International Journal of Emerging Technologies in Engineering Research (IJETER)
Volume 4, Issue 5, May (2016) www.ijeter.everscience.org

Defluoridation of Drinking Water Using Low Cost Natural Adsorbent (Sugar Cane Bagasse)

Nusrat Ali
Assistant Professor, Department of Civil Engineering, Integral University, Lucknow.

Mahtab Ahmad
Student, Integral University, Lucknow.

Shilpi Singh
Assistant Professor, Department of Civil Engineering, Integral University, Lucknow.

Abstract – In India large population is mainly belong to rural areas which depend on ground water for their drinking purpose. The fluoride concentration in ground water varies from place to place. The data show that the fluoride distribution in ground water varies from 0.01mg/l to 48 mg/l [2] therefore it is require to observe defluoridation by cheap and easy method. This paper review about the defluoridation by a natural absorbent i.e. sugarcane bagasse which is cheap and effective and gives perfect removal of fluoride in drinking water upto 84%. Also paper present the information on occurrence of fluoride and its effects on human health and various control method for the removal of fluoride (specially sugar cane bagasse)

Index Terms – Deflouridation, adsorption, low-cost adsorbent.

1. INTRODUCTION

Fluoride is found in all natural waters at some concentration. Seawater typically contains about 1mg/l while rivers and lakes generally exhibit concentrations of less than 0.5 mg /l. In ground waters, however, low or high concentrations of Fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride-bearing minerals High fluoride Concentrations may therefore be expected in ground waters from calcium-poor aquifers and in areas where fluoride-bearing minerals are common [3]. The population explosion and rapid industrial growth demands huge quantity of fresh water to meet various requirements Very small quantity of water (i.e. 0.0132% of total water) only is available in the rivers and lakes and most of these water sources are getting polluted due to waste disposal and human activities [10]. Fluoride contamination in drinking water and resulting endemic in India is specially the case with the rural population, which largely depends on the groundwater as their drinking water sources. India is among 23 nations in the world where Fluoride contaminated ground water is creating problems sixty-two million people including 6 million children in the country in 17 states are affected with dental, skeletal and non-skeletal fluorisis[3]. The extent of fluoride contamination in the ground water varies from 1.0 to 48.0 mg/l in Rajasthan.[4] Fluoride is one of the most important elements for both human and animal health. Within the permissible limit of 0.5 – 1.5mg/L, fluoride serves to maintain healthy teeth and bones. On the other hand, elevated levels of fluoride (>1.5mg L-1) can cause long-term diseases such as dental (1.5 – 4.0mg/L) and skeletal fluorosis (4.0 – 10.0 mg/L). The most seriously affected states in India are Andhra Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Tamil Nadu and Uttar Pradesh. The highest concentration observed to date in India is 48 mg/l in Rewari District of Haryana[10].

2. EFFECTS OF FLUORIDE

Fluorine is the most electronegative element and it is always present in a combined state as fluoride because of its high chemical reactivity. The fluoride is a great calcium-seeking element and it can disturb the calcified structure of bones and teeth in the humaluoride body at higher concentration resulting dental fluorosis or skeletal fluorosis similar kinds of effects are found in animal body parts also. [10]

Dental fluorosis:

If fluoride present in this range of 0.7 to 1.5 mg F/l in drinking water may cause dental fluorosis, in dental fluorosis loss of luster and shine of the dental enamel. The discoloration starts from white yellow, brown to black enamel matrix is laid down on incremental lines before and after birth. Fluorosis is seen as mild moderate and severs depending on the amount of fluoride ingested during the stages of formation of the teeth. [5]

Skeletal fluorosis

Excessive quantity of fluoride deposited in the skeleton, Fluoride poisoning leads to severe pain associated with rigidity and restricted movements of cervical and lumbar spine, knee and pelvic joints as well as shoulder joints.

Symptoms of skeletal fluorosis are as given below

Pain in neck, back bone or joints, stiffness in the neck, backbone or joints sever pain and rigidity in the hip region (pelvic girdle) construction of vertebral canal and intervertebral forearm exerts pressure on nerves and blood vessels leading to paralysis and pain. Skeletal fluorosis is an irreversible process as the dental fluorosis.

Non –skeletal fluorosis:

Fluoride when consumed in excess can cause se eral other kind of manifestation.

3. ADVANTAGES OF ADSORPTION PROCESS

Cheap: The cost of adsorbent is low since they are often made from locally, abundantly and easily available materials.

No Sludge Generation: Unlike the problems in other techniques (ex: precipitation), there is no issue of sludge generation in adsorption process.

Competitive Performance: Performance of adsorption process in terms of efficiency and cost is comparable with the other methods available

4. PRACTICAL EXPERIENCES OF THE RELATED WORK:

The Nalgonda technique, based on precipitation processes, is also a common defluoridation technique. The limitations of the process are, daily addition of chemicals, large amount of sludge production, and low effectiveness for water having high total dissolved solids and hardness. Ion exchange methods are efficient for fluoride removal, but a tedious and difficult process of preparation of resins as well as the high cost necessitates a search for an alternative technique. Adsorption techniques have been quite popular in recent years due to their simplicity, as well as the availability of wide range of adsorbents. Adsorption methods can be implemented for the removal of fluoride due to physical, chemical, or ion exchange interactions with the adsorbents. Two types of contacting systems of adsorption are usually encountered, namely, the batch and fixed-bed processes. Batch type processes are usually limited to the treatment of small volumes of effluents whereas the bed column systems have the advantage of continuous operation up to the point of saturation. Adsorbent is a porous substance that has a high surface area and has the ability to absorb or adsorb other substances using intermolecular forces onto its surface.

C.M. Vivek Vardhan and J. Karthikeyan(2011) carried out investigations for removal of Fluoride from water employing physico-chemical processes of adsorption and coagulation employing abundantly available and low-cost materials like Rice Husk, seed extracts of Moringa Oleifera (Drum stick), and chemicals like Manganese Sulphate and Manganese Chloride. Rice husk of 6g/l accomplished a removal of 83% of Fluoride from a 5mg/l of Fluoride solution requiring an equilibrium time of 3 hours. Equilibrium Isothermal data fitted well into rearranged linearised Langmuir adsorption model. Moringa oleifera seed extracts, Manganese Sulphate and Manganese Chloride accomplished removal percentages of 92, 94 and 91 of Fluoride from a 5mg/l test solution at a dosage of 1000 mg/l. A slightly acidic pH of 6.0 was found favourable for Fluoride removal by Manganese sulphate, Manganese Chloride and MOE.

S. T. Ramesh, R. Gandhimathi, P. V. Nidheesh and M. Taywade (2012) investigated the adsorption potential of bottom ash for defluoridation of drinking water using batch and continuous fixed bed column studies. The optimum contact time for fluoride was found to be 105 minutes with the maximum efficiency of 73.5 % at 70mg/100ml bottom ash dosage. The optimum pH was found to be pH 6 with the maximum efficiency of 83.2 %.During the column studies; increase in fluoride ion uptake with an increase in the bed height was due to an increase in the contact time. A high degree of linearity of the BDST plot indicates the validity of the BDST Model when applied to continuous column studies.

S. A. Valencia-Leal, R. Cortés-Martinez, R. Alfaro-Cuevas-Villanueva (2012) evaluated the Guava Seeds (Psidium Guajava) as Low-Cost Bio sorbent for the Removal of Fluoride from Aqueous Solutions. Maximum adsorption occurred between pH5.0 to 8.0.The adsorption of fluoride was found endothermic in nature Langmuir and Freundlich adsorption isotherm models were applied to evaluate the adsorption data. The pseudo-second order model describes the fluoride sorption kinetics using guava seed at different temperature. The Langmuir model best describes the isotherm’s experimental data, which may indicate that the sorption mechanism of fluoride ions on guava seed is chemisorptions on a homogeneous material.

Mohammad Mehdi Mehrabani Ardekani, Roshanak Rezaei Kalantary, Sahand Jorfi, Mohammad Nurisepehr (2013) compared the efficiency of Bagasse, Modified Bagasse and Chitosan for fluoride removal from water by adsorption. The pH value of 7, contact time of 60 min and adsorbent dose of 2 g/L were determined as optimum conditions for all three adsorbents. Chitozan and bagasse did not show good capability for fluoride removal, but modified bagasse showed more than 90% removal at optimized conditions, including the pH value of 7, contact time of 60 min and adsorbent dosage of 2 g/L. Both Langmuir and Freundlich isotherms show good correlation for description of results, but the Langmuir model with the correlation value of 0/99 is superior.

5. MATERIALS AND METHODS

5.1. Result and discussion:

Effect of adsorbant dose (sugar cane bagasse on fluoride removal):

The effect of the adsorbent dose on the removal of fluoride was studied by varying the adsorbent dose from 1 to 9 g/L. The results are presented, where it can be seen that maximum removal of about 84% is found at a dose of 9 g/L and thereafter the percent removal became more or less constant.

Removal of excess fluoride from water can be broadly classified into four categories: A) Adsorption methods, B) Ion exchange methods, C) Precipitation methods, and D) Miscellaneous methods. Some defluoridation techniques developed to control fluoride content in water are reverse osmosis, adsorption using sunflower plant dry powder, steam of phyto mass, Holly Oke, neem bark powder, activated cotton jute carbon, bagasse ash, burnt bone powder, phosphate-treated saw dust, bone char, etc. as adsorbents, Nalgonda technique, activated alumina process and ion exchange process. [2]

5.2. Preparation of Adsorbent

Adsorbent of Sugarcane Bagasse (SB):

Sugar cane bagasse is low cost and easily available from all local juice corners. Firstly we cut into small pieces and then washed several time with distilled water and dried for 3-4 hours in hot air oven or 3-4 days sun dried .then treated with .1N HCl and again wash also treated with sodium carbonate. To observe the fluoride removal, we use spectrophotometer, first we calibrate the spectrophotometer by double distilled water to set absorbance zero, and then set 100 absorbance by the spand reagent solution. And plot a standard curve by known fluoride solution and absorbance.

Treated Sugarcane Bagasse

Effect of Stirring rate:

The effect of the stirring rate on the removal of fluoride was studied by varying the stirring rate from 20 to 150 rpm. The results are presented, where it can be seen that maximum removal of about 84% is found at a stirring rate of 100 rpm and thereafter the percent removal became more or less constant.

Effect of Temperature:

The effect of the temperature on the removal of fluoride was studied by varying the temperature from 283 to 313 K. The results are presented, where it can be seen that maximum removal of about 78% is found at a dose of 7 g/L and thereafter the percent removal became more or less constant.

Effect of pH:

The effect of the pH on the removal of fluoride was studied by varying the pH from ph 2 to 10. The results are presented, where it can be seen that maximum removal of about 52% is found at a dose of 7 g/L and thereafter the percent removal became more or less constant.

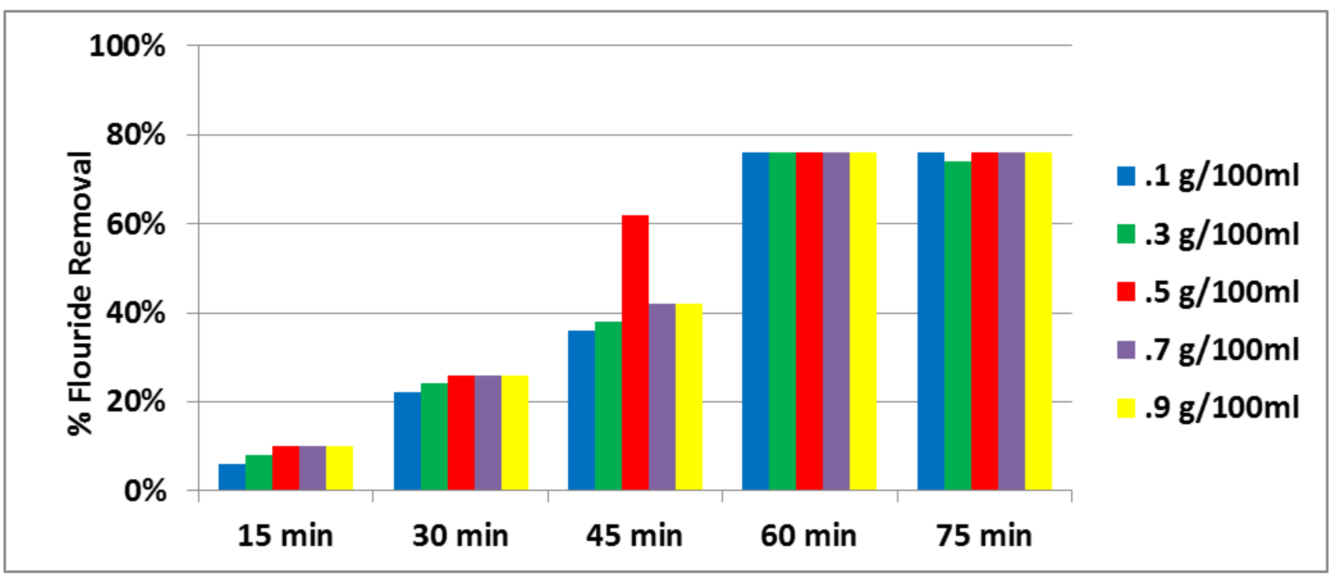
Dose(g/100ml)	**Contact time (min)**	**Initial fluoride (mg/l)**	**Final fluoride(mg/l)**	**Reduction in fluoride (mg/l)**	**% removal efficiency**
0.1	**15**	**5**	**4.7**	**0.3**	**6**
0.1	**30**	**5**	**3.9**	**1.1**	**22**
0.1	**45**	**5**	**3.2**	**1.8**	**36**
0.1	**60**	**5**	**1.2**	**3.8**	**76**
0.1	**75**	**5**	**1.2**	**3.1**	**76**

Dose(g/100ml)	**Contact time (min)**	**Initial fluoride (mg/l)**	**Final fluoride(mg/l)**	**Reduction in fluoride (mg/l)**	**% removal efficiency**
0.3	**15**	**5**	**4.6**	**0.4**	**8**
0.3	**30**	**5**	**3.8**	**1.2**	**24**
0.3	**45**	**5**	**3.1**	**1.9**	**38**
0.3	**60**	**5**	**1.2**	**3.8**	**76**
0.3	**75**	**5**	**1.3**	**3.7**	**74**

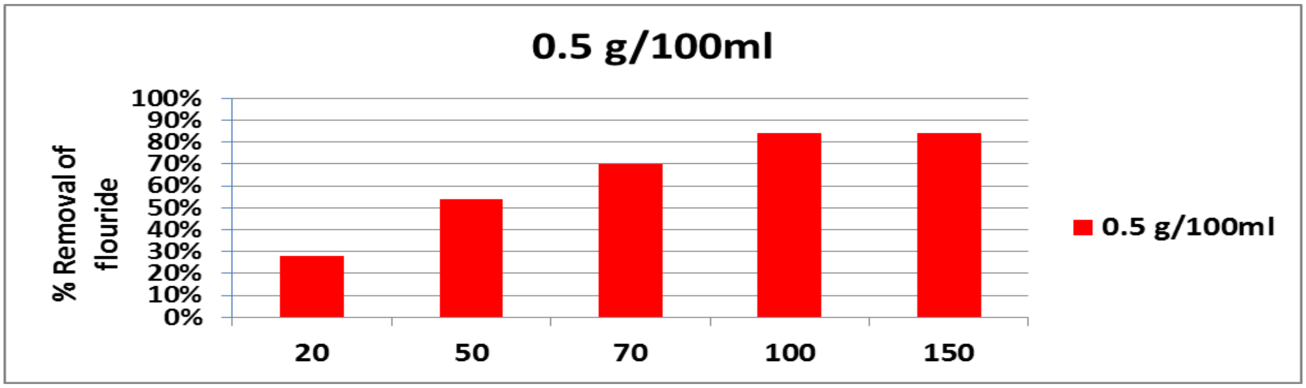
Dose(g/100ml)	Contact time (min)	Initial fluoride (mg/l)	Final fluoride(mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.5	15	5	4.5	0.5	10
0.5	30	5	3.7	1.3	26
0.5	45	5	2.9	3.1	62
0.5	60	5	1.2	3.8	76
0.5	75	5	1.2	3.8	76

Dose(g/100ml)	Contact time (min)	Initial fluoride (mg/l)	Final fluoride(mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.7	15	5	4.5	0.5	10
0.7	30	5	3.7	1.3	26
0.7	45	5	2.9	2.1	42
0.7	60	5	1.2	3.8	76
0.7	75	5	1.2	3.8	76

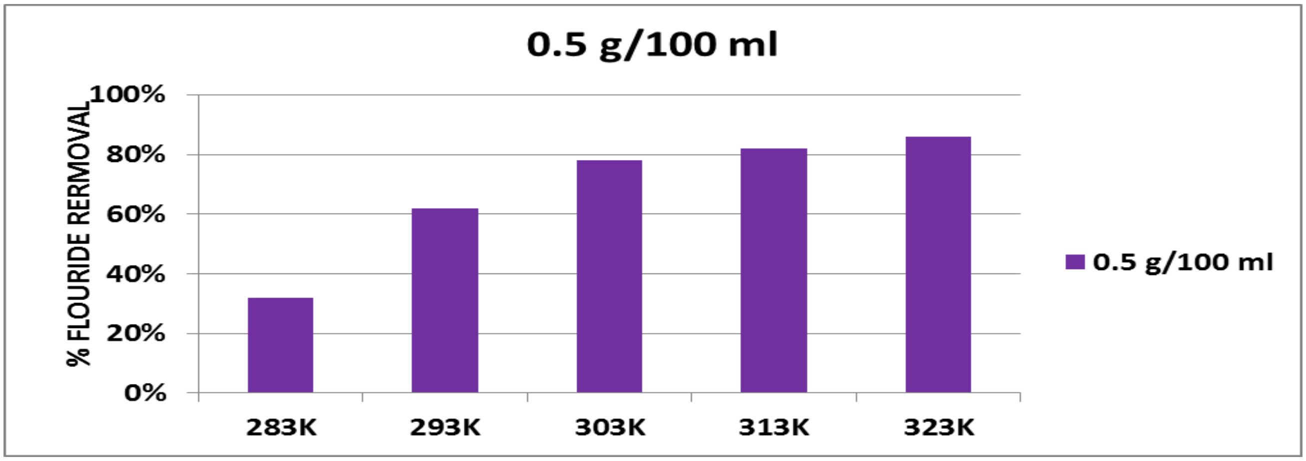
Dose(g/100ml)	Contact time (min)	Initial fluoride (mg/l)	Final fluoride(mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.9	15	5	4.5	0.5	10
0.9	30	5	3.7	1.3	26
0.9	45	5	2.9	2.1	52
0.9	60	5	1.2	3.8	76
0.9	75	5	1.2	3.8	76



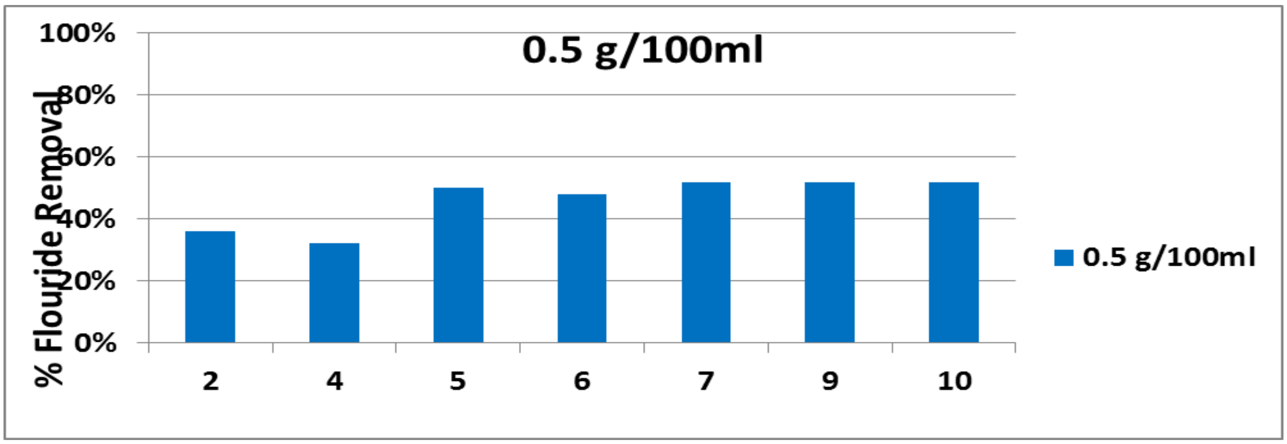
Dose(g/100ml)	Stirring rate (rpm)	Initial fluoride (mg/l)	Final fluoride(mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.5	20	5	3.6	1.4	28
0.5	50	5	2.3	2.7	54
0.5	70	5	1.5	3.5	70
0.5	100	5	0.8	4.2	84
0.5	150	5	0.7	4.2	84



Dose(g/100ml)	Temperature (in K)	Initial fluoride (mg/l)	Final fluoride(mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.5	283	5	3.4	1.6	32
0.5	293	5	1.9	3.1	62
0.5	303	5	1.1	3.9	78
0.5	313	5	0.9	4.1	82
0.5	323	5	0.7	4.3	86



Dose(g/100ml)	pH	Initial fluoride (mg/l)	Final fluoride(mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.5	2	5	3.2	1.8	36
0.5	4	5	3.4	1.6	32
0.5	5	5	2.5	2.5	50
0.5	6	5	2.6	2.4	48
0.5	7	5	2.4	2.6	52
0.5	9	5	2.4	2.6	52
0.5	10	5	2.4	2.6	52



6. CONCLUSION

Based on the results of this study, it can be concluded that sugarcane bagasse have good performance to adsorb fluoride from drinking water especially for high concentration of flouride and had given an excellent results of 86% removal of fluoride from the drinking water of 5 g/l dose at 323K temperature. Also it is concluded that it is necessarily to aware about ground water contamination and use cheaply method specially adsorbent process use to remove fluoride in which several cheap adsorb and use like red mud, pine apple peel powder, orange peel powder, chalk powder, ragi seed powder, and sugar cane bagasse. Etc.

REFERENCES

[1] Priya goswami et al defluoridatio of water using low cost adsorbent International journal of chemical studies 2015
[2] A.V Jamode et al defluoridation of water using inexpensive adsorbents J Indian inst sci, sept-Oct. 2004
[3] Tarundeep Gill et al A review on feasibility of conventional fluoride removal techniques in urban areas , International journal of Environmental Research and Development.ISSN 2249-3131 volume4, Number 2 (2014
[4] Drshrikants.Patil et al studies on defluoridation – a critical review jounal of engineering research and studies E-ISSNo976-7916
[5] A tewari et al , defluoridation of drinking water ; efficacy and need journal of chemical and pharmaceutical Research 2009, 1 (1)
[6] K Bjorvatn et al defluoridation of drinking water by the use of clay/soil, 2ndinternationl workshop on fluorosis prevaention and defluoridation of water.
[7] Sutapachakrabarty et al , Defluoridation of contaminated drinking water using neem charcoal adsorbent kinetics and equilibrium studies , International journal of chem tech Research Coden (USA) vol.4, N0.2 april-june 2012
[8] KoteswareRao m et al Effective low cost adsorbents for removal of fluoride from water : A Review, International journal of science and Research (IJSR) Impact factor (2012)
[9] Sheetal Bandewar et al , Removal of fluoride from drinking water by using low cost adsorbent International journal of research in Engineering and Technology, volume 04 issue 04 Apr-2015
[10] Mohammed arif tikki Fuloride Removal from water – a review Internation journal of scientific & engineering research volume -5 issue 1, january 2014
[11] RanjeetaS , Removal of fluoride from drinking water using fly Ash after pre treatment ranjeeta , j environ anal toxicol 2015
[12] M srimurali and J karthikeyan activated alumina : defluoridation of water and household application – a study twelfth international water tehnology conference IWTC12 2008, Alexandria, Egypt.