International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.11, pp 54-61, 2017

Deflouridation of Water- A Comprehensive Review in Dharmapuri District

[1]*Kavisri.M, [2]Mary Kutty Abraham, [3]SenthilKumar P., [4]Priyadharshini.B

[1]Research Scholar, Department of Civil Engineering, Sathyabama University, Chennai-600119, TamilNadu, India
[2]Scientist E, Centre for Water Research, Sathyabama University, Chennai-600119, TamilNadu, India
[3]Department of Chemical Engineering, Sathyabama University,Chennai-600119,TamilNadu,India
[4]Department of Civil Engineering, Sathyabama University,Chennai-600119,TamilNadu,India

Abstract : At present, lack of safe drinking water and contagion of water bodies are major problem in India. Fluoride contamination in potable water occurs in many states of India. According to Indian standards, the acceptable amount of fluoride ions in drinking water is less than 1mg/l. hence defluoridation must be carried out to remove excessive fluoride ions. In this paper various techniques for defluoridation of water such as adsorption technique, precipitation technique, ion-exchange process, membrane separation technique are reviewed with its pros and cons. Electrodialysis is one such process which does not involve any chemical to remove excessive fluoride with higher efficiency which is also dealt in this paper .
Keywords : Defluoridation, fluorideions, electrodialysis, membrane, ion-exchange, precipitation.

I. Introduction

Water is a universal solvent consumed by all living organisms including humans, flora and fauna. The main source is by ground water, which is provided free, as a gift of nature. Ground water varies from location to location depending upon the rainfall level in the place. Due to uneven rainfall, ground water is affected. When water is contaminated with colloidal, dissolved impurities and heavy metals; it becomes unfit for drinking and other usages. Water contamination rises due to natural environmental factors and human activities. To make water potable, several parameters like fluorides, chlorine, chlorides, sulphate, iron, manganese, total solids and lead are analyzed and ranges within permissible limits are checked. The main concern on water is because of presence of fluoride content inwater.

Fluoride is considered as a ‘double edge sword’ as lack of intake results with dental caries and huge amount of ingestion associated with mottled enamel, dental fluorosis and skeletal fluorosis, causing joint pain in the body. Fluoride prevalence all around is reported as 3.2% [1].Nearly 80 million people suffer from flurosis[2]. In order to protect the future generation against these infection, water must be supplied with optimal fluoride concentration. The best solution is lowering of in the drinking water, which is known as deflouridation of water.

Through the world to remove excess fluoride ions various types of materials and techniques are adopted. Deflouridation techniques are widely categorized into four types such as adsorption technique, precipitation technique, ion-exchange process, membrane separation technique[3].In this paper the effect of excess fluoride in the intake water of humans being is discussed in section I. Section II deals with the case study of fluoride in ground water and its ill effects are dealt in section III. Samplings of ground water are discussed in section IV. Reviews on the various methods on defluoridation of water are discussed in section V. The effective electro dialysis technique is carried out by various researchers are discussed in section III. Eventually, it is concluded in sectionIV.

II. Methodology

The methodology flow chart initializes with collecting toposheet from SOI and determining the geological status, rainfall level and water level data from PWD of Dharmapuri district . By analyzing the soil profile of the location, it makes to under estimate the presence of fluoride content more accurately. Using GIS, fluoride range in various places of Dharmapuri are known.

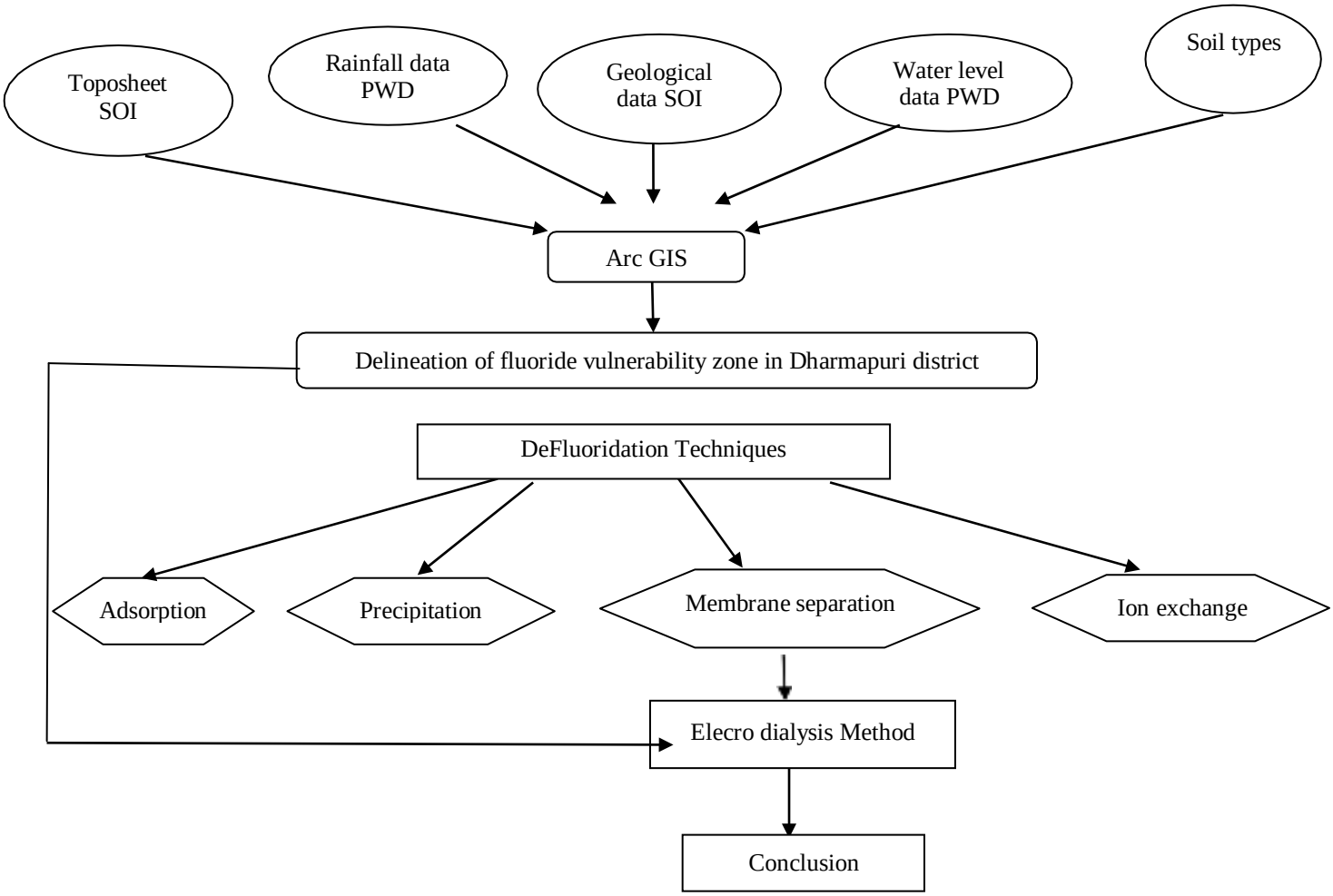

Fig 1 :Shows the methodology flow chart

BIS-Bureau of Indian Standards, GIS-Geological Information system

SOI-Survey of India, PWD – Public Work Department, SSI – Soil Survey of India, WHO – World Health Organization.

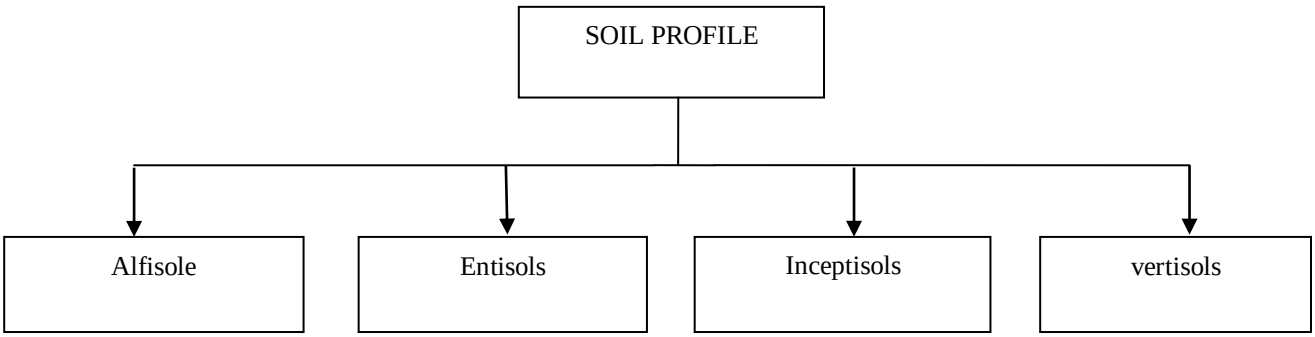

Fig 2:Soil profile of Dharmapuri district

III. Dharmapuri Disrict details

1. Geological location

Dharmapuri is located to the south of India, Tamil Nadu.

The district is covered over a large area with forest. Tribes depend on these forests in Dharmapuri. For domestic, agriculture and industrial uses about 3-3 m every year the ground water is being exploited in Dharmapuri.

2. Physiography

The annual rainfall in the district of Dharmapuri is about 750mm-900 mm. The physiographic view of the district is located between latitudes N $11^{O}47'$ and $12^{0}33'$ and longitude E $77^{0}02'$ and$78^{0}40'$.

It is bounded on the north by Krishnagiri District, on the east by Tiruvannamalai District and Viluppuram District districts, on the south by Salem District, and on the west by Karnataka's Chamarajanagar District.

3. Soil types

3.1 Alfisols

Alfi=aluminium (Al), iron(Fe). The productivity of Alfisols are abundant , used for agriculture and forestry. The nitrogenous fertilizers which are used in the soil for agriculture purpose make the soil acidified.

3.2 Entisols

In entisols, there is no profile development.

The soil is unaltered from the parent rock and they also cannot be consolidated.

3.3 Inceptisols:

The inceptisols are formed usually from the parent material. These soil are older than entisols. There are no accumulation of clays, iron oxide ,Aluminium oxide or organic material.

3.4 Vertisols:

The vertisols consist of high content of expansive clay known as montmorillonite. The soil are typically formed from highly basic rocks such as basalt. The colour of the soil is either grey or red, sometimes even deep black.

This type of soil is suitable for rice cultivation since the soil impermeable insaturation.

4. Hydrogeochemistry And Gis:

Chemical properties of ground water are associated with the underlying rock strata and their

respective time of decomposition process. Elevated concentrations of total dissolved solids in ground water results in higher electric conductivity[4]. The concentration relays on factors like amount of carbon di oxide and mineral souble in water.

5. Geomorphology

The major portion of fluoride in the ground water is due to the presence of rocks and minerals beneath the ground surface. Quartzofeldspathic high grade gneissis and charnockite with granitic constituents are foremost rock present in Dharumapuri district. Most of these rocks intimated foliations, by deterioration of its properties.

IV. Ill Effects Offluorine

As mentioned earlier fluoride is a double egdes word , its lack of consumption causes denetal caries and over intake leads to dental flurosis, skeletal flurosis. It even affects the nerves and the circulatory system of the body. Excessive ingestion of fluoride malfunctions the iodine content in the body by lowering the secretion of the thyroid gland. Loss of appetite, nausea, vomiting, pain in abdomen, unquenchable thirst and fatigue in muscular system are the outcomes of continuous consumptions. Prolonged consumers of high fluorine can cripple at a point of time.

V. Sampling of groundwater

To analyse the chemical nature of water, 50 samples are drawn from bore wells which are used for purpose of drinking and cultivation of agriculture lands. These samples are made to collect in bottles, which are of polyethylene material. The physio-chemical parameters includes pH, Electrical Conductivity, Total Dissolved Solids(physical) and Calcium, Magnesium, Sodium, Fluoride, Chlorine, Sulphate, Carbonate, Nitrate(chemical) . Using various laboratory techniques, the water parameters are noted.

Table 1: IONIC Concentration of Ground Water Samples (Dharmapuri Distt) in ppm.

S.No	Location	F	Mg	Ca	Cl	ph	EC	TDS
1	Agraharam	0.71	30.11	103	253.9	7.9	1679	1030
2	Bairanaichanpatty	1.1	60.54	40.43	81	8.3	1150	625
3	Dasirihalli	0.32	27.5	104.4	249	8.3	2904	710
4	Ettipatti	1.5	5.38	74.5	113.4	8	2546	450
5	Harur	0.5	23.9	96.15	216.3	9.5	2797	310
6	Hanumanthirtham	0.8	113.9	76	143.6	8.3	2007	1127
7	Kiraipatty	0.43	11.65	80.93	294.2	8.6	2651	525
8	Kambainallor	0.5	58.43	59.75	56.8	8.2	915	570
9	Kadathur	0.6	91.23	114	49	7.9	1972	1089
10	Motiripatti	1.1	25.28	106.43	220.54	8.23	2798	1050
11	Morappur	0.35	57.05	153.43	333.90	8.6	2728.6	1260
12	Mattalampatti	0.7	34.89	140.5	142.9	8.1	1156	620
13	Maniyanur	0.9	20.87	49.6	157	8.5	1275	754
14	Jammanahalli	0.43	57.45	147	52.7	7.4	1560	815
15	Palayapettai	0.7	29.45	108.26	275.98	8.2	1865	590
16	Pappireddipatti	1.4	51.78	42.1	34	8.3	1149	590
17	Tandekuppam	0.84	32.65	100.34	123.76	8.6	1513	380
18	Theerthanmalai	0.8	42.7	112.8	28.6	8.5	540	275
19	Velimadurai	0.96	9.45	76.98	210.48	8.6	1876	960
20	Kottapatti	0.4	20.65	136	47.56	8.3	1060	570

Note: pH – hydrogen Ionic Concentration (mg/l), EC – Electrical Conductivity (μ Simons), TDS – Total Dissolved Solids (mg/l,),F-Fluoride concentration(mg/l),Mg-Magnesium concentration(mg/l),Ca-Calcium concentration(mg/l), Cl-Chloride concentration(mg/l).

VI. Review on various techniques for Defluoridation Of water

1. Adsorption

Using this adsorption technique, fluoride ions are adopted on the activated agent's surface. Highly recommended active reagents are activated alumina, carbon, bone char, etc.

Adsorption of fluoride can be done using activated alumina[3]. The technique is available at specific phrange, which needs ph adjustment of water. Adsorption efficiency of the activated alum decreases when it is used for a number of times. Hence the alum must be activated frequently which makes technique costlier.

1.1 Bone Char

Defluoridation can be done using bone char. When the bone char is used in the raw water, the plant efficiency depends on the temperature and ph of the water. Disadvantage of this technique is it natures bacteria and hence unhygienic.

1.2 Chitin and Chitosan

There are few animals that yield two biopolymers namely, chitin and chitosan. In these two chitosan is used for fixing heavy metals in water[5,6]. Chitosan is draw out from the unwanted material known as shrimps. The chitosan adsorbent requires certain stages of chemical treatment that are portrayed in former paper[7]. In the previously told chemical treatment process, the synthetic solution is prepared from distilled water and sodium fluoride. The final product adsorbent is expressed in terms of per unit mass of chitosan.

1.3 Bricks piece column

Brick piece column can also be used to reduce the fluoride level similar to activated alum. The brick is manufactured from the soil which contains alum oxide, when it is burnt in kiln, gets activated and excess fluoride in raw water is adsorbed. But the filter media has to be replaced once in three months on basis offluoride content.

1.4 Mudpot

Similar to bricks, mud pot also acts as a adsorbent media. Using this methodology, the acceptable alkalinity limits and the ph value are not obtained. Hence the technique is not a promising one. However, people can use mud pot to store water which enhances partial deflouridation and makes it economically.

Other natural adsorbent are taramind seeds, seeds of drumstick tree and roots of vetiver grass. Among these, using taramind seeds maximum elimination of fluorides is achieved under netural ph value.

2. *Ion-Exchanget echnique*

Anion and cation exchange resins are used to remove fluoride. Example of synthetic chemicals used are poly anion, tulsionetc[8]. The resins are used in chloride and hydroxyl form. Its fluoride exchange capacity relays on the ratio of fluoride to total anions in water. Once the resin is saturated, it can be super saturated with dissolved sodium chloride salts. Since wastage is very large, the technique is inexpensive.

3. Precipitation technique

In this method, chemicals (i.e.) coagulants are added to the water. This is done by separating the solids from liquids. Aluminum salt, lime and poly aluminum chloride are some of the materials frequently used in this technique. Nalgonda technique of defluoridation is the best example for the precipitation method which was developed in CSIR-National Environmental Engineering Reasearch institute(NEERI)[9].

In Nalgonga technique, lime and alum are the coagulants usually used for defluorodation of water. Initially, lime is added so that coagulation occurs. At this moment two reactions takes place when alum is added in water. Insoluble aluminum hydroxide ($Al(OH)_3$) is produced when alum reacts with alkaline portion. Then alum reacts with fluoride ions which is present in water. When a ph range 5.5-7.5 [10] is achieved, it indicates

the best removal of fluoride. In this process, the amount of lime utilized is 1/20thof the amount of alum. Lime enables fast settling. Main advantage is that it can be easily utilized and understandable. Disadvantage lies in the transferring of sludge and requires more skilled labor

4. Membrane separation

Membrane separation process is more effective for deflourodation of ground water and industrial water. In this process, semi-premeable membrane is used to isolate the particles in their premise depending on its molecular size and shape. The membrane may be of polymeric film or metallic material or even a liquid or a gas. Membrane must not dissolve, disintergrate or break.

Reverse osmosis, Nano-filtration, Donnan-dialysis and electro dialysis are common method under membrane separation.

4.1 Reverse osmosis

High pressure is applied on the feed water to remove anions, to pass through semi permeable membrane. RO predominately eliminates solids dissolved in water. Depending on the size and charge of ions they are rejected. This process is the reverse of natural osmosis.

Using this technique, more than 90% of the fluoride can be removed, irrespective of the initial fluoride concentration[11].

4.2 Nano-filtration

It is a innovation technique for the removal of fluorine from water. When compared to RO membrane, Nano filtration has pores larger in size and provides less resistance to solute and solvent. Hence the requirement of pressure and energy needed for the process is reduced. This increases the flow rate. Since, the permeability of Nano filtration is greater than membrane used in RO. This method provides a good barrier to pesticides and microbes.

The method does not involve any chemicals and thus found to be best suited. Main drawback is, it is not economical

4.3 Electrodialysis

The ionic components present in aqueous solution are removed using ion exchange membrane, under the influence of electric driving force. In this process, electric current is applied to separate ions from water. This process is flexible and inexpensive, since it does not involve pre and post treatment of water.

M.A. Menkouchi Sahli et al have discussed about electro dialysis process[12]. This process is carried out in a laboratory cell[13]. Electro dialysis unit consist of 5compartments. They are separated alternatively using cationic and anionic membrane. The electric field was applied using platinum coated titanium electrode coupled to an electric generator. In order to avoid mixing of composition of solution, the two electrodes compartments are kept apart. The scheme of the process is shown in the fig3.

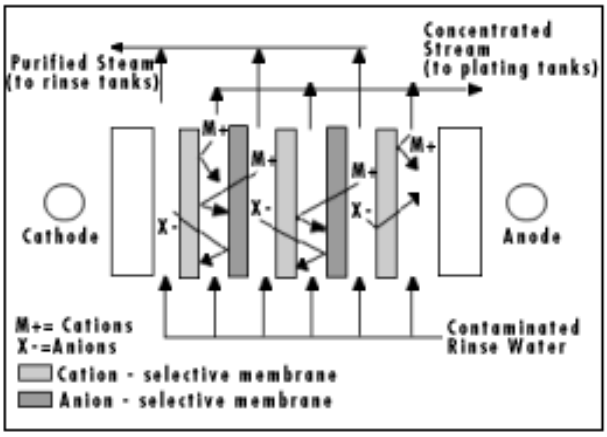

Fig.3 : Schematic diagram of Electro dialysis

During the test, sample of water sporadically, using analytic method, the ion concentration were observed. In this work, ion method using ELIT 8221 fluoride and reference electrode ELIT 001N used to determine the fluoride content. The process was performed using ACS membrane. The content of fluoride was found at high demineralization of 80%. Due to high energy consumption, this method is not found to be convenient.

Z.Amor et al have discussed about elimination of fluoride through electro dialysis [14]. The influence of Electro dialysis parameters such as applied voltage, temperature, flow rate to remove fluoride from brackish water to convert it to potable water. Here the sample water contains 3ppm of fluoride and 3gms of salt.

The system apparatus was a batch-type dialysis unit with 10pairs of anions and cations exchange membrane. Periodically, water sample are taken from dilute and concentration streams. The ion-concentration was calculated by analytical method. In order to avoid scaling and fouling, the stack was flushed using acidic solution. Finally they observed that deflouridation and desalination rate depends on the parameters like applied voltage, flow rate and temperature.

Erdem Ergun et al have discussed about electro dialysis by testing with different current densities[15]. The membrane used in anion exchange is SB-6407. Donnan dialysis determines the large transfer of fluoride ions. In the non-appearance of mono and bi-valent, the elimination of fluoride takes place in faster rate. Electro dialysis was performed in water, which had fluoride content of 20.6 mg/l. Fluoride concentration is lowered due to the existence of chloride and sulphate, which was less than of1.5mg/l(WHO).

IV Conclusion

Fluorosis is one of the major health issue in our study area. It must be prevented from passing on to upcoming generations. Curing of fluorosis in highly impossible, hence care is taken is taken to prevent from the diseases, by having fluoride free water. The public awareness about the illness of fluorides must be created to eradicate the consumption of fluoride. Communities should be encouraged in using easily available and cheaper materials for deflouridation of water. Hence various deflouridation techniques are discussed. From literature reviews observed among the various techniques Electro dialysis method gives good act for salt and fluoride removal from water and it is also economic. The future work is to be carried out in our study area to reduce the fluoride concentration by using the effective Electro dialysis process.

References

1. S.kumar and k.Gopal. “A review on fluorosis and its preventive strategies”, Indian J.Environmental Protection, june 2000;20(6):430-6.
2. Wang Hongato,JiJunfeng, Chen Jun, “Deflurodiation of drinking water with hydrotalcite-like compounds”, Denver annual meeting of the Geogogical society of America, Oct 27-30,2002
3. Marriapan p, vasudevan T “Domestic defluoridation techniques and sector approach for flurosismitigation”, pages 1-11, 4-1-2011.
4. Srinivas, C.H., Piska, R.S., Venkateshwar, C., Rao, M.S.S. and Reddy, R.R.,(2000) Studies on Ground Water Quality of Hyderabad, Poll. Res.,v.19(2), pp.285-289.
5. E. Piron, M. Accominotti and A. Domard, Role of physical and physicochemical parameters on the kinetics of sorption, Langmuir, 13 (1997) 1653–1658.
6. C. Milot, Doctorate Thesis, University Montpellier II, 1998, 256 p.
7. S. Annouar, A. Soufiane and M. Mountadar, Phys.Chem. News, 16 (2004) 128–135.
8. Thomson j, Mcgravey FX “ion exchange treatment of water supplies”, Journal American Water Works Assosication, 1953;45:145- 152.
9. M.Kavisri,”Modelling of flow in an unsaturated zone in a tank clustered catchment using Geo-spatial technology” International Journal of Applied Engineering Research, ISSN 0973-4562,vol.10,Number 6(2015),pp14529-14536
10. Sanghratna S. Wagmare and Tanvir Arfin “fluoride removal from water by various techniques:

Review",International Journal Of Innovative science, engineering & technology, vol2,issue 9, sep 2015.
11. N.Razbe, R Kumar, Pratima and Kumar, "Various options foe removal of fluoride from drinking water",IOSR Journal of applied physics,3(2),2013,pp 40-47.
12. P.I Ndiayae, P.Moulln, L.Dominguez, J.C.Millet and F.Charbit "removal of fluoride from electronic indusrial effluent by RO membrane separation", Desalination 173,2005,pp 25-32.
13. M A MenkouchiSahli, S Annouar, MTahait, M Mountadar, ASoufiane,water by adsorption on natural chitosan and by elecrodialysis", Continuous Operation. Desalination, 167, 357.
14. M.O. Elkhattabi, A.R. My.Hafidi and A. Elmidaoui, Desalination, 107 (1996) 149.
15. Zakia Amor, SuadMalki, Mohammed Taky, Bernard Bariou, Nabil Mameri, Azzeddine Elmidaoui "optimization of fluoride removal from brackish water by electrodialysis" Elsevier, desalination 120(1998), 263-237.
16. PiddennavarR enuka and Krishnappa Pushpanjali, "Review on defluoridation techniques of water," The International Journal Of Engineering and Science,volume 2,issue3, pages 86-94,2013.
17. C.Anand, D Sujish, M S Murugappa, GMohanakrishan, P kalyanasundram and Baldev Raj "A Comprehensive treatment method for deflouridation of drinking water" Indian Journal of Chemical Technology,vol.18,july 2011,pp.314-318.

*****