bijnore, Dehradoon, Saharanpur and Muzaffarnagar districts of Western Uttar Pradesh. They found that the highest fluoride content of 0.08 mgL\(^{-1}\) was recorded only at two places of Nazibabad (Bijnore and Aterna (Muzaffarnagar).

Rastaugi (1995) analyzed 131 underground water samples of Mathura district (U.P.) and found that water EC less than 2 content nitrates less than 45 mg L\(^{-1}\) (acceptable WHO 1994), Nitrate concentration increased with the increase in EC. The underground water of Fonder, Govardhan and Vrandavan places contain 180, 224, and 310 mgL\(^{-1}\) nitrate, respectively which were quite above the WHO standard. The fluoride concentration range 0.0-0.5, 0.5-1.0, 1.0-1.5, 1.5-2.0, 2.0-2.5 and >2.5 mgL\(^{-1}\) was found in 2.60, 14.0 16.8 13.0 10.7 and 19.5 per cent of water samples analyzed, respectively.
Fluoride content in water was negatively correlated with Ca and positive with phosphatic fertilizers.

Antil et al. (2002) conducted a study on leading of NO$_3$ as influenced by water regimes at Hisar (Haryana). It was found that movement of NO$_3$ N increased with increasing initial water content and moved up to 4, 5, 6 and 7 cm at 25, 50, 75 and 100% of field capacity. NO$_3$ moved along with per collating water and depth of penetration of NO$_3$ depended on time and amount of water application rates. The percentage of NO$_3$ N recovered decreased as the initial water content of soil increased and accounted for only 93, 91, 90 and 88% of the applied N at water respectively. This study suggests that application of irrigation water frequently and at low rates (depth) could reduce the leaching losses of NO$_3$.

Arora et al. (2002) were studied at Ludhiana (Punjab) on concentration of 0.01, 0.1 and 1.0 M NaCl and 0.01 0.033 and 1.0 M CaCl$_2$ solutions for evaluate the effect of ionic strength of supporting electrolytes on the extent of boron (B) adsorption by soils. They found that boron adsorption increased with increase in ionic strength of the supporting electrolyte solution. At a given molarity, the B adsorption was higher in the presence of NaCl as compared to CaCl$_2$.

Chaudhary and Shukla (2004) concluded that available boron content varied form 0.26 to 7.10 mg kg$^{-1}$ soil and 0.22 to 1.15 mg kg$^{-1}$ soil with mean values of 1.51 and 0.51 mg kg$^{-1}$ soil for irrigated and rainfed soils of western Rajasthan. High content of B in irrigated soils is due to high B content in irrigation water.

Available boron content in irrigated soils showed significant and positive correlation with EC ($r=0.78$), pH ($r=0.70$) and organic carbon ($r=0.39$). With the increasing concentration of soluble salts, the available B content in irrigated arid soils increased, indicated that the onset of salinization is accompanied by and increase in the available form of B. Association of B with organic matter prevents its leaching and results in its accumulation in surface soil. But in case of rainfed soils the organic matter content is low and it does not seem to have an obvious effect on available B.
Chaudhary and Shukla (2004) studied the boron forms and their relationships with characteristics of arid soils. Mathur and Kalicharn (2003) worked on quality parameter of underground water in adjacent leather industrial area of Agra city. They found that EC of ground water ranged from 1250 to 952 micro sencer/cm and water was sodium chloride type. The groundwater samples were classified as CaHCO$_3$ NaHCO$_3$, CaMg, Cl-SO$_4$ and NaCl type and corresponding percentage was 8, 13.5, 13.5 and 65. The fluoride content was varied from 0.8 to 3.6 mgL$^{-1}$ in which 28% of water samples contain fluoride more than 1.5 mgL$^{-1}$. The underground water samples contain 20 to 540 mgL$^{-1}$ of nitrate in which 50 and 25% of water samples contain NO$_3$ more than 45 and 200 mgL$^{-1}$, respectively. It was also observed that 2 samples of ground water contain 200 and 480 mgL$^{-1}$ of Cr. There hand pumps were situated near the effluents nala of leather industry.

### III. Metal ion accumulation

Certain metal ion or trace elements are essential for human, plants and animals, but become toxic at higher concentrations. For many metal elements, the margin of safety between beneficial and harmful is narrow. Deficiency and toxicity of metal elements are common plant nutritional problems in crop production. While most metal elements in water and soil are beneficial to plant growth, a buildup of metal elements may have a negative affect on whoever eats the plant. Metal elements in excess amount may also degrade water quality down stream and ultimately soils which are irrigated by this degraded water.

A study was conducted by Singh et al. (1979) to find out the effect of different levels of zinc (0, 10, 20, 30 and 40 kg ha$^{-1}$) and SAR of irrigation water (SAR 20, 40, 60 and 80) on soil properties, growth and yield of wheat. They reported that increasing levels of adj. SAR of irrigation water increased significantly the EC, SAR ESP and pH of soil while decreased plant height, effective tillers, grain and straw yield of wheat. Application of zinc sulphate has increased plant height, effective tillers and grain and straw yield of wheat.
Yediler et al. (1994) found highest concentration of Cu and Zn was in top soil when irrigated with municipal waste water. Both metal ions were considerably more mobile (50-80%) than other ions. Heavy metal measured in rice leaves and rice gram were significantly lower than in the roots, which contained high amounts of copper and zinc corresponding to the soil content.

Singh and Singh (1994) analysed soils adjacent to highway and carpet industries recieving efflerents of different kinds at Varanasi. The data indicated that in surface layer of three profiles metal contents ranged as Cd 3.68-3.90, Pb 21.61-23.42, Cr 3.34-5.01 Cu 30.26-30.70, Zn 15.52-15.78, Mn 225.62-232.24 and Fe 79.28-88.24 ppm. On the other hand, in the lower most horizons, the metal contents ranged from 0.18 to 0.48, 0.26 to 0.84, 0.28 to 0.62, 8.08 to 12.24, 4.32 to 10.02, 204.01 to 213.20 and 68.16 to 86.42 ppm respectively for Cd, Pb, Cr, Cu, Zn Mn and Fe. It was concluded that almost all the soil surface layers contained higher amount of metal and the content of the same decreased with depth.

Helal et al. (1995) reported that saline (Na) water irrigation increased heavy metal solubility in soil, reduced root viability and enhanced the uptake of Na, Cd, Cu and Zn by plants. Calcium counteracted these effects partly. The results demonstrate a dual effect of salinity on heavy metal availability to plants. Helal et al. (1995) also found that NaCl accelerated root mortality and increased both the concentrations of heavy metals in soil saturation extract and their uptake by maize. While the solubility of heavy metals was enhanced by CaCl₂ both root mortality and the uptake of heavy metals were depressed. It was concluded that salinity of irrigation water affects heavy metal uptake at least partly by modifying root functions.

The soil irrigated with polluted water was tested by Petkovski et al. (1997) for their soluble metal ion content. Average samples from depths of 0-20 and 20-40 cm were collected from four rice plots. The soil contained 33.76-90.6 mg/kg Zn and 5.6-8.3 mg/kg Cu, which were quite higher than the soils of irrigated with fresh water.

The effect of poor quality irrigation water on the availability of micronutrient metal cations (Zn, Cu, Fe and Mn) was evaluated by Chhibba et al. (1997) in Paddy and
wheat crop at cultivation field. The increasing ESC in irrigation water caused a general
decrease in the contents of available Zn, Cu, Fe and Mn in the soil. The crop yields were
also adversely affected by the rise in the RSC of irrigation waters.

Gupta and Guptal (1998) reported that metal ion toxicities in crops are more
frequent for Mn and B than other nutrients. Manganese toxicity is found on acid soils in
many part of the World. Boron toxicities occur in irrigated regions where the well or
irrigation waters are exceptionally high in B. Most of the other nutrient toxicities occur
when large amounts of nutrients have been recorded in waste i.e. sewage sludge. Crops
grown near mines and smelters are prone to nutrient toxicities. Generally the symptoms
of toxicity in crops occur as burning chlorosis and yellowing of leaves. Toxicities can
result in decreased yield and/or impaired crop quality.

Metal ion accumulation in soil irrigated with polluted water was studied by
Markov and found that heavy metal ions were accumulated in upper (A) horizon and
slowly distributed in the soil profile. Mendez et al. (2003) analyzed soils from 16 sites
which were irrigated with river water which received municipal and industrial waste
waters for more than 30 years. It was found that soils contained high calcium and Mn and
Fe ant 85.08 and 68.63 mgkg$^{-1}$, respectively which were exceed from the maximum
permitted levels of the standard.

Change and Page (2000) reported that metal ions were added to soils from the
atmosphere, irrigation water and agricultural inputs including chemical, biosolids,
manures and compost. On crop land, important metal ion (Fe, Mn, Zn and Cu) may also
be depleted from the soil profile through leaching, crop harvest and surface runoff. To
ensure desirable levels, water and soil sources of there elements must be monitored.

The safety of the groundwater supplies in Shiraz (South Iran) was studied by
Farjood et al. (2001) with respect to metal ion concentrations. Studies of 50 local wells,
which supply water for agricultural production, examined water for physical and
chemical characteristics. The results showed that the concentrations of Ca$^{2+}$, Cr$^{2+}$, Fe$^{2+}$,
Mn$^{2+}$ and Pb$^{2+}$ exceed from permissible values for crop production. In other areas, the
concentration meter with irrigation water will help control concentrations of heavy metals.

Fertility status, trace elements and heavy metal accumulation in soils irrigated from Gediz Revere in Turkey was determined by Elmali et al. (2002). Total N and available P, K, Mg, Fe and Zn levels were low or average, whereas available Ca, Na, Cu, Mn were present at good and sufficient levels. Thirty three per cent of soils had available B and 83% of soils had total B levels above the phytotoxic lower boundary, soil samples from the Grediz source (Sample site 1) had high amounts of total Fe, Zn, Mn, B, Ca, Ni, Cr, and Co.

Dwivedi et al. (2002) worked at Kanpur (U.P.) and reported that application of zinc up to 5 kg/ha increased the yield of maize by 19 per cent over control. The optimum dose of Zn was found to be 7.1 Kg/ha giving maximum grain yield of 29.8 q/ha. The uptake of Zn also increased with level of zinc. The protein content was increased with the application of S and Zn over control. Tryptophan and Lysine contents were found to increase with increased levels of Zn. Application of S @ 30 kg/ha increase the grain yield by 22% over control.

Nayak et al. (2002) found at Kolkata (W.B.) that Dithionite extractable Fe content in all the soils under red and lateritic ecosystem increased usually with depth (0.64 to 1.75%) showing highest value in sub soil. On the contrary the amount of Fe in the soils of Gangatic alluvial plain representing inceptisols and entisols was low (0.26 to 0.93%) and did not show any definite trend with depth. The content of Mn did not show any noticeable trend in their distribution in the soils under study.

Poongothai and Mathan (2002) working at Coimbatore observed that a linear increase in grain yield of maize was recorded up to 12.5 kg CuSO₄ ha⁻¹ accounting for 3.8 and 4.5 qha⁻¹ increase over control with the application of CuSO₄ @6.255 and 12.5 kg CuSO₄ respectively and thereafter the yield declined with further increase in level of CuSO₄.
Among methods soil application was better than foliar spray indicating the need of Cu at early stages for better establishment and growth of the crop in a Cu deficient soil.

Samanta et al. (2002) found at Kalyani (W.B.) that total Fe and Zn decreases with the depth in soil pH showed significant negative correlation with Zn extracted by MgCl (r=0.47**), HCl (r=0.43**) and EDTA-(NH$_4$)$_2$CO$_3$ (r=0.28**) and with Fe extracted by HCl (r=0.34**) DTPA (r=0.49**) and EDTA (NH$_4$)$_2$CO$_3$ (r=0.55**).

Singh and Pathak (2002) worked on wheat crop at Kanpur (U.P.) and found that grain and straw yields increased up to 30 kg Mg/ha and 80kg K$_2$O/ha and thereafter declined uptake of K and Mg showed antagonistic effect on their absorption. Mg addition had positive effect on protein and starch content but negative on lysine content.

Similarly grain and straw yields of wheat increased upto 80 kg K$_2$O ha$^{-1}$ however the yields of 40 and 80 kg K$_2$O were at par. The optimum dose of K and Mg varied from 62-70 kg K$_2$O ha$^{-1}$ and 32-34 Mg/ha for 40-41 and 39-40 q/ha maximum economic yield (MEY) of grain respectively.

Yadav et al. (2002) reported that seed and stover yield of mungbean increased with the increasing P levels but significantly increased up to 30 kg P$_2$O$_5$ ha$^{-1}$ at Jobner (Rajasthan).

The seed and stover yield of mungbean increased upto 4 kg Fe ha$^{-1}$ at Jobner Rajasthan. Similarly protein content was also increased with the application of 30 kg P$_2$O$_5$/ha and 4 kg Fe ha$^{-1}$ over their lower level. The optimum dose of P and Fe were found to be 38.30 kg P$_2$O$_5$ ha$^{-1}$and 3.139 kg Fe ha$^{-1}$, respectively.

Environmentally sound management of the nation’s fresh water resources is a global priority that is gaining increasing attention. Water pollution increased due to increasing population, heavy growth of industries and use of fertilizer and chemicals in agriculture. Further more severe water pollution problem by many fold. Keeping view a study was undertaken to test the water pollution by Mn in the districts of Agra, Basti, Bahraich, Itawah, Noida, Gajipur, Meerut, Muradabad, Sitapur and Varanasi of Uttar Pradesh.
Pradesh. The results indicated that very high content of Mn was recorded in Noni Agra (2.1 mgL$^{-1}$) and Ajhauta Meerut and Gajraula Muradabad (1.8 mgL$^{-1}$) whereas, Mn content drinking water should not be more than 0.1 mgL$^{-1}$. The accumulation of Mn depends upon pollution percentage of river. In general Mn deposit on organic matter and soil but whenever redox potential is reduced it become mobile and resulted in higher concentration in ground water. Still industries and mining are also responsible for pollution of water by Mn. Higher Mn in drinking water may cause paralysis in lower portion of body. The maximum manganese content of 1.1 mgL$^{-1}$ was recorded in groundwater of Sitapu (Biswan), Behrainch (Nanpara) and Basti (Bansi) districts. It was also observed that managanese concentration in ground water was found in descending order from western U.P. (Meerut, Itawah Agra) to south eastern districts of U.P. (Basti, Varansi and Gajipur) (Nigam, 2003).

Dixit et al. (2003) collected water samples from Bhagirathi, Haiderpur, Okhla and Wazirabad treatment plants and 80 tube wells water at Delhi to test the heavy metal contamination such as Cd, Cr, Cu, Fe, Pb, Mn, Ni, Se and Zn and found that Mn, Pb, Cd and Cu were marginally higher than Indian standard (IS) specifications of 0.1, 0.05, 0.01 and 0.05 mgL$^{-1}$ respectively. Levels of Zinc were found with in the IS specification of 5 mgL$^{-1}$. Nickel levels ranged from nondetectable to 0.164 mgL$^{-1}$, Selenium was found in below non detectable level (NDL) in all the samples analysed Lead levels were found marginally higher than IS specification and ranged from 0.011 to 0.6 mgL$^{-1}$. Iron was found in low concentration in all the reasons and did not exceed the IB specification.

Mendez et al. (2003) analysed the soils irrigated with non treated waste water for heavy metal concentration. The results showed that the soils have a high cation exchange ability, considerable organic fraction and alkaline pH. The total heavy metals average concentration showed the sequence Fe>Mn>Zn>Cu>Cr>Pb>Ni>Mo>Cd. The total concentration in soil of Zn, Pb, Cr, Ni, Mo and Cu and the concentration of Cd, Cr, Du, Pb, Mo, Mn and Ni in irrigation waters were above the limits established for their safe use.

A study was conducted in Rajasthan using various effluents and canal water for irrigation to the seedlings of Acacia nilatica and Eucalyptus camaldulensis. The aim was
to monitor to toxic effect of the accumulated mineral ion on the physiological functions ultimately to utilize these effluents in tree plantation. The accumulation of Mn, Fe, Cu and Zn was the highest (PC 0.001) in the seedlings of stul effluents, stul+municipal effluents stul+municipal+ testule effluents and stul+ toxile effluents effecting N, P,K, Ca,Mg, and Na concentration. The seedlings of textile effluent had less Mg Mn, Fem Cu, and Zn and medium N, Ca, and P concentration, which were negatively correlated with Na concentration in foliage and the amount added through effluent irrigation, concentration fo M, K, Ca, Mg and Na was higher in the foliage of *Acasia nilatica* whereas, P, Mn, Fe, Cu and Zn were high in *E. comoldueensis*.

Patel *et al.* (2004) analysed different effluents being used for irrigation in Gujarat. The results showed that the effluents from Ankleshwar site were the most polluted with respect to different elements viz. Fe, Cu, Mn, Cd, Ni, Co and Cr. The dissolved oxygen was observed only in well water and not in effluents. The COD value of effluents from Ankleshwar site was extremely high, while the BOD values were within the safe limit in all the samples. The soil Namdej site of Ahmedabad zone registered comparatively high amount (30mg l⁻¹) of Cu for which the toxic limit is 100 mg l⁻¹. The Zn content at both the sites was high and it was maximum (12.08 mg l⁻¹) at the surface soils of Jaspur. Other metal ions (Fe and Mn) were either marginal or sufficient. The metal ions (micronutrients) were sufficient in soils collected from all the sites of Vadodara, Bharuch and Ankleshwar Industrial zone. The brinjal crop in Bharuch irrigated with fertilizer effluents showed exceptionally high amount of iron (3360 gg⁻¹) and Mn (260 ggg⁻¹) as compared to that in Vadodara irrigated with fertilizer effluent. Zn and Cu were also high in sorghum grawn in Bharuch. Chang and Page (2000) reported that metal ions were added to soils from the atmosphere irrigation water and agricultural inputs including chemicals, biosolids manures and compost on crop land, important metal ions (Fe, Mn, Zn and Cu) may also be depleted from the soil profile through leaching crop harvest and surface runoff. To ensure desirable levels, water and soil sources of these elements must be monitored.

The content of Cr found to be above the toxic limit irrespective of the crops and sites surveyed. The highest content of N (26.1 mg l⁻¹) was absorbed in maize (Vadodara)
followed by, tobacco (12.9 mg⁻¹) at Bharuch irrigated with fertilizer and refinery effluents, respectively. The results of relative availability of trace and heavy metals indicated that Cu, Pb, Zn and Cd were the most available elements in different soils.

The underground water of maniur State was studied by Prakash and Kour (1995) and found that Ca, Mg, Na and K cations were found in highest range of 20-42, 12-46, 15-660 and 4-34 mgL⁻¹ in Thumbal district and lowest range of 3-8, 4-6, 6-7 and 1-2 in Birhnpur district, respectively. Fe content of 0.8-1.5 and 0.2-5.2 mgL⁻¹ was highest in the water of Bishampur Chura Chandpur districts, respectively which required cleaning before drinking. The water of Thumbal district had Cl, Na, Fe, Mn, Ni, Pb, and Li simultaneously of 8946, 6600, 11, 970, 150, 270 and 3150 mgL⁻¹, respectively, found as unsuitable for drinking. The water of Imphal, Senapati and Tamenglong districts were found suitable for drinking purpose. The water of all 7 districts of Manipur was found suitable for agricultural purpose.

The ground water quality of Kakinads coastal aquifer has been studied with reference to metal and toxic ion contamination. The various elements analysed include Cu, Fe, Mn, Co, Ni, Cr, Pb, and Cd. The data revealed that the concentration of Fe and Mn at certain location exceeded the desirable limits prescribed for drinking water. The maximum concentration recorded for Fe and Mn was 0.910 and 1.022 mgL⁻¹, respectively. The presence appearance of water and has adverse effect on domestic uses and water supply structures. The content of Cu, Co, Ni, Cr, Pb and Cd were found use within the desirable limits for drinking water (Annonymous 2000). The river Yamuna is a major river of India and traverses a distance of 1367 kms. From, its source in Himalayas its influence with river Ganga at Allahabad, the water of the river is used for domestic, industrial and agricultural purposes.

The investigation suggests that Cu has a tendency to remain associated with residual reducible and Carbonate fractions. The Risk Assessment Code (RAC) as applied to present study reveal that about 30 to 50% of Pb at most of the sites exist in exchangeable fraction while 30 to 50% of Cd at almost all the sites in either exchangeable or carbonate bound and therefore comes under the high risk category and can easily enter the food chain. Most of the Cu was in immobile fraction at Delhi while at
other sites a sizable portion (10 to 30%) was found in carbonated fraction thus posing medium risk for the aquatic environment. Specification pattern of Zn showed at low to medium risk to aquatic environment (Anonymous 2000).

The under ground water of Aligarh city was examined by Singh et al. (2003) and found that Fe, K and NO$_3$ concentration was higher than IS permissible limits in most are of the city. The Fe concentration of 7.1, 3.5, 3.5, 3.10 and 1.9 mgL$^{-1}$ was recorded in Raisalganj, Shahpur, Stnam service, Shahjamal and Kohirmath bypass areas respectively. After monsoon the under ground water of Railway road, Gudriabagh, Phoolpur Chauraha, Jalalpur and Laxminagar areas contain 58, 57, 56, 56 and 49 mgL$^{-1}$ NO$_3$ respectively. Similarly K concentration was found as 260, 105, 96, 70 and 52 mgL$^{-1}$ in Aligarh Fort, Jawahar Road, Phoolpur Charuaha, and ADA colony area of the city. The permissible limit (B.E.S. 1997) for Fe, NO$_3$ and K are 0.1-10, 45 and mgL$^{-1}$ respectively. It was concluded that the drinking water of the city was belkow the standard and health hazard.

**IV. Ionic imbalance**

The saline sodic underground waters are of usual occurrence in semi acid parts of the north-west India and their long term use poses serious threat to the sustainability of agricultural productivity. Most of the saline sodic waters contain various cation Na$^+$, Ca$^{2+}$, Mg$^{2+}$, K$^+$, Bonona and omions CO$_3$, HCO$_3$, Cl$^-$, SO$_4$ in various ratios resulted in various qualities of water. The interaction was found with EC, RSC and SAR with ground water effect on the physico-chemical properties of soils. Some work done by various workers on this aspect in past and recently have been presented in succeeding pages.

Kanwar and Kanwar (1971) found that increase in equilibrium SAR with SO CO$_3$ and HCO$_3$ was more in coarse texture than fine textured soils. Adverse effect of RSC was more on light soils than heavy soils.

Paliwal and Gandhi (1976) reported that salt accumulation in soil increased with fineness of texture and similling characteristics of the soil clay. Soils irrigated with water of High SAR as well as of high mg/Ca ratio. Increase exhangeble sodium more in soil and effect was more visible on coarse soil than fine textured soil.
The increase in Mg/ca ratio enhanced the equilibrium SAR as was also soils irrigated with waters of high SAR as well as high Mg/Ca ratio increases exchangeable sodium more (Yadav and Girdhar (1981) Girdhar and Yadav (1982) reported that on irrigating the soils at the same SAR and salinity, the EXP was more with higher Mg/Ca ration and effect was more visible on coarse textured soils than fine textured. Excess mangnesium deteriorate the physical properties soil. The increase of salt accumulation was more with fine textured and smelling characteristics of the clay.

Bajwa et al. (1992) observed that soil pH increased in the presence of SAR or RSC due to hydrolysis of soils. Mehta et al. (1983) found that a given equivalent fraction in Na and SAR the ESP was more sulphate than in chloride rich system.

Manchanda et al. (1985) studied the effect of sodic water fixed SAR (16) and total soluble salts (25m.e/L) on ESP of sandy loam and crop yield. The maximum ESP in the zero and 2.5 m. eL RSC treatments was about half of the SAR (16) even after 225 cm depth of water had been added. However in the 7.5 and 12.5 SAR level the ESP of the surface soil (0-15 cm) was almost equal to SARiw. The pH of the soil was increased with the rise in the RSC of water whereas infiltration rate of soil was highest (0.9 mm/p) in canal irrigation and lowest (0.12 mm/h) in the 12.5 m.e/L RSC.

Effect of the use of sodic water (EC-4; SAR-26, RSC-15) alone and in conjunction with graded dose of gypsum and FYM was studied investigated by growing wheat for eight years in sandy clay loam soil. The maximum ESP of soil (0-15 cm) was 38-40 per cent after the irrigation phase in nogypsum and FYM @ 25 tonne/ha/year. Soil ESP and EC decreased by 20 to 30% and 47 to 50% respectively after monsoon. The highest ESP developed in 0-60 cm soil profile was not more than 50% over and above that SAR even in non gypsum treatment. Gypsum decreased ESP in proportion to the neutralization of original SAR.

Dubey et al. (1987) observed that after 20, 40 and 50 irrigation cycles with Chloride water, cumulative amounts of sodium and mineral dissolution, measured as the amount of Ca$^{2+}$ released, Increased with increasing irrigation cycles and SAR. The irrigation with bicarbonate rich water, resulted precipitation of calcium carbonate leading
to higher soil acidity as compared with chloride irrigation water. Mineral dissolution also occurred in bicarbonate water irrigated soil up to 20 irrigation cycles but this was also followed by precipitation in latter cycles. The results indicate that the irrigation waters of SAR<20 and RSC<5 applied to a smectic clay soil in 50 irrigation cycles were not deterious (ES<10) if the leaching fraction was at least 0%.

Chauhan et al. (1990) reported that pH declined and hydraulic conductivity increased with application of Gypsum and FYM as amendments. Due to supply of calcium, Gypsum was superior to FYM in reducing the ESP in soil. Use of gypsum was found better over FYM and its amount equivalent to reduce RSC of water to 10 mg/l was most economic.

Yadav et al. (1989) observed that hydraulic conductivity was increased by 33% and decreased by 15% on increasing and decreasing the Mg:Na (1:1) ratio to 4:1 and 1:4 respectively. The results bring out the favourable effect of magnesium over sodium in influencing the hydraulic conductivity of the soils. On the other hand, increase of Mg Ca (1:1) improved it by 48%. Swelling percentage increased with decrease with decrease of Mg:Na and increase of Mg:Ca ratios in irrigation waters. The hazardous effect of cations on physical properties of inceptisols and vertisols may be rated as: Na>Mg>Ca.

Soil pH and ESP increased with increase in RSC of irrigation water. The magnitude of increase in sub soil was smaller than in the surface soil. At 15meL\(^{-1}\) RSC the pH of surface soil increased from 8.6 to 8.9 soil ESP (0-15 cm) even at RSC 5 meL\(^{-1}\) attained a value of 20.5 Hydraulic conductivity of the soil declined with RSC owing to the gradual increase in ESP (Chauhan and Kumar, 1993).

Guptal et al. (1982) studied the effect of bicarbonate and chloride irrigation water on soil properties and reported that the pH and EC of soil increased from 8.0 to 8.6 and from 1.4 to 3.0 dSm\(^{-1}\), respectively in bicarbonate water treatment whereas, it increased from 8.0 to 8.4 and from 1.4 to 3.4 dSm\(^{-1}\) in chloride water treatments. They also found that chloride in toxicity was more severe the bicarbonate in the survival of the ber seedling. Chloride ion is not adsorbed by soils, moves readily with soil water is taken up by the crop and C accumulates in the leaves and causes injury. The soil tended to become
more saline on irrigation with chloride water. Bicarbonate water induced significant changes in pH of the soil but increase in EC.

Different volumes of prepared irrigation water of total electrolyte concentration 100 meL$^{-1}$ and SAR 25 meL$^{-1}$ were percolated through sandy loam and clay loam saturated soil. The exchangeable sodium percentage (ESP) decreased gradually with depth and increased with increase in volume of the solution per collated (Kapoor et al. 1989).

Poonia et al. (1990) studied in laterally confined and vertically continuous soil columns (56 cm diameter) to find out depth development of exchangeable sodium percent ESP resulting from 100 cm deep cumulative irrigation with sodic water (RSC)14 meL$^{-1}$ total electrolyte concentration (t.e.c.) 20 meL$^{-1}$ SAR 13.9 mmo L$^{-1}$ the untreated soil ($T_1$). There results were compared with the ESP development in gypsum treated soil irrigated with sodic water ($T_2$) and untreated soil irrigated with gypsum treated sodic water ($T_1$). The buildup of ESP was maximum in $T_1$ followed by, $T_2$ and ESP was maximum in surface layer and decreased gradually with depth. The average ESPs for the whole soil profile for $T_1, T_2$ and $T_3$ were 7.1 4.5 and 4.1 respectively.

Yadav (1992) observed that increased concentration of Mg/Ca ratio from 0.125, 0.25, 0.5, 1.0, 2, 4 and 8 in equilibrating water decreased the adsorption of phosphate from 95 to 80 and 76 to 60 per cent in calcareous and non calcarceous soils, respectively. Increased CaCO$_3$ content (5-30%) in soils induced greater adsorption irrespective of the salinity and Mg/Ca ratio in the water, wide Mg/Ca ratio (>2) along with P adsorption magnitude.

Chauhan and Kumar (1993) concluded that an increase in residual sodium carbonate in irrigation water progressively increased the pH (From 8.2 to 8.9) sodium adsorption ratio (7.8 to 10.0) and percentage (10 to 21) and decreased the hydraulic conductivity, (From 1.1 to 0.7 cm/hr) of soil. The increase in pH was due to hydrolysis of Na and increased concentration of CO$_3$HCO$_3$ in the soil. Residual sodium carbonate of 5 and 10 mg/litre in irrigation water decreesed the seed yield of lentil, gram and pea by 15.4 and 38.0 per cent compared with best available water advered effect of RSC was less on
straw than on grain yield but protein content in seed increased with the increase of RSC in irrigation water.

Girdhar and Idnami (1994) reported that relative hydraulic conductivity decreased with increase in exchangeable Mg percentage at specific soil SAR and ESP values. The harmful effect of Mg on hydraulic properties was more apparent at greater soil SAR and ESP. The continuous use of Mg rich irrigation water induced sodicity and increased the soil pH.

Irrigation with water of EC from 2-3 dSm\(^{-1}\) containing RSC as high as 10 mgL\(^{-1}\) can be practiced continuously without any problem provided that SAR in <10. Although high carbonates are more harmful than bicarbonates (Gupta (1994)).

Singh et al. (1994) studied with water having Na: Ca activity ratio (SCAR) of 7 or 10 and RSC of 0, 2.5, 5.0, 7.5 or 10.0 mg/l. Increasing SCAR and RSC in the irrigation water decreased soil EC, hydraulic conductivity, water holding capacity, contents of organic carbon, soluble cations and anions and increased pH and ESP.

The number of tillers per plant, height of the plants and total dry matter yield decreased with increasing levels of RSC (0, 7.0, 15 and 22.5 mmoL\(^{-1}\)) and even the lowest RSC level had an adverse effect on yield and yield attributing characters as compare with control. The content of Ca\(^{2+}\) and Mg\(^{2+}\) decreased and Na content increased with increasing levels of RSC (Singh et al. (1995)).

Brar and Bajwa (1996) while working on sodification of soil found that the increase in the rate of HCO\(_3\)/Ca\(^{2+}\), HCO\(_3\)/Mg\(^{2+}\) and HCO\(_3\)/((Ca\(^{2+}\)/Mg\(^{2+}\)) in irrigation water resulted more salt concentration which increased the SAR and ESP. The increase in SAR and ESP was more pronounced under HCO\(_3\)\(^{-}\) system followed by, HCO\(_3\)\(^{-}\)/((Ca\(^{2+}\)/Mg\(^{2+}\)) and HCO\(_3\)\(^{-}\) system in descending order due to higher calcium precipitation under HCO\(_3\) Ca\(^{2+}\) in the equilibrium solution. The value of selectivity coefficients viz. Kg, Kv and K\(_{\text{KDG}}\) decreased with increase in the salt concentration.

Girdhar (1996) reported that hydraulic conductivity (HC) of soil decreased with application of leaching water of increasing RST at a given SAR and EC. The hazardous
effect of high RSC further increased with an increase in SAR and decrease in EC of the irrigation water. The adverse effect of high RSC at low SAR on HC was practically the same as affected by low RSC at high SAR. Soil pH and ESP increased significantly with an increase in RSC and its adverse effect become additive at high SAR. RSC of soil extracts was greater than the RSC of leaching water, as a result of this adsorption of Na increases, significantly.

Sharma and Minhas (1998) studied the effect of sodic water of various EC, RSC and SAR are soil properties and found that the soil pH increased initially and stabilized after 3 years of irrigation whereas, sodicity and salinity continue increased during the course of study. The mean SAR of surface layer (0-60 cm) showed a significant increase with EC (1.6 times) and RSC (1.14 times) of the applied water. The interaction of EC x SAR was significant for the SAR data. The SAR values at EC 2.0 dSm⁻¹ and SAR 20-30 were even less than at EC 4.2 but SAR 10 which point out that the low salinity sodic water at comparable SAR and RSC have a much lower sodication potential compared to its high EC counterparts. Salinity build up increased with high SAR and RSC irrigation waters.

Effect of poor quality water having different EC, SAR and RSC on soil properties was evaluated. Application of low saline water in saline soil helped leach salt to lower depths. Further with the leaching of salt, SAR of the soil solution was reduced. ESP and SAR increased with soil depth in all the water quality treatments (Girdhar et al. (1999).

Lal et al. (1999) worked on the irrigation water quality of Ca/B ratio of 100-800, EC 6.0 or 12 dSm⁻¹ and SAR 25 or 30 and found that EC, SAR, ESP and boron content of soil increased while, pH of soil decreased significantly with an increase in salt concentrations of irrigation water but increased with increase in SAR of water.

National Institute of Hydrology, Roorkee collected 60 ground water samples shallow and deep wells from Ghatoprabha command area (Karnaka) to see the suitability of ground water for irrigation and domestic purposes during pre and post monsoon seasons of 2001. As per the classification majority of the samples were found to be a sodium bicarbonate and calcium bicarbonate type followed by, magnesium bicarbonate,
sodium chloride and calcium chloride type. In the piper trilinear diagram, 55.0% samples fall in Ca-Mg-HCO facies, 18.0% samples in Ca-Mg-Cl-NO$_3^-$-SO$_4^-$ hydrochemical facies, 8.3. Samples in Na-K-Cl-NO$_3^-$-SO$_4^-$ facies and 8.4% samples in Na-K-HCO$_3^-$ facies 40.0% samples in Na-K-HCO$_3^-$ hydrochemical facies. According to U.S. salinity laboratory classification of irrigation water, more than 50% samples fall under water type C3-S1 (High salinity) during both pre and post monsoon seasons (Anonymous(2002)).

Rao and Pal (1978) reported that increase in fluoride content of litter and soil accumulated of organic matter content in the accumulated of organic matter content in the surface soil. It is suggested that the presence of fluoride in the litter and soil decreased the growth and activity of microorganism.

Aydin and Yurdun (1999) reported the presence of \( \alpha \)-HCH \( \gamma \)-HCH and aldrin in Istanbul waters. Their levels were under the acceptable limit value. Our finding showed that these pesticides are under the acceptable limit of the EC in Afyonkarahisar.

Madhnure et al. (2007) studied on occurrence of fluence in the ground waters of Pandharkawada area, Yavatmal district, Maharashtra, India. They reported that ground water occurs under unconfined conditions in the weathered and fractured portions of rock. The ground water of the area is of bicarbonate (HCO$_3^-$) type and high fluoride concentration in deeper aquifera.

Jha et al. (2008) reported that F concentration of water varied between 1.05 to 13.9 mg/L$^{-1}$ in shallow aquifers of Maker, unnao district. The correlation study of fluoride indicated that F has a significant (p<0.05) positive relationship with pH and RSC and negative relation with Ca+Mg (R=-0.53) during the study. Shankar et al. (2008) studies on impact of industrialization on water quality and reported that most of the study area on highly contaminated may it due to the excessive concentration of nitrate total harmless calcium magnesium, TDS, sulphates and fluoride.

Nayak et al. (2008) found that F has a positive correlation with pH and HCO$_3^-$ whereas as negatively correlated with ca$^{2+}$. It study indicated that high fluoride in ground water is associated with low calcium content. Gupta et al. (1999) collected 658 samples from 261 villages in Tehsil kheragarh of district agra and found that 27% samples were in
the range of 0-1.0 mg/L, 25% in 1.0 to 1.5 mg/L, 32% in 15-30 mg/L and 16% above 3.0 mg/L. They concluded that significant correlation of fluoride was found with pH alkalinity, Na, so$_2$ and Po$_4$.

Jego et al. (2008) reported that nitrate leaching could be more pronounced with the potato crop than with the sugarbeet of lower N uptake by the form with its shallow roots and shanker growth period.

Singh et al. (2007) concluded that the fluoride concentration of urine in childrens may be associated with drinking water. In this study the fluoride concentration in drinking water of different villages were analysed i.e. Pataudi, Hali Mandi and Harsaru was 1.68 +0.35, 3.22 +1.18 and 1.78 +0.12 mg/L and urinary concentration was 2.26= 0.024 mg/L at Patandi, 2.48 0.77 mg/L at haily Mandi and 2.43+-0.84 Mg/l at Harsaru villages, respectively.

Zhang and Edward (2007) reported that free chloride better controlled red water and microbial activity in the solution. Although, higher chloride is associated with increased localization of corrosion and pitting. They have also concluded that high level of nitrate increased the rate of chlorine decay and caused release of more iron, but had no effect on chloraniure decay test.

Sarin et al. (2004) reported that iron was released to bulk water primarily in the ferrous form. They have also concluded that iron is released from corroded iron pipes by dissolution of corrosion scales and scales are important parameters that can influence the amount of iron released from such system.

V. Pesticides accumulation

Tsipi and Hiskia (1996) perform a study and found 16 organochlorine pesticides and 3 tetraaazine in the drinking water of Athens, Greece.respectively. Galfionpoulos et al. (2003) studied the organochlorine pesticide contamination in the in the surface water of northern Greece and found HCH isomer, aldrin, dieldrin and endosulfan frequently. They reported that the concentrations of these pesticides were found to be higher than that of the EC’s acceptable levels. Our results showed a similarity to their finding with respect to
their concentration level. Chemical that are applicable in tropical and sub tropical countries are transported over long over long distance by global circulation. Pesticide residues reach in aquatic environment through direct runoff, leaching, careless disposal of empty container, equipment washing etc. (Atamanalp and Yank 2001).

Irani et al. (2002) investigated 15 OCP residues in drinking water sample around Delhi. They found that organochlorine pesticide in the groundwater and irrigation sample water sample were below the maximum Contamination level prescribe by the WHO, and no organochlorine pesticide were detected In any of the drinking water samples.

El-Kabbany et al. (2000) investigated the pesticide level in some water resource of El-Haram, Giza. The water samples were collected from El-Harm Giza, canal water supplies in addition to the El-Moheet drainage water. They reported that the residue of pesticide was varied and organochlorine pesticide residues in El-moheet darning water were relatively higher than in the canal water. They detected sixteen organochlorine pesticide in most of the water sample and their presence frequency, and order was as follows; drins (aldrin, endrin, dieldrin etc.) > total BHC > total DDT > endosulfan > heptachlor epoxide > heptachlor.

Trungut (2003) investigated the organochlorine pesticide and heavy metal contamination in The Küçük Mendred River of Turky. He reported that the contamination have remained although these pesticide were banned. He also reported DDT derivatives such as 4,4′-DDD in high concentration. The highest concentration belonged to heptachlor epoxide (128ng/l.).

Zhulidov et al. (2002) investigated the presence of DDTs (DDT, DDE, DDD), and HCHs (α- HCH, γ- HCH) in the water, sediment and fish of north Russia. They found that 4,4′-DDT and 4,4′-DDE level were higher than the acceptable limits and 4,4′-DDD was to be in the lower level of acceptable limits in the water. They reported the presence of α- HCH and γ- HCH in river sediments. In the present study it was found that the 4,4′-ddt level was over the acceptable limit while the 4,4′-DDD was lower.