Review of Literature
Fluoride were recognized as important trace element for the human health on their role in prevention if dental caries. Ground water is the natural source of fluoride which results from weathering of primary rocks such as granite and gneiss and leaching of fluoride containing minerals. Over the past few decades, extraction of ground water has far exceeded its recharge rate especially in developed countries. Consequently, the concentration of has crossed it permissible limit (i.e.1.5mg/l according to WHO 1984). The excess intake of fluoride for a long period of time results in fluorosis and non-skeletal manifestation. Excess fluoride problem prevails in 29 countries of the world including Africa, China Japan India Sri Lanka Thailand USA etc. The ground water, fluoride concentration varies with type of rock the water flows through but do not usually exceed 10 mg/l (US EPA, 1985). Ground water with high fluoride content is found mostly in the calcium deficient ground water in many basement aquifers. The fluoride content in ground water of Indian aquifers varies from < 1 ppm up to 25 ppm (Rao et al., 2004).

Bhagavan and Raghu (2004) studied the utility of check dams in dilution of fluoride concentration in ground water of Anantapur district of Andhra Pradesh. They studied the resultant impact on the health aspect of certain village of Anantapur through the analysis of their blood serum and urine.

Arif Mohammed et al. (2014) studded Fluoride Toxicity and its Distribution in Groundwater of Makrana tehsil in Nagaur district, Rajasthan. India. The samples were collected from manually operated hand pumps. Fluoride concentration of groundwater samples from fifty six villages of Makrana tehsil was monitored and forty six villages were found to have a fluoride concentration above 1.5 mg/l. The maximum fluoride concentration (9.27 mg/l) was recorded in groundwater of the
Chakrani Gaon, while minimum (0.29 mg/l) was recorded in Kacholiya. As per the desirable and maximum permissible limit for fluoride in drinking water, recommended by the WHO and BIS. Seven villages found in a category-I which is below 1.0 mg/l. In these villages there are no possibilities of any kind of fluorosis and this. Concentration of fluoride is beneficial, for calcification of dental enamel especially for children under 10-year age. Three villages found in category II which is between maximum desirable limit and the maximum permissible limit as recommended by BIS (10, 500: 2012). Eighteen villages recorded in category III (above 1.5 mg/l and below 3.0 mg/l). In twenty villages fluoride concentration in groundwater is above 3.0 mg/l and below 5.0 mg/l and this fall in category IV. The eight villages fall in category (above 5.0 mg/l). The most alarming condition for fluorosis may see in these villages. The water in these villages (Category III, IV and V) is not suitable for drinking purpose. The groundwater of about forty six villages is unfit for drinking purpose.

Saxena et al. (2013) assess the fluoride contamination status of ground water in Bassi tehsil of district Jaipur, Rajasthan, India. Fluoride concentration in these sampling sites varied from 0.1 to 12.5 mg/L in ground water samples, with lowest value 0.1 mg/L (S45) in village Tunga and highest value 12.5mg/L (S31) in village Hanumanpura. Out of 50 villages, maximum 14 villages (28%) were found to have fluoride above 1.5 but below 3.0 mg/L and minimum 5 villages have fluoride content in between the range of 1.0-1.5 mg/L. 6 villages (12%) have fluoride concentration above 3.0 but below 5.0 mg/L and 12 villages (24%) are having fluoride above 5.0 mg/L. As per the desirable and maximum permissible limit for fluoride in drinking water, determined by WHO and Bureau of Indian Standards, 74% of groundwater sources are unfit for drinking purposes. Due to the higher fluoride level in drinking water several cases of dental and skeletal fluorosis have appeared at alarming rate in this region.
Verandani S. et al. (2012) studied physico-chemical parameters of ground water of Ulhasnagar city in Thane district, Maharashtra, India. The pH values of groundwater were varied from 6.8-8.5 indicate slightly alkaline nature. The E.C. value ranged from 554 to 1040 mhos/cm. Calcium Hardness ranged from 24 to 222 mg/land Magnesium Hardness ranged from 15 to 144 mg/l water hardness in most groundwater is naturally occurring from weathering of limestone, sedimentary rock and calcium bearing minerals. The concentration of fluoride in the studied water samples ranged from 0.4 to 3.0 mg/l.

Singh p et al. (2011) analyzed the concentration of fluoride in ground water of Churu city. Majority of ground water sample of this area were found to contain much higher fluoride content, beyond the permissible limits. Maximum concentration (8.5 ppm) occurred at Madersa, (7.8 ppm) at Van Vihar and (7.3 ppm) at Eye’s Hospital’s Tube well. As a result the leeching out of fluoride from the above source contaminates water and soil. During the study it was also found the water from the deep well had more fluoride contamination as compare to relatively less deep wells.

Meena K.S et al. (2011) conducted a survey of Fluoride contaminated ground water and its implications on human health in Deoli Tehsil (Tonk District) in Rajasthan. Physico-chemical study of 130 villages was done. The fluoride content of ground water ranged from 0.26 to 9.60 ppm. The highest fluoride (9.60) concentration was reported from Akodiya village and minimum was observed from Jalseena village. The data revealed that 80% villages are affected with high concentration of F. Lower in 14% villages, However 6% villages contained optimum limit of F concentration. The populace of study area were suffering from skeletal fluorosis and dental fluorosis.

Prasad R.N. et al. (2010) analyzed physico-chemical properties of groundwater of Bapi and Sundarsanpura industrial area of Dusa district, Rajasthan to assess their
suitability for drinking purposes. These ground waters were alkaline (pH 7.16-8.37) and their electrical conductivity varies from 1032 to 5025 mhos/cm and fluoride concentration varies from 1.65 to 5.85 mg/l. Salinity and fluoride contamination are the two major problem in the area, which is alarming considering the use of this water for drinking purposes. It is observed that high alkalinity leads to increase in the fluoride level and high calcium content decreases the fluoride level. A correlation study has been carried out for all possible pairs of eleven physic-chemical parameters of ground water of study area. Magnesium and chloride shows geo-chemically moderate relationship. Calcium and Sulphate shows geo-chemically no relationship. Correlation coefficient \((r \geq 0.08\) to 0.99).

Tailo et al. (2010) identify the hydro geochemical processes influencing the high fluoride concentration in ground water of Malpura Tehsil, Tonk (Rajasthan, India). During study total twenty six ground water samples were collected from hand pumps, open wells and bore wells of different sampling sites of Malpura Tehsil. The ground water samples were collected during the post monsoon session the fluoride concentration along with physico chemical parameters in ground water samples was determined in various sampling sites of Malpura Tehsil, since in most of the sampling point it is only sources of drinking water. The Fluoride concentration in these sampling points varied from 0.08 to 11.30 mg/L with highest level at G7 sample (11.30 mg/L) and lowest at G8 sample (0.08 mg/L). Most people in these study areas suffer from dental fluorosis and skeletal fluorosis such as mottling of teeth, deformation of ligament, bending of spinal column and ageing problem.

Rafique et al. (2009) studied the geochemical factors controlling the occurrence of high fluoride concentration in ground water in the Nagar Parkar area in Sindh (Pakistan). The fluoride concentration ranges from 1.13 to 7.85 mg/l. 78 percent samples contended fluoride more than permissible limit (1.5 mg/l) set by
WHO. The ground eater is alkaline, pH ranges between 7.1 to 8.4 and Total Dissolve Solids are in the range of 449 to 15, 933 mg/l and classified as Na-Cl type water. Their prevailing chemical characters reflected the influence of salt water intrusion, high evaporation rate and ion exchange.

Gautam (2009) conducted extensive hydro geochemical studies of ground water of Nawa Tehsil of Nagaur district. Highest fluoride concentration in Nawa was recorded at Rulaniyo ki Dhani of govindi village (14.62 mg/l) 78.99% villages were having aquifers beyond permissible limit of WHO (1.5 mg/l) in the study area, 100% prevalence of dental fluorosis in males and 95% in females was observed above the age of 40 years. 64.78% respondents interrogated were reported to have sever skeletal fluorosis.

Yadav Kumar Ashok et al. (2009) observed fluoride contamination in groundwater of Tonk (Rajasthan). Deoli tehsil have high fluoride concentration in water (i.e. 1.5 mg/l) it has been observed 58.19% villages have fluoride in the range of 1.5 to 3.0 mg/l 45.57% villages of Todaraising tehsil have fluoride in the range of 3.0-6.0 mg/l. 12.50% village of Malpura have fluoride in the range of 6.1-8.0 mg/l and 6.81% village content fluoride level in more than 10 mg/l. 4.84% village of Tonk Tehsil villages have fluoride in the range of 8.31-10 mg/l.

Saini (2009) conducted physic-chemical studies of ground water in and around Udaipurwati tehsil of Jhunjhunu district and impact of high fluoride in fauna and flora was analyzed. Highest concentration of fluoride was 5.6 mg/l in the south-eastern zone of the tehsil. However 52% villagers are suffering from dental fluorosis and 58% residents having skeletal fluorosis in central zone of the tehsil.

Chaudhary et al. (2009) assessed fluoride toxicity level in Gang canal catchment area of north-western Rajasthan. Fluoride concentration was found to
vary from 0.50 to 8.50 mg/l in Sujangarg Tehsil of Churu district, ground water analysis revealed 56.94% of the samples had fluoride beyond permissible limit and highest level recorded was 45.02 mg/l (Jangid, 2008). Epidemiological study revealed that 56.37% respondents have sever skeletal fluorosis.

C. LI. et al. (2009) carried studded the effect of excessive fluoride (F) on physiological function in Tea plant with spatial reference to the superoxide dismutase (SOD) activity catalysis (CAT) and guaiacol peroxidase (GPx) activities. Their studies include growth parameters, antioxidant defense system, and photosynthesis and leaf ultra-structure. Fresh and dry mass, chlorophyll content and net photosynthesis rate decrease with increasing fluoride concentration.

Sabal Daisy et al. (2008) analyzed Fluoride contamination status of groundwater in Phulera tehsil of Jaipur district, Rajasthan. Phulera tehsil is facing the problem of groundwater pollution. In the present investigation, determination of fluoride (F) in drinking water was conducted in (200 samples of) 40 villages of Phulera tehsil having fluoride content more than permissible limits (>1.5 mg/l). The water samples were alkaline with pH ranging from 7.05 to 10.16. Electrical conductivity (EC) ranged from 157 µmhoS/cm to 1018 µmhoS/ cm. Calcium hardness (Ca-H) ranged from 10 to 127 mg/l. Total hardness (TH) varied from 69 to 572 mg/l. Chloride varied from 92.00 mg/l to 1422.00 mg/l and fluoride from 1.20 to 18 mg/l. The alkalinity of all water samples were found to be more than the permissible limit. The results envisaged that the quality of ground water of Phulera is very poor, and is not suitable for drinking purpose and can only be used after proper treatment. After the pilot survey symptoms of skeletal and gut fluorosis have been found in almost every inhabitant.
Hussain Ikbal et al. (2008) studied the distribution of fluoride in the groundwater of Nawa block. Fluoride concentration ranges from 0.3 to 5.9 mg/l. The minimum concentration was recorded for Rajliya village while maximum concentration was recorded from Sirsi village (5.9 mg/l). Data on the concentration of fluoride in different samples of Nawa block indicate that maximum habitations have fluoride concentration between 0.4 and 1.5 mg/l. The present investigation reveals that 19 habitations (43%) fall in category I in which fluoride concentration is below 1.0 mg/l, a maximum desirable limit of standards for drinking water recommended by Bureau of Indian Standard (BIS) in IS 10500 (1991). There is no possibility of fluorosis in these habitations because this concentration of fluoride is beneficial for calcification of dental enamel especially for children below 10 years of age. Once fluoride is incorporated into teeth, it reduces the solubility of the enamel under acidic conditions and thereby provides protection against dental carries. Out of 44 habitations of Nawa block, 13 habitations (30%) have fluoride concentration between 1.0 and 1.5 mg/l and fall in category II. About 17% of population of 7 habitations (16%) consumes water with fluoride concentration between 1.5 and 3.0 mg/l. In four habitations (9%), fluoride concentration in groundwater is above 3.0 mg/l and below 5.0 mg/l, and this fall in category IV. About 6% population of these habitations may have all degree of dental fluorosis (mild, moderately, moderately severe, and severe fluorosis) including skeletal fluorosis after 30 years of age.

Sabal et al. (2008) studied in Amber tehsil of Jaipur district. 25 villages were under surveillance. Groundwater samples were periodically collected and analyzed for physico-chemical parameters including Fluoride (F-), pH, electrical Conductivity (EC), total dissolved solid (TDS), total hardness, calcium (Ca^{2+}), chloride (Cl^-) and alkalinity. The analytical results revealed considerable variations in the chemical composition of water samples. Fluoride concentration varies from 0.91 to 4.20 mg/L.
The result reveals that fluoride content in groundwater samples of five villages varied from 0.0 - 0.99 mg/L. In eight villages, fluoride content ranged from 1.0-1.49 mg/L followed by more than 1.50 mg/L in twelve villages. The maximum content of fluoride was recorded in Bhimpura (4.00±0.02mg/L), Khora Meena (4.00±0.01mg/L) and Peelwa (4.2±0.09mg/L). The permissible limit for fluoride content is 1-1.5 mg/L according to W.H.O. (1996). The data revealed that 48% villages of Amber tehsil are affected with high concentration of fluoride, where as 52% villages with in limit. Among groundwater samples Peelwa area had maximum EC (1423 mhos/cm) while Chamanpura area had minimum (132 mhos/cm). Total dissolved solid reduces utility of water for drinking, irrigation and industrial purposes (WHO, 1996). In the groundwater samples of Amber tehsil, Peelwa area had maximum TDS (1053 mg/L) while Chamanpura area had minimum (84 mg/L).

Guo et.al. (2007) studied the geochemical process controlling the elevated fluoride concentration in Taiyvan Basin of Northern China. They observation that high fluoride ground water zone containing up to 6.20 mg/ l fluoride were mainly located in discharge areas, especially investigation indicated that processes including hydrolysis of silicate minerals, cation exchange and evaporation were responsible for the increased average content of major ions in ground water from the recharge areas to the discharge area. The concentration of fluoride was also found to be positively related to $\text{HCO}_3^-$ ions, $\text{Na}^+$ ions and pH valve.

Srivastava et al., (2007) investigated that Temperature, pH, extent of contact porosity of rocks and soil quality are the determining factors of leaching of fluoride in aqueous medium. The fluoride content of surface water and ground water are depends on availability and solubility of the parent fluoride containing minerals whit which this are in contact.
Farooqi et al. (2007) studied the distribution of high Arsenic and Fluoride contamination ground water from East Punjab, Pakistan. Out of 147 ground water samples investigated, 75% exceeded the WHO standard (1.5 mg/l) for fluoride. The highly contaminated fluoride (max. 22.8 mg/l) ground water were found from shallow depths to 30 m from the surface. The contaminated ground water were characterized by high pH (max. 8.8), alkalinity (HCO$_3^-$ up to 1281 mg/l), SO$_4^-$ (max. 960 mg/l), Na$^+$ (max. 1058 mg/l) and maximum electrical conductivity 4.6 mS/cm. fluoride concentration showed positive correlation with those of Na$^+$ and HCO$_3^-$ and negative Ca$^{2+}$ and Mg$^{2+}$.

Msonda et al. (2007) carried out a study to determine fluoride concentration in ground water of Lilon gune district in central region of Malawi. Fluoride data was used to produce a fluoride distribution map. From map, it was inferred that central part of Natheje had high fluoride concentration between 2 and 7.02 mg/l. Sajidu et al. (2008) conducted geochemical study of fluoride level in the village of Southern Malawi. The fluoride data in 21 of 49 sampled locations was found to be above the WHO maximum limit of 1.5 mg/l.

Ravindra and Garg (2007) performed hydro-chemical survey of groundwater of Hisar city. The relatively higher concentration of fluoride and chloride were found in most groundwater samples. Data were assessed statistically to find the suitable marks of groundwater an aid to monitor the ground water quality.

Ashutosh et al. (2006) studied the concentration of fluoride in drinking water samples of open well and hand pump of Uniara tehsil of Tonk district (Rajasthan). Fluoride concentration in the area varies from 0.76 to 10.1 mg/l. highest concentration was found to be 10.1 mg/l in hansolai village. The data depicted that in 80.95% villages concentration was found higher than the standard value of fluoride (1.5 mg/l).
In 66.67% village fluoride concentration was ranging from 1.5 to 5.0 mg/l and 19.05% villages contained optimum limit of fluoride concentration.

Jain Nisha (2006) done extensive study of geochemical analysis of groundwater and it impact assessment in and around the Padampura area (in Chaksu Tehsil) of Jaipur. All the 16 villages has fluoride concentration more than permissible limit (1.5mg/l). In the impact assessment of fluoride revealed that 40% of these residents interrogated had dental fluorosis and only 1.2% had skeletal fluorosis.

Shivkumar (2004) conducted detailed geochemical study of Shivdasapura area in Chaksu Tehsil situated in southern part of Jaipur. 20 out of 22 villages’ samples contained fluoride more than permissible limit and maximum fluoride concentration was reported from Chanlai village (14.11 ppm).

Das et al. (2003) studied the groundwater quality of Guwahati, Assam with spatial reference to fluoride. Fluoride concentration was found to be higher in eastern and southern plain of the city. Correlation analysis revealed a positive correlation of fluoride contents with Na\(^+\), K\(^+\), total Alkalinity and depth of source and negative correlation with hardness. Absence of any correlation with chloride. Indicated recharge of the aquifers by Brahmaputra and/or rain. Physic-chemical studies of groundwater’s of Karbianglon district (Assam) were conducted by Kotoky et al. (2008) was found high concentration of fluoride in Ramsapathar (20.6 mg/l) and Lungnit (15.7 mg/l) areas. 7, 00,000 residents of this district were at risk of dental and skeletal fluorosis.

Joshi (2004) carried out random sampling of Sanganer tehsil and 21 villages in around Sitapura. Fluoride concentration in ground water ranges from 0.34mg/l to 13.00 mg/l.
Gangal (2007) contacted an extensive geochemical study of 25 village groundwater and results of ground water samples showed a vast change in ground water quality of Sanganer area of Jaipur district. One of the most relevant cause was the seepage of effluent of dyeing and printing industries of Sanganer area. The fluoride concentration ranged between 1.5 to 16.5 ppm and the results of this study revealed that there is acute fluoride problem.

Singh (2008) performed physic-chemical studies of 125 water samples from 81 villages of Phagi Tehsil. 71.2% of samples and 81 villages had fluoride concentration in ground water beyond permissible limit. Highest concentration was found 13.47 mg/l from Bhomiya Ji Ke Dhani. Amongst the residents of this region, 96.30% were suffering from skeletal fluorosis.

Madhavan N. et al. (2002) studded natural abundance of fluoride in soils of the Ajmer district, Rajasthan was examined. From undisturbed soil, the top 15 cm of the profile was examined and the soil split into fractions based on sand, silt and clay particle size. Clay contained a high amount of fluoride, whereas sand and silts are enriched with much less fluoride. The relation between the soil fractions in observed clay fraction fluoride content matched groundwater fluoride variation. However, the enrichment of fluoride material extracted from the largest soil fraction had considerably lower amounts of clay relative to that from the smaller fractions. Groundwater fluoride concentrations from the soil sampled region show high variation, 0.3–5.4 ppm and the multiple regression results indicate that the fluoride concentration present in the fractionated bulk soil sample does not correlate well with groundwater fluoride. A moderate correlation was obtained for the amount of clay present in bulk soil versus groundwater fluoride ($r \approx 0.403$).
Saxena S. *et al.* (2014) studied the leaching rate profile of F⁻ by loading MgF₂ on undisturbed vertical soil column of the soil collected from Sambhar region of Rajasthan, India. Alkaline soil (pH= 8.2) had been collected from Sambhar region of Rajasthan, India. Linear relationship is established between the concentrations of leachable fluoride [F⁻] i and rate of leaching (LRobs). With increase in added Mg^{2+} concentration, the Na⁺-Mg^{2+} exchange is also found to increase which increases total leachable F-initially present in the soil solution. First order model is found to be best fit for representing fluoride leaching in the present experimental conditions.

Saxena S *et al.* (2014) observed leaching kinetics of fluoride by loading AlF₃ on undisturbed vertical saline soil columns and compared using various kinetic models. Saline soils from Sambhar region of Rajasthan was selected to study leaching mechanism and effects of various parameters on leaching mechanism under atmospheric pressure. Linear relationship is established between the concentrations of leachable fluoride [F⁻] i and rate of leaching (LRobs). [F⁻] i and LRobs are found to decrease with increase in Na⁺ and Ca^{2+} levels of extract while an increase has been observed with increase in temperature and OH⁻ ions. Maximum [F⁻] i are resulted with addition of NH₄OH in percolating water and minimum with addition of KOH. Total leachable F⁻ was found to be unaffected by incubation time. First Order model are found to be best fit for representing fluoride leaching in the present experimental conditions.

Saxena Shweta (2013) studied leaching kinetics of F⁻ by loading NH₄F on undisturbed vertical soil column of the soil collected from Sambhar region of Rajasthan, India The increase in leaching due to bonding of free fluoride with NH₄⁺ ions through H-F bonds. NH₄F adopts the structure with an increased degree of hydrogen bonding between NH₄⁺ and F⁻ ions. The leaching of fluoride will be more in presence of NH₄⁺ ions. On the basis of the results of this study, this can be
concluded that in an agriculture field, if the added fertilizers rich in ammonium ions and fluoride is present simultaneously, the leaching of F will be more.

Abuagri D. A (2011) assess the fluoride content in tropical surface soils used for crop cultivation of Bongo district of the Upper East Region of Ghana relies on groundwater. The level of fluoride (F) in cultivated soils and its implication to crops, since the soils form the essential medium for crops growth. Cropland soils were collected at a depth ranged 1.0 cm to 30.0 cm. The pH of the soils was generally low ranging from 3.34 to 6.78, all less than 7 the soils in these areas are within a strong acidic and slightly neutral range. The low pH range of 3.34 to 4.99 suggests high acidity of the soils which implies that only plants with high acid tolerance can survive. While the specific electrical conductivity ranged from 420.0 to 1735.0 µs/cm of soils used. The fluoride concentrations in the soils ranged from 219.26 to 1163.01 mg kg-1 DW. However, the mean fluoride content of soils in the respective samples locations ranged from 476.64 to 924.69 mg kg The trend could be partly attributed to the physical and chemical characteristics of the soil, for instance a Pearson correlations analysis depicts positive correlations between soil fluoride and soil pH, soil fluoride and EC with $r = +0.23$ and $+0.38$ respectively. This means that the fluoride content increases with soil pH and EC respectively. A similar trend was observed between soil pH and EC with $r = +0.28$. The ions bioavailability is controlled by physical and chemical characteristics of the soils. Although, this was the first study of its kind in the district it depicted that excess fluoride in water reported in the area has a relationship with the trend reported

Chaudhary Veena et al. (2009) analyzed Water-extractable F was determined in soil samples from 60 village sites in the Indira Gandhi, Bhakra, and Gang canal catchment areas of northwest Rajasthan, India. Mean water-extractable soil F concentrations varied between 0.50 and 3.00 mg/L and groundwater F between 0.50
and 5.00 mg/L. Most of the water extractable soil F leaches into the groundwater due to the alkaline sandy loam type soil. The study revealed the generally low water-extractable F content in the soils in comparison to groundwater F at the same sites. Sorption of F is minimum due to alkaline sandy loam type soil and most of the F leaches into the groundwater. In the depth range of 15 to 30 cm, F concentration was elevated by 20–40%, indicating greater F movement to depth in sandy loam type soils. Heavy use of di-ammonium phosphate (DAP) fertilizer and certain geological features are possible sources of elevated F in the area.s

Blagojevich S et al. (2002) Determines the content of fluoride in soil in the vicinity of aluminum plant in Podgorica 60 soil samples (26 of brown and 34 of alluvial soil) were collected from two depths 300 mg/kg, which is maximum permissible value for the content of this element in agricultural soils (Pravilnik, 1990). Highest values for total F content are noticed on locations within and southwards of the aluminum plant. This especially refers to soil layer from 0 to 20 cm. Significant and positive correlations were found between available F and soil pH (in water and 1M KCl) as well as the contents of CaCO₃, humus and sand. The obtained values for correlation coefficients are low, ranging from 0.26 to 0.32. It is interesting to note that there is no significant correlation between total and available fluorine.

Wuyi Wang et al. (2002) Studied the Adsorption and leaching of fluoride in typical Chinese soils in relation to physical and chemical parameters of the soils. The ability of different soils to adsorb F can be expressed as saturation F-adsorbing capacity (Qm) ranked as follows: Black soil > Purplish soil > Red earth > Dark brown earth > Drab soil > Sierozen. The results imply that the adsorption of F in soils decreases from humid areas to arid areas and from acid soils to alkaline soils. The leaching rate of fluoride (percentage of total amount of fluoride in leachate to total fluoride in soil) relates to the mobility of fluoride from different soils. They rank as:
Drab soil > Sierozem > Black soil > Purplish soil > Red earth > Dark brown earth. Chemical properties of soil such as CaO, Fe₂O₃, Al₂O₃, clay particles, organic matter, and pH impact the binding ability of fluoride and leaching of F. pH is significantly correlated positively with leaching rate and negatively with Qm. There are no significant correlations between organic matter and Qm, and with leaching rate. Clay particles are correlated positively with saturated adsorbing capacity Qm. Al₂O₃ correlated positively with Qm and negatively with leaching rate, but not significantly. Fe₂O₃ is negatively correlated with Qm and is positively and significantly related to the leaching rate. The positive correlation coefficient of CaO with the leaching rate is very high, and the correlation coefficient with Qm is negative. MgO is closely related to Qm negatively. The total F in soils is not significantly correlated with Qm and leaching rate. Water-soluble F has a very high negative correlation coefficient with Qm and positive one with leaching rate.

P. C. Mishra et al. (2009) investigated fluoride status of Hirakud the Aluminum smelter in Hirakud is in operation since last 45 years the fluoride content varied from a minimum of 0.5 to a maximum of 0.65 (ppm) in pond water, 0.4 - 0.60 mg/L in ground water, 88.30 - 191.20 in soil, 23.75 - 65.96 in paddy straw, 15.60 - 70.36 in grass and 10.00 - 44.60 in leaf tissue. The level of bio-concentration of fluoride in relation to surface water ranged from 79.30 in vegetation to 304.21 in leaf tissues.

Imed Mezghani et al. (2005) Monthly observed from May through October during the year 2000 on the southwest side of a phosphate fertilizer plant located in the coastal zone of the Sfax region of Tunisia showed that vegetation close to the factory accumulates large quantities of F with variable specific symptoms of toxicity. According to their F content, cultivated species can be classified into five different categories. At the same level of exposure, species with high F content include olive trees (420 µg F/g dry weight), while those with low F content are represented by
apricot trees (50 µg F/g dry weight). As expected, F concentrations decreased with increasing distance from the pollution source. Beyond 8 km, they were lower than 30 µg F/g dry weight. Analysis of atmospheric fluoride revealed a close interrelationship between concentrations of F in the atmosphere and in plant leaves.

Jianyun Ruan et al. (2004) analyzed the effects of pH and Ca\(^{2+}\) on F uptake by Tea plants (Camellia sinensis L.) F uptake was highest at solution pH 5.5, and significantly lower at pH 4.0. In the soil experiment, leaf F decreased linearly with the amounts of lime, which raised the soil pH progressively from 4.32 to 4.91, 5.43, 5.89 and, finally, 6.55. Liming increased the water-soluble F content of the soil. Including Ca in the uptake solution or adding Ca to soil significantly decreased leaf F concentrations. The distribution pattern of F in tea plants was not altered by Ca treatment, with most F being allocated to leaves. The activity of F± in the uptake solution was unaffected and water-soluble F in the soil was sometimes increased by added Ca.

Barbier O. (2010) analyzed the high internal F concentration disturbs almost all the physiological and biochemical process in plants. A number of cellular processes identified to cause deleterious effects on plants include disruption of enzyme activity involved in metabolic processes, inhibition of protein secretion and synthesis, generation of reactive oxygen species (ROS) excessive ROS production leads to macromolecule oxidation, resulting in free radical attack of membrane phospholipids with resulting membrane damage via the induction of lipid peroxidation, mitochondrial membrane depolarization, and apoptosis, and alteration of gene expression, F disrupts enzyme activity by binding to functional amino acid groups that surrounds the enzyme’s active center. Inhibition of protein synthesis and secretion interrupts the signaling pathways involved in cell proliferation and
apoptosis. F can increase oxidative stress leading to the degradation of cellular membranes and reduced mitochondrial activity.

Fluoride can be present in soil as specifically and non-specifically adsorbed ions and compounds (Bowen, 1966 and Robinson, 1978). Widespread source of fluoride pollution in agriculture soil in long term application of phosphatic fertilizers (McLaughlin et al. 1997). Laboratory studies have shown that soil amendment of <200 μg/g Fluoride inhibited soil respiration and dehydrogenase activity, but amendments over this level and up to 2000 μg/g Fluoride influenced nitrification (Ottow and Kottas 1984). Fluoride in ground water many adsorb to soil and many such soils may be useful filters to purify groundwater containing high fluoride concentrations (Gilpin and Johnson, 1980).

The amount of fluoride taken up by the plant appears to be unrelated to the total fluoride concentration of the soil and instead depends on the soil type, pH, organic matter, Ca $^{++}$ and Phosphate content (MacIntire et al., 1942; Prince et al., 1949; Hurd-Karrer, 1950; Treshow, 1971; Hall and Cain, 1972; Cooke et al., 1976 and Mc Clenahen, 1976). Some studies have suggested that fluoride complex ions such as Al-F complexes (Takmaz-Nisancioglu and Davison, 1988) and Si-B-F complexes (Colletr, 1969) may be taken up by the plants to a greater degree. Davison (1983) suggested that low pH may drive increased f uptake by plants.

Singh et al. (1995) studied the uptake of fluoride by lady’s finger (Abelmoschus esculentus) Fluoride in the water were used for irrigation. Lady’s finger (Abelmoschus esculentus) was grow in Sand-cultures and Soil-cultures foe 18 Weeks. Uptake of fluoride by sand-culture plant was greater in comparison to soil-cultured plant maximum fluoride accumulate in the roots.
Agarwal Rinku et al. (2014) observed fluoride (F) accumulation in *Triticum aestivum* (Wheat) var. Raj 3077 and its effect on the growth and crop yield was conducted in Pot experiment. Eight different concentrations of Fluoride in the water were used for irrigation ranging from 3 to 21 ppm with distilled water as the control. Potentiometric determinations of the Fluoride content in different parts of the plant were made after sowing the seeds (Pre, Peak and post-harvest, respectively). Due to this high concentration of fluoride, it resulted in the necrosis and chlorosis in the plant, reduction in growth of shoot and root and ultimately reduced the yield of *Triticum aestivum* var. Raj 3077. Bioaccumulation of fluoride in wheat grains creates secondary source of fluoride to human population resulting in food-borne fluorosis, primary source being water. Bioaccumulation of fluoride in *Triticum aestivum* var. Raj 3077 varied in the root, shoots, leaves, and seed showing a monotonic trend with increasing concentration of fluoride in the irrigation water. Overall the fluoride concentration was highest in the leaves, next highest in the stem and lowest in either the root or seeds. At the post-harvest the highest mean concentrations of fluoride were recorded with 21 ppm in the irrigation water 20.64 mg/kg in the leaves, 16.69 mg/kg in the stem, 15.28 mg/kg in the roots and 10.65 mg/kg in the crop (seeds).

Ram, Amra et al. (2014) studied the effect of sodium fluoride (NaF) on seed germination and biochemical parameters were studied in *in vitro* grown seedlings of watermelon (*Citrullus lanatus*) under salicylic acid (SA) treatment. After seven days of NaF treatment, reductions were observed in percentage of seed germination, root and shoot length, vigor index, pigment content, chlorophyll stability index (CSI), and membrane stability index (MSI) with increasing concentrations of NaF (1 and 10 mM). Seedlings treated with SA, both alone and in with combination of NaF, showed an increase in seed germination as well as other growth parameters. NaF treated seedlings were found to accumulate more soluble sugars and phenolics,
which were further increased by SA treatment thereby indicating a synergistic effect of SA and NaF on the accumulation of sugars and phenols. Therefore, these parameters are not directly related to a higher vigor index, membrane stability, and seedling growth. Treatment with SA reduced the adverse effects of NaF by increasing seed germination, root and shoot length, vigor index, pigment content, CSI, and MSI by some mechanism other than the accumulation of sugars and phenols. The higher concentration of NaF (10 mM) reduced the germination percentage by 23% as compared to the control. The average root and shoot length decreased with increasing NaF concentration. Shoot growth in the seedlings was more affected than root growth. Percentage of chlorophyll stability index (CSI) was significantly decreased by NaF treatment and increased by SA. Furthermore, the CSI showed a positive correlation with pigment content as SA-treated NaF-stressed seedlings had a relatively higher CSI and pigment level. The increased CSI in the presence of SA indicates a greater stress tolerance capacity in the growing seedlings.

Chakrabarti Sakuntala et al. (2013) studied the effect of aqueous solutions of 0, 10, 20, 30, 40 and 50mgl sodium fluoride (NaF) on seed germination, seedling growth and biochemical parameters of two varieties of paddy (i.e. Oryza sativa L. var. IR-36 and O. sativa L. var. Swarno). The percentage of seed germination decreased up to 50% with increasing NaF treatment. The seedling growth parameters (root length, shoot length and vigor index) and biochemical parameters i.e. chlorophyll and ascorbic acid content as well as the F uptake by the germinated seedlings were estimated after 15 days of treatment. The chlorophyll and ascorbic acid content decreased with increasing NaF treatment. However, the antioxidant ascorbic acid content showed an increasing trend between 20 and 30mgl NaF treatment, which may be considered as an adaptive mechanism to F stress. The F uptake increased many fold with the F uptake by shoots being slightly lower than by the roots. Between the
two studied paddy varieties, the F uptake as well as other effects was more pronounced in swarno than IR 36. The study demonstrates that sodium fluoride inhibits seed germination and seedling growth as well as adversely affects the chlorophyll and ascorbic acid concentrations. In both the paddy varieties, the ascorbic acid content decreases gradually from control up to 20mg/l of NaF concentration. The total chlorophyll content of the leaves decreased with increasing NaF treatment and rate of decrease was more in swarno than IR-36. At 10mg/l of NaF, it was about 50 and 60% of the control value in Swarno and IR-36 variety respectively. At 50mg/l NaF, the values were only 1.5 and 4.5% of the control values. Even in the control condition, the shoot and roots of both the variety of paddy contained about 40mg kg of F. This may be due to the presence of F in the paddy seeds collected from the local areas which is fluorosis endemic. The uptake in the paddy seedlings of both the varieties (Swarno & IR-36) increased many fold with increasing NaF concentrations with Swarno seedlings showing relatively higher accumulation. At 50 mg/l of NaF, the F uptake were above 7000mg/kg which was about 20 times more than the value at 10mg/l NaF. In both the varieties, roots have greater tendency for accumulation of F.

Singh Munna et al. (2013) studied the Influence of fluoride contaminated irrigation water on physicochemical of poplar seedlings *Populus deltoides* L. clone-S7C15. When exposed to 100–500 ppm fluoride-contaminated irrigation water for six weeks, six-week old poplar (*Populus deltoides* L. clone-S7C15) seedlings showed decreases in the following physiological characteristics: growth, leaf expansion, photosynthetic CO2 assimilation, stomatal conductance, chlorophyll fluorescence yield, plant biomass, and harvest index. An enhanced electrolyte leakage triggered susceptibility of the seedlings to loss in the harvest index. The 500-ppm F level induced marked inter-vein chlorosis, leaf-margin necrosis, and leaf-curl on younger leaves with a xerophytes condition for rhizosphere that altered the tree habit of
poplars in scrub vegetation. With increasing F concentrations, the harvest index and other growth parameters were successively reduced.

Saini Poonum et al. (2013) investigated the *Prosopis juliflora* capacity as bioindicator plant and its efficiency to accumulate fluoride. *Prospis juliflora* seedling grown in seedling grown in hydroponic culture containing different concentration of F were analyzed for germination percentage together with some biochemical plant parts after 15 days of treatment, root growth ($r = -0.928, p < 0.01$), shoot growth ($r = -0.976, p < 0.01$) vigor index ($r = 0.984, p < 0.01$) were in decreasing trend with increasing concentration of NaF. Both catalase (3.2 fold) and peroxidase (2.7 folds) enzyme activities increase with increasing in F concentration plant accumulate large portion of the F in root (1024.63 µg/g d wt.) followed by shoot (492.30 µg/g d wt.). As *Prosopis juliflora* did not show any morphological changes (marginal and tip chlorosis of leaf portion, narcosis and together these features are referred to as leaf “tip burn”). Therefore, this species may be used as suitable bio-indicator species for potentially F affected areas. Further higher accumulation of F in root indicates that *Prosopis juliflora* is suitable species for the removal of F in phytoremediation purposes.

Chakrabarti Sakuntala et al. (2013) studied the effect of fluoride on superoxide dismutase activity (SOD) in four common crop plant. Radish (*Raphunus sativa*), coriander (*Coriandrum sativum*), mustard (*Brassica juncea*), and spinach (*Spinacea oleracea*) plants were grown in earthen pots watered with aqueous solutions containing 0, 5, and 10 mg F/L. Fluoride (F) uptake and superoxide dismutase (SOD) activity (unit/mg protein/min) were estimated from the edible plant parts following harvest after 60 days. The values of both entities rose with increasing F exposure in the order radish > coriander > spinach > mustard. The results indicate that plant species tolerant to F toxicity induce higher antioxidant SOD activity, which may be
an adaptive reaction in plant cells to attenuate the damaging effect of reactive oxygen species (ROS) generated during F stress.

Kartick C. Pal et al. (2012) estimate fluoride concentrations and water quality along with the translocation of fluoride into vegetables through soil and the stress effect of fluoride on some biochemical parameters in this area. The result has been compared with a non-contaminated area of Burdwan University farm of the Burdwan District as a control zone by collecting equal numbers and types of samples. The results showed a positive correlation of fluoride concentration with depth, indicating higher concentrations of fluoride in drinking water drawn from deep tube wells in this semi-arid region. A high bio-concentration factor (BCF) of fluoride in vegetables imposes a high health risk due to fluoride intake both from water and vegetation. Probable exposure to the inhabitants of these villages is speculated due to changed biochemical parameters like chlorophyll, sugar, amino acid, ascorbic acid and protein in the vegetables as a result of fluoride stress. In the future, ground water monitoring to supply safe drinking water may be an effective way against the negative impact of fluoride on the inhabitants. The depths of sources of the samples showed a positive correlation with the fluoride concentration in the polluted area. But this correlation is not as significant in the control area as the control area contains low level of fluoride. The highest mean values of fluoride were found to be 10.0 mg/L in groundwater having the highest depth (100 ft) in the fluoride-contaminated area. The amounts of fluoride in surface water were lower in comparison to groundwater

Yadav Rajesh Kumar et al. (2012) assess accumulation of fluoride in vegetables and cereal crop grown in potentially fluoridated area in Dausa district, Rajasthan, India. Certain types of food can have high fluoride content. In the present investigation food items were collected from Dausa district and analyzed. Variable fluoride accumulation occurs in crop (wheat) and vegetables (potato and tomato).
Fluoride concentration in ground water samples (Hand pumps and open well) of 7 villages was found to vary from 5.1 ppm to 14.7 ppm the present study revealed that fluoride concentration in wheat crop was found between 3.24 µg/g (village) to 14.3 µg/g (village). In this study area fluoride concentration in tomato and potato was estimated 1.10 µg/g to 4.6µg/g and 1.22 µg/g to 2.92 µg/g respectively. The fluoride content of cereal crop was found to be higher than that of vegetables.

Devika Bhargava et al. (2011) studded the effects of different concentrations of NaF on different morphological characters, yield and its bioaccumulation in wheat variety (Triticum aestivum var. Raj.4083). In a pot experiment, a wheat variety was irrigated with 4-16 mg/L NaF (4, 8, 12, 16, and 20 mg/L). The experiments were carried out for the entire life cycle of 120 days of this wheat variety. Plants were harvested after 120 days of sowing of seeds. With increased concentrations of fluoride, phytotoxicity was observed on both, root and shoot length there were significant changes in morphological characters and yield attributes in plants treated with 16 and 20 mg/L NaF. In plants treated with 20mg/L, significant reductions in shoot length (by 25.16%), root length (by 32.14%), number of leaves (by 42.40%), leaf area (by 19.50%) and grain yield (by 16.26%) were observed. Bioaccumulation studies of fluoride in plant parts revealed maximum accumulation in roots (4.24µg/g) and minimum in leaves (1.45µg/g) in plants treated with 20mg/L NaF. Results of the study showed that use of groundwater containing high fluoride content for irrigating wheat plants may be detrimental to its growth and yield. Increased concentrations of NaF on number of leaves, tillers and ears per plants. In plants treated with 20mg/L NaF, there was 42.40% (3.26) decrease in number of leaves/plant. At the time of harvest, leaves dried and began to shed off. But aging and senescence was faster in fluoride treated plants compared to control.
Kumar and Roa (2008) analyzed the effects of irrigated water containing fluoride (2-30 ppm) from deep wells on two cultivars of mulberry. Mulberry variety (S54) was more sensitive to fluoride and reduction in photosynthetic capacity, chlorophyll a and b concentrations and leaf area was reduced with increasing with concentration of fluoride in irrigated water was observed.

Sudhakar Pant et al. (2008) studied the effects of 0.001, 0.01, and 0.02 M sodium fluoride (NaF) on the growth of seedlings of wheat (Triticum aestivum), Bengal gram (Cicer arietinum L.), mustard (Brassica juncea), and tomato (Lycopersicon esculentum). At the end of 7 days of treatment, decreasing trends in the growth of roots and shoots were observed with increasing F concentrations. The stimulation of root growth in wheat, shoot growth in mustard, and both root and shoot growth in Bengal gram were observed at 0.001 M NaF. Inhibition of root growth in mustard and shoot growth in wheat were also recorded at the same concentration. Concentrations higher than 0.001 M were found to be detrimental to both shoot and root growth with 0.02M NaF more than 30 to 92% reduction was observed in the growth of shoot and root in wheat, Bengal gram, and mustard. Between the root and shoot systems, the latter was more affected at higher concentrations. Very high uptake and accumulation of F have been recorded in the range of 280 to 4000 mg/kg for both grass and legume species.

Chang and Thompson (2008) studied the effects of fluoride (0.01M) on nucleic acid and growth germinating corn seeds. RNA content of 3 mm root tip were found to be directly proportional to the growth rates while amount of DNA was found related to growth rate. Since fluoride reduced the mitotic figures, it was likely that fluoride inhibited DNA synthesis during the interphase of mitotic cycle. Fluoride also induced Maturity in seedlings root in proportion to the period of fluoride exposure.
Chaudhry et al. (2008) studied the Effect of fluoride toxicity on chlorophyll, protein percentage and energy content of Wheat (Triticum aestivum L.) and Chick pea (Cicer arietinum L.) The Chlorophyll content in green leaves was studied on 60th day of sowing. Chlorophyll content gradually decreased with increasing the concentration of NaF (10, 25, 50, 100 and 250 ppm). Protein and energy contents were studied after harvesting. 100-200 ppm concentrations of NaF were found toxic to wheat and chickpea.

Eli Dahi et al. (1995) studied the Defluoridation using the Nalgonda Technique in Tanzania to remove the excess of fluoride in drinking water in order to avoid endemic fluorosis, i.e. mottling of teeth, stiffness of joints and crippling. The concentration of fluoride in the raw water was 12.5± 0.9 mg/l. The adopted dosages of 12.8g alum and 6.4g lime has been reducing the fluoride concentration to 2.1± 0.7mg/l in the sample. Optimum fluoride removal is obtained in the 6-8 pH range.

Gill Tarundeep et al. (2014) evaluated the feasibility of conventional rural based defluoridation technique - Nalgonda technique, Activated alumina in urban areas. Nalgonda technique is being used extensively due to ease in construction of the reactor, operation & maintenance. This technique is very effective even when the fluoride concentration is above 20 mg/L. However, generation of acid or alkali water, residual aluminum, soluble aluminum fluoride complexes and fluoride contaminated sludge limits its practical applications. Above this, leakage of sulphate as aluminum sulphate with concentration as high as 400 mg/L in treated water, makes it un-potable and caused pitting effect on RCC reservoir/reactor or container. Cement paste is also employed for effective removal of F- due to high concentration of Ca2+ and additional adsorption of the remaining F- into amorphous calcium phosphate. However lime creates the problem of hardness of effluent water and co-precipitation particle of CaF2 are too fine to be sediment without coagulation. Limitation of CaF2
precipitation also includes its inability to reduce F- concentration of less than 10-20 mg/L against permissible limit of 1.5 mg/L. Activated Alumina though showed effective removal of fluoride, slow rate of adsorption, pH adjustment, accumulation of bacteria in the long run inhibits its commercial application. Also sludge generation is one of its main drawbacks. Application of these conventional techniques in urban areas will lead to generation of large amount of fluoride sludge which creates another issue of solid waste management. It will be advisable to set up decentralized locality based fluoride removal treatment unlike high capacity water treatment in urban areas.

Piddennavar Renuka et al. (2013) Review on Defluoridation Techniques of Water. Inadequate ingestion of fluoride is associated with dental caries, whereas excessive intake leads to dental, skeletal and soft tissue fluorosis- which has no cure. Considering the fact that fluorosis is an irreversible condition and has no cure, prevention is the only solution for this menace. Providing water, with optimal fluoride concentration is the only way by which the generation yet to be born can be totally protected against the disease. Defluoridation was the conventional and widely tested method for supplying safe water to the fluorosis affected communities. Various techniques and materials were tried throughout the world for defluoridation of water. Defluoridation techniques can be broadly classified into four categories; Adsorption technique, Ion-exchange technique, Precipitation technique, and other techniques, which include electro chemical defluoridation and Reverse Osmosis. This paper discusses various defluoridation techniques used across the world and current status of defluoridation in India.

Parlikar A.S et al. (2013) studied on defluoridation of water by naturally available absorbent Moringa oleifera (Drumstick). Absorbing media was prepared by 40 gm of powder Drumstick (Moringa oleifera) seeds added to 400 ml of 1N
HNO₃ for acid treatment and 0.5N NaOH for alkali treatment. The mixture was boiled for about 20 minutes, dried again in an oven at 50°C for 6 hrs. The adsorbent having 600 µ size initial fluoride ion concentration was 10 mg/lit, with adsorbent dose of 2.5 gm/lit and contact time of 1 hr. In case of acid washed adsorbent the maximum removal efficiency was 39% at pH 1. Whereas in case of alkali washed adsorbent the maximum removal efficiency was 51% at pH 10. The extreme pH values will give rise to higher costs for post treatment. Therefore it is not advisable to adopt extreme pH values. It is generally recommended to maintain near neutral pH for the solution. Therefore at pH of 8, the percentage removal was 13% and 49.5% for acid washed and alkali washed adsorbents respectively.

Arif Mohammed et al. (2013) analyzed the fluoride concentration in ground water of sanganer tehsil Jaipur district India and defluoridation from plant material. 20 water samples were collected from hand pump, bore well and open well. Fluoride in all samples of study area varied from 1.1 to 6.45 mg/L, 1.3 to 6.45 mg/L and 1.1 to 5.40 mg/L, in hand pump, bore well and open well water samples respectively. Defluoridating materials were prepared from the dry fruits, collected from the plants Enterolobium saman (ESC), Acasia arabica (AAC), Prosopis juliflora (PJC) belongs to Mimosideae family and Citrus limon (CLC) belongs to Rutaceae family in the plant kingdom. the dose of adsorbent is 4.0 g/l for those water samples, which contain fluoride, ranging from 1.5 to 3.0 mg/L, and 5.0g/l those contain fluoride range between 3.0 and 6.0 mg/L. These materials successfully decrease the fluoride ions concentration to an acceptable limit (from 0.5 to 1.5 mg/L) without disturbing drinking water quality standards.

Razbe Neelo et al.(2013) Review on the available technologies for fluoride removal and advantages and limitations of each one have been presented based on literature survey and the experiments conducted in the laboratory with several
processes. It has been concluded that the selection of treatment process should be site specific as per local needs and prevailing conditions as each technology has some limitations and no one process can serve the purpose in diverse conditions. Modi Shikha et al. (2013) compiled all the merits and demerits of some defluoridation methods including Nalgonda method, Activated Alumina, bone char, fly ash, brick and reverse osmosis methods etc.

Yaday R. N. et al. (2012) investigated removal of fluoride in drinking water by green chemical approach. Aluminum oxalate was used by as adsorbent in the traditional soil pots for minimize fluoride content in drinking water samples. Fluoride concentration of water sample (10 mg/L fluoride) decreases in the all soil pots with increasing amounts of aluminum oxalate (2g, 4g, 6g and 8g) at contact time periods (3hrs., 24hrs, 48hrs and 72 hrs). It is noticed that soil pot No-1 (having 2 g \( \text{C}_6\text{Al}_2\text{O}_{12} \)), decreases the fluoride concentration of the water sample about 20% but in case of soil pot No. 3 (having 6 g \( \text{C}_6\text{Al}_2\text{O}_{12} \)), and the concentration of fluoride decreases about 70% at time interval 72 hours. The linear Langmuir plots between \( \text{Ce}/x \) and \( \text{Ce} \) are shown. The linear Freundlich isotherm models are shown in the Fig. 7-10 by plotting \( \text{log } x/\text{log Ce} \). The constant values of the both isotherms for each soil pot were 3.723.95, 1.73 and 5.88

Vaish A. K et al. (2011) studied Fluorosis Mitigation in Dungarpur District, Rajasthan, India. In Rajasthan, 18 out of 32 districts are fluorotic and 11 million of the population are at risk. In the absence of perennial rivers, surface and canal system, groundwater remains the main source of drinking water. It contains 2 to 20 mg/L of fluoride. Defluoridation at household level has been popularized under the sponsorship of UNICEF. Few villages of Dungarpur district of Rajasthan are covered adopting both techniques of activated alumina and the Nalgonda technique. 800 defluoridation units were distributed in six villages. significant relief in several non-
skeletal symptoms of fluorosis, i.e. recover of appetite, least backache, activity in daily routine life, decrease in gas formation, less thirsty, least joint pain, no stiffness in neck etc. 100% cost sharing of recurring expenses have been observed.

Pranati Eswar et al. (2011) conducted a field study on community water defluoridation. The first community defluoridation plant for removal of fluoride from drinking after was constructed in the district of Nalgonda in Andhra Pradesh, in the town of Kathri. The technology was developed by National Environmental Engineering Research Institute (NEERI), Nagpur in 1961. Technique involves addition of aluminum salts (aluminum sulphate or aluminum chloride), lime and bleaching powder. The dose of lime depends on the alkalinity of raw water. The dose of lime is empirically 1/20th the dose of aluminum slats. Bleaching powder is added to the raw water at 3 mg/l for disinfection. The process of flock formation and setting requires an hour. Highly efficient removal of fluoride from high levels of 1.5 to 20 mg/l to desirable levels

Venkobachar et al. (2009) developed of a simple "Point of Use" domestic defluoridation unit (DDU) using indigenously manufactured activated alumina (AA) and its evaluation for adoption in rural areas in India. Different products of indigenously manufactured AAs were screened for fluoride uptake capacity. Using 3 kg of AA, around 500 L and 1500 L of safe water (F- £ 1.5 mg/L) could be produced when the raw water fluoride was 11 and 4 mg/L respectively (alkalinity 450 = mgCaCO3/L). Exhausted AA was regenerated with alkali and acid using the simple 'Dip procedure'. After 30 cycles of regeneration, the decrease in capacity was only marginal. Effect of raw water constituents on fluoride uptake was studied in the laboratory using simulated as well as natural waters. Results indicated that there was a decrease in treated water volume as raw water alkalinity increased. Presence of 250 mg/L sulphate in raw water decreased the AA fluoride uptake capacity by 15%.
Nearly 400 DDUs have been distributed in tribal areas of Dungarpur district in Rajasthan, India.

Munavalli G.R et al. (2009) carried out a comparative study of absorption and precipitation method of defluoridation. The absorbent used in this study included active alumina, active carbon, and brick powder and used tea powder. Active alumina and active carbon were found to have higher absorption capacity while the brick powder and used tea powder were useful low cost absorbent. Defluoridation by Nalgonda technique used Alum and lime water used for the precipitation of fluoride. Results shows that alkalinity increases the fluoride removal efficiency. Fluoride removal were observed to be 68.75%, 71.25% and 80.0% at alkalinites 202 mg/l, 340 mg/l and 410mg/l respectively. There was an increase in fluoride removal efficiency with increasing alum dose. The fluoride removal efficiency was observed to be in the range of 40% to 80% for the alkalinites 200 mg/l to 410mg/l. the alum dose of 55mg/l to 60 mg/l was observed to be appropriate for achieving maximum removal of fluoride.

Gumbo F. et al. (2009) studied the water Defluoridation for Rural Fluoride affected communities in Tenzania. In Tanzania the issue of excessive fluoride levels in drinking water. The Nalgonda technique involves flush mixing of alum and lime solutions with the raw water, flocculation, sedimentation, and filtration. The Nalgonda technique involves addition of high concentrations of alum and lime. The Nalgonda technique was able to reduce fluoride concentrations in water from 22.1 mg-F/l to an average of 3.5 mg-F/l. Lower levels of fluoride would have been reached if dosages of more than 800 mg/l alum were applied. With addition of 800 mg/l alum, residual sulphate was found to be below 600 mg/l. In a pH range of 6.0 - 8.0, where pH 6.5 is the optimum residual aluminum was found to be below 0.2 mg-Al/l. While the Magnesite technique involves contact with magnesia (MgO), obtained
by calcination of Magnesite (MgCO3). Addition of 800 mg/l alum and 80 mg/l lime could reduce fluoride concentration in the water from 22 mg-F/l to 3.5 mg-F/l. By filtering the treated water through a filter bed filled with calcinated magnesite the fluoride concentration could be reduced further by approximately 1 mg-F/l. However the pH of the water which has passed the magnesite filter bed, has raised to around 10, and require further treatment.

Brajesh K et al. (2009) Comparative Study was carried out to analyze and select most appropriate method for removal of fluorides in rural areas. Five methods were analyzed. The methods are: Activated Alumina, Red Mud, Montmorillonite, Nalagonda Technique and Magnesia. Maximum adsorption by activated alumina takes place at certain pH range, the most effective pH range is 5.0 to 7.0. At pH > 7, silicate and hydroxide become stronger competitor of the fluoride ions for exchange sites on activated alumina and at pH less than 5, activated alumina gets dissolved in acidic environment leading to loss of adsorbing media. Research have revealed that the maximum adsorption of fluoride by red mud us at pH 5.5. For pH greater than 5.5 fluoride removal decreases sharply. Nalgonda technique is effective even when the fluoride concentration is above 20 mg/L.

Tembhurkar A. R. et al. (2006) Studied on Fluoride Removal Using Adsorption Process. Batch adsorption studies were carried out to assess the suitability of commercially available activated charcoal to remediate fluoride-contaminated water. The effects of some of the major parameters of adsorption, viz. pH, and dose of adsorbent, rate of stirring, contact time and initial adsorbent concentration on fluoride removal efficiency were studied and optimized. The optimum sorbent dose was found to be 2.0 g/100 mL, equilibrium was achieved in 120 minutes and enhanced adsorption was obtained at pH 2. Maximum fluoride removal was observed to be 94% at optimum conditions.
Gangal R.K. (2005) contended geochemical study of ground water of Sanganer of Jaipur District of Rajasthan (India) and de-fluoridation methods to mitigate fluoride problem. There are sever problem of fluoride. Fluoride concentration ranges in between 1.5 to 16.5 ppm. Nalgonda technique and FUC technique have been used to mitigate fluoride. Fluoride concentration has been reduced from 16 ppm to 2 ppm. NF membrane technology remove over 95% fluoride from ground water in a single operation. NF membrane were not affected by source water composition.