Indian Journal of Chemical Technology
Vol. 16, July 2009, pp. 361-363

Removal of fluoride from low TDS water using low grade coal

L Borah* & N C Dey

Analytical Chemistry Division,
North East Institute of Science & Technology, Jorhat, India
Email: laxmi.bh@rediffmail.com; ncdey49@yahoo.co.in

Received 1 September 2008; revised 27 April 2009

Defluoridation of ground water using low grade Assam coal as an adsorbent is studied by batch sorption experiments. Effect of the variables, like quantity of adsorbent, contact time, particle size of the adsorbent are examined to establish the optimum conditions. The results show that the low grade Assam coal, collected from Tirap colliery of the North Eastern coalfield, after pretreatment, can be used as an effective adsorbent in removing fluoride from ground water. The optimum conditions for the efficient removal of fluoride are observed to be (i) quantity of adsorbent = 1.25 g in 100 mL water, (ii) contact time = 60 min, (iii) particle size of adsorbent = −72 BSS or lower.

Keywords: Defluoridation, Fluoride, Adsorption, Low grade coal, Fluorosis

Being present in drinking water, the role of fluoride to human health is of special significance. On one hand presence of fluoride is linked with health aspect such as prevention of dental carries but on the other hand, when present beyond the permissible limit, it causes dental or skeletal fluorosis. It has been reported that a large population in India is very severely affected by fluorosis[1-3]. In Assam (Karbi Anglong and Nowgaon districts) a large population suffers from fluorosis. Recently the presence of fluoride up to 6.88 mg/L in drinking water samples from various parts of the capital city of Guwahati, Assam and suburbs has been reported[4]. To prevent fluoride related diseases, the exposed population has to be provided with drinking water having fluoride concentration within the permissible limit of 1.5 mg/L[5]. Considerable work on defluoridation has been done all over the world. The most economical adsorbent for fluoride removal from drinking water is activated alumina[6]. In recent years, much effort has been made towards investigation and evaluation of other adsorbent for removal of fluoride such as fly ash[7], silica gel[8], soil[9], water hyacinth[10], bone charcoal[11], zeolites[12], bentonite[13], etc. A locally available, cost effective fluoride adsorbent for the North Eastern Region of India is highly desirable. Therefore, effort has been made towards the defluoridation of ground water by using an indigenous material which is locally available, nontoxic and low-cost adsorbent. The present study aims at using low grade Assam coal duly pretreated for removal of fluoride from low TDS ground water having moderate hardness which is common in Karbi Anglong and Nowgaon districts of Assam.

Experimental Procedure

Materials

The low grade Assam coal was collected from Tirap colliery of North Eastern coalfield. The coal sample was ground to five different particle sizes for the present study.

Pretreatment of adsorbent

As these coals have high sulphur, it has inherent disadvantage of releasing soluble sulphur compounds in contact with water, thereby, lowering the *p*H value of water to an acidic range. Therefore, to maintain the normal *p*H of treated water (6.5 to 8.5) using Assam coal, and to impart potability, it is desirable to remove the water soluble sulphur compounds and other soluble trace organics from the low grade Assam coal before it can be used as an adsorbent for excess fluoride. For the pretreatment, the coal sample was washed and boiled with distilled water containing 1% ferric alum for one hour. The addition of ferric alum not only helps in removing the undesirable components from low grade coal but also adds specificity for adsorption of fluoride. The material after rinsing with distilled water and filtering was dried in hot air oven at 80°C for one hour. Analysis of the adsorbent before and after pretreatment is summarized in Table 1.

Procedure

The ground water sample was collected from Narengi, Guwahati where excess fluoride contamination was reported earlier. The fluoride concentration was found to be 5.8 ppm in the collected sample. The physico-chemical properties of the groundwater sample as determined by standard methods, are summarized in Table 2. Experiments were performed by taking 0.2 to 2.0 g of pretreated

Table 1—Composition of adsorbent before and after pretreatment

Serial No.	Parameters	% Composition before treatment	% Composition after treatment
1.	Moisture	2.6	2.2
2.	Ash	29.6	26.2
3.	Volatile matter	23.9	22.2
4.	Fixed carbon	43.9	49.4
5.	Carbon	71.2	73.1
6.	Hydrogen	7.2	6.8
7.	Nitrogen	1.1	1.0
8.	Sulphur	2.9	2.3
9.	Oxygen	17.6	16.8

adsorbent with 100 mL of the ground water sample in high density polyethylene vials, which were continuously rotated in a magnetic stirrer at room temperature for 65 min. Various parameters were studied during the period of experiment. At the end of the contact time, the plastic vials were removed from the stirrer and allowed to stand for 2 min for settling the adsorbent. Then the water samples were filtered using sintered crucible (G-4) and filtrate was analyzed for residual fluoride concentration by SPADNS method[14]. Batch study was conducted to determine the optimum conditions and to study the adsorbent dose, particle size of adsorbent and contact time with the water samples. Optimum conditions were selected for further studies.

Results and Discussion

Effect of adsorbent dosage

The residual fluoride in the ground water sample containing 5.8 ppm of initial fluoride decreased with increase of dose of adsorbent. The optimum dose of adsorbent was found to be 1.25 g/100 mL where removal of fluoride was 85 percent. Further increase of adsorbent showed only marginal increase in the rate of defluoridation and resembled an exponential character. Table 2 shows the quality of water before and after treatment.

Effect of contact time

The percentage removal of fluoride by the new adsorbent was studied for different contact times by treating with optimum dose (1.25 g/100 mL) at 5.8 ppm initial fluoride concentration. As contact time was increased, percentage removal of fluoride also initially increased, but gradually approached an almost constant value at about 60 min.

Table 2—Physico-chemical properties of ground water sample before and after treatment*

Parameters	Ground water sample	Treated water sample
*p*H	6.8	6.8
Turbidity (NTU)	1.5	1.4
Hardness (as $CaCO_3$)	130	128
Calcium (as $CaCO_3$)	83	82
Magnesium (as $CaCO_3$)	46	45
Dissolved iron as Fe	0.2	0.18
Sulphate	2.0	1.4
Chloride	1.5	0.8
Nitrate	0.5	0.4
Methyl orange alkalinity	118	115
Fluoride	5.8	0.84
Total dissolved solid	130	125

*All values expect *p*H and turbidity are in mg/L

Effect of particle size

The effect of particle size of the adsorbent on adsorption of fluoride from water was also studied. The experiments were carried out by using various particle sizes of the adsorbent (-72 to -7 BSS). It was found that as the particle size increases, the fluoride uptake rate of the adsorbent decreases. The optimum particle size found for the experiment is -72 BSS. Further reduction of particle size was found to interfere with subsequent filtration.

Conclusions

The forgoing study suggests that the low grade Assam coal is an effective adsorbent for removal of fluoride from drinking water. There is no adverse change in the physicochemical properties of treated water. Pretreatment of the coal is simple and cost effective and the above method may be adopted for domestic purposes in fluorosis affected areas.

Acknowledgement

Authors are thankful to Dr. P. G. Rao, Director, North East Institute of Science and Technology, Jorhat, Assam, for inspiration and permission to publish this paper. We are also thankful to Mr. B. P. Baruah, Scientist, NEIST Jorhat for providing the coal samples for the study.

References

1 Susheela A K, *Sci Dev Env,* (1987) 147.
2 Choubisa S L, *Fluoride,* 34 (2001) 61.

3 Kotoky P, Barooah P K, Baruah M K, Goswami A, Borah G C, Gogoi H M, Ahmed F, Gogoi A & Paul A B, *Fluoride,* 41 (2008) 42.
4 Das B, Talukdar J, Sarma S, Gohain B, Dutta R K, Das H B & Das D C, *Curr Sci,* 85 (2003) 657.
5 World Health organization, Geneva.VOL. 2 (1984).
6 Rubel Jr. F, *Fluoride effects on vegetation, animals and humans (*Paragon Press, Salt Lake city), 1983.
7 Chaturvedi A K, Yadava K P, Pathak K C & Singh V N, *Water, Air, Soil Pollut,* 49 (1990) 51.
8 Wassy S A, Haron Md J & Tokunaga S, *Water Environ Res,* 68 (1996) 295.
9 Yanxin Wang & Eric J Reardon, *Appl Geochem*, 16 (2001) 531.
10 Simha U L, Panigrahy B K & Ramakrishna S V, *IJEP,* 22 (2002) 506.
11 Bhargava D S & Killedar D J, *Water Res,* 26 (1992) 781.
12 Mayadevi S, *Ind Chem Eng, Sect A,* 38 (1996) 155.
13 Simurali M, Pragathi A & Karthikeyan J, *Environ Pollut*, 99 (1998) 285
14 *Standard methods for the examination of water and waste water,* 17th edn (American Public Health Association), 1989.