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Fluoride estimation and reduction in Indian water samples, using spectrometer method with optimum alumina, pH and optimum time of operation

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Abstract— **Fluoride is an acute toxin and is deemed to be slightly more dangerous than even lead. Hence in order to determine the fluoride content, various samples of water was taken and estimated before and after the pre-treatment (removal of metal ions) by way of treatment in a distillatory and their results were compared. Optimum amounts of Alumina, pH and time required were calculated for removing the fluoride efficiently from water, keeping in mind the important factors like cost , energy, labour and power consumption. Spectrometer was used in this analysis to obtain the concentration of the fluoride. It was found that 40g of Indian alumina with a pH of 4 and a running time of 40 min for the jar apparatus reduced the fluoride content from 16.2mg/l to 2.1mg/l**

Keywords- *fluoride, water, optimum, alumina* **.**

I. INTRODUCTION

Water is an essential resource for living systems, industrial processes, agricultural production and domestic use. One of the key things to be determined in a pure drinking water, is the optimum amount of fluoride content present in it. Presence of fluoride in water is known to cause many crippling diseases either by its insufficient or excess intake. The problem connected with a deficiency or excess fluoride content in water is urgent in many regions of Russia including Novosibirsk and Omsk oblasts. [1] According to the data of the State Sanitary and Epidemiological Inspectorate of the Ministry of Health of Russia, almost the whole population in these regions drinks water with an insufficient fluorine concentration [1].

Also fluoride is known to cause dental fluorosis, a defect of the tooth enamel caused by fluoride's interference with developing teeth. Its visible signs are mottled or yellowed teeth. Nearly 30% of children drinking fluoridated water suffer from dental fluorosis on two or more teeth [2] .Black and McKay(1916), were pioneers whose researches led to the discovery made by Smith, Lantzand Smith(1931) that if was fluorine contained in drinking water, in a concentration of not less than 1 part per million(1ppm) and ingested during the period of calcification of teeth, which was the direct cause oh dental dystrophy[2]. Fluoride can cause a crippling bone disease called skeletal fluorosis. Hence its estimation and reduction in water becomes of paramount importance. Fluoride is associated with Alzheimer's disease and other forms of dementia. Fluoride enters the brain and enables aluminum to cross the blood-brain barrier, resulting in increased risk for these diseases. Fluoride has also been associated with low IQ and mental retardation in children.

There have been many developments in fluoride analysis. Membrane methods have been used in India but not very efficient as it is costly and the membrane gets clogged as the days pass by. Hence a new membrane material for fluoride selective, chemically modified field effect transistors (CHEMFETs) was developed by incorporation of a uranyl salophen derivative as the anion receptor into a polysiloxane membrane doped with acetylphenoxypropyl or phenylsulfonylpropyl substitutes [3]. Experiments have been conducted to reduce fluorine by electro dialysis from a brackish water containing 3000 ppm of total dissolved solids (TDS) and 3 ppm of fluoride [4] using the studies that have been made on the Optimization of fluoride removal from brackish water by electro dialysis [5]. Recently, an interesting method of coupling both adsorption on natural chitosan and electro dialysis using membranes was also used for the removal of fluoride for brackish water with a high fluoride content[6].

This paper presents a novel way of reducing fluoride content in water samples using optimum amounts of alumina, Ph and time of operation. This innovative method can be used in efficient reduction and analysis of fluoride content in water samples and make it safe for further use. Spectrometer is used to detect the concentration of the chemical species .The basic principle of reduction of fluoride concentration is that, when alumina is used, the pores in alumina help trapping the fluorides. It combines with fluoride ions and settles down at the bottom of the jar used in the operation and the alumina is eventually removed by filtration. Factors such as cost, duration of operation, purity obtained, energy used and chemicals available are taken into consideration. Optimum pH and time of operation coupled with optimum amount of alumina is used to efficiently decrease the fluoride content in this case.

II. FLUORIDE ESTIMATION

A. Fluoride Analysis- Without pre-treatment

Solution of concentration 10 ppm was prepared. Zero, 0.5, 1, 2 ml of the same were taken in various measuring tubes

and 25 ml of distilled water was added to each of it. These are the standards. Next, required volume of sample was taken in each of the measuring tubes. Depending upon the number of samples, enough alfusone reagent was taken. 5ml of the same was added to each of the tubes .10ml of acetone was added to each and made up to 50ml with distilled water. It was allowed to stand for one hour. The samples were then taken and the value of absorption corresponding to 620nm was found out using the spectrometer. The values were tabulated and the amount of fluoride present was calculated by the formula. The various samples taken numbered from one to six were tap water from trichy, tap water from guindy, under ground water in thoraipakkam, tap water from mylapore, underground water at mylapore and Japanese tap water. The results were tabulated**.** Fig.1 depicts the calibration curve. Equation (1) is used to calculate the fluoride content from the Calibration curve.

Fluoride content= ((ABS)+0.0018)/0.0143 (1)

ABS is the value obtained by using the spectrometer.

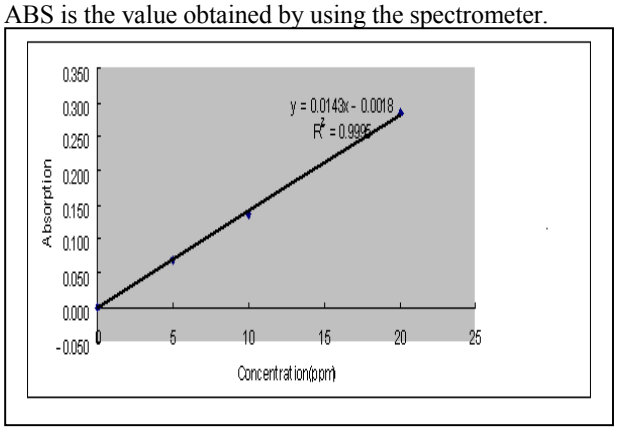

Figure 1. Calibration curve

TABLE I.

Fluoride content from various Indian water samples without pre treatment

Sample	Volume taken (ml)	ABS	Fluroride content (mg/l)
1	10	0.089	0.635
2	10	0.069	0.495
3	10	0.027	0.201
4	10	0.055	0.397
5	10	0.071	0.509
6	25	0.033	0.097

B. Fluoride analysis-with pre-treatment

200ml of the samples to be tested were taken in 300 ml beakers. Few drops of phenolphthalein was added to each of the beakers . Akaline condition is to be maintained .NaOH was added to those beakers where colour didn`t change to pink, to make it alkaline. The beakers were then kept in hot trays till the level dropped to 50ml.

The samples were then transferred to distillators with the required reagents i.e silicon di-oxide (1g), boiling stone, phosphoric acid (1ml), perchloric acid(40ml) and thermometer was attached at the sides. Heater was turned on and temperature of 140 degrees was maintained until all the fluoride was collected along with sodium hydroxide in measuring jars.The pH in each of the measuring jar was adjusted to 7 using NaOH and sulphuric acid, and made upto 250ml with distilled water. Then required amount of sample was taken and made up to 25ml with water, 5ml of alfusone reagent and 10ml of acetone were added .The absorption was then measured using spectrometer and the fluoride content was measured using corresponding calculations

TABLE II.

Sample	Volume taken(ml)	ABS	Fluoride content (mg/
1	10	0.023	0.171
2	10	0.021	0.156
3	10	0.011	0.082

Fluoride content from first three Indian samples after pre treatment

The first three samples under without pre-treatment and with pre-treatment were chosen and their fluoride contents were compared. As observed the fluoride content for the samples after pre treatment were found to be lesser, giving

the correct amount of fluoride present in the water samples. Fig.2 gives the comparison of fluoride content obtained from without pre treatment and with pre treatment.

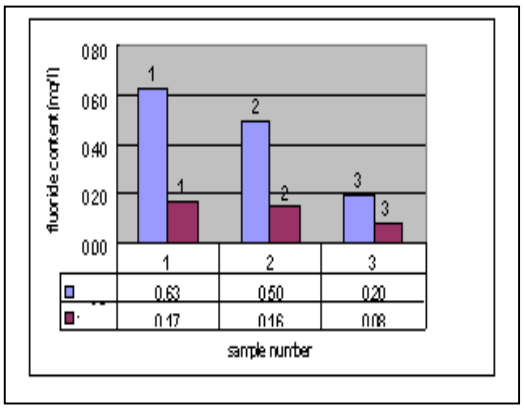

Figure 2. Comparison of fluoride contents

III. FLUORIDE REDUCTION

Fluoride analysis by jar test is adopted to reduce the fluoride content. Under this, three tests were performed namely weight analysis, pH analysis and time analysis. Further conformation test were also done to ensure the decrease in fluoride content.

A. Weight analysis

In this test, different amounts of alumina were taken, weighed and transferred to a beaker. Around 500ml of water was added to each of the beaker and kept under the jar test

instrument and stirring takes place. After an hour the alumina was filtered out and using pack test , the amount of fluoride content in each of the beakers was observed. The amount of alumina which was the best, i.e. having acceptable fluoride content on comparison with factors such as cost , duration of operation , purity etc. was thus selected. Fig.3 – shows the calibration curve in this case. Equation (2) is used to calculate the fluoride content.

Fluoride content = ((ABS)+0.0002)/0.0136 (2)

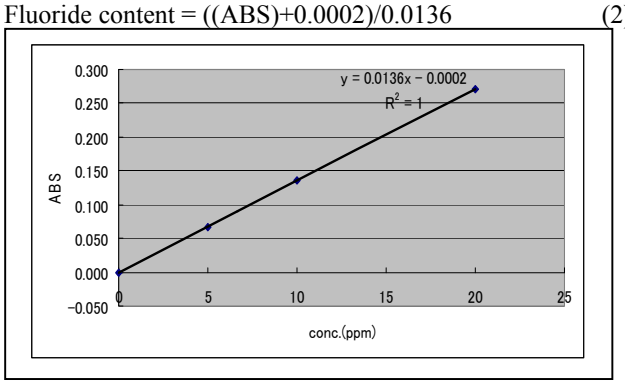

Figure 3. Calibration curve

TABLE III.

Alumina weight (g)	ABS	Volume taken (ml)	Fluoride content (mg/l)
0	0.240	1	16.2
10	0.186	1	12.5
20	0.137	1	9.2
40	0.173	2	5.8
60	0.054	1	3.7
80	0.132	4.5	2.0
100	0.190	10	1.3

Weight analysis of Indian samples

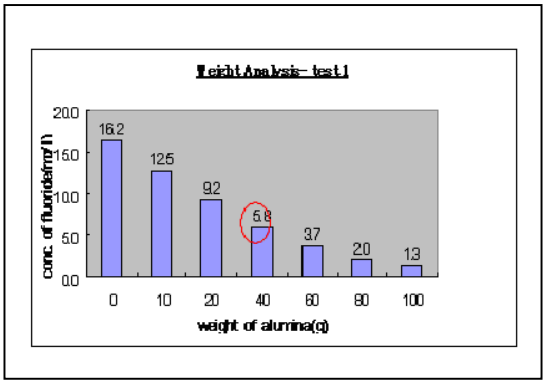

Figure 4. Graph depicting the weight analysis test

In Fig.4, 40g of Alumina has been chosen as the optimum weight, reducing the fluoride concentration to 5.8mg/l. Though the fluoride concentration was found to be lesser in the 60g, 80g and 100g weight samples, we chose 40g considering the cost factor. The fluoride concentration was reduced further through an optimum pH and time of operation.

B. pH analysis

In this test the amount of alumina selected in test 1 was kept constant and taken in all the beakers and different pH was maintained in each of the beakers. The pH was maintained throughout the one hour process during which it was kept under jar test apparatus. It was then removed, filtered and the amount of fluoride content was found out by pack test. The best pH was then selected on the same grounds as mentioned in the weight analysis test.

TABLE IV.

pH	ABS	Volume taken(ml)	Fluoride content (mg/l)
2	- 0.11	20	- 0.6
4	0.153	5	2.2
5	0.179	4.5	3
6	0.282	4.5	4.9
7	0.121	2	4.2
9	0.132	1	9.3

Ph analysis of Indian samples

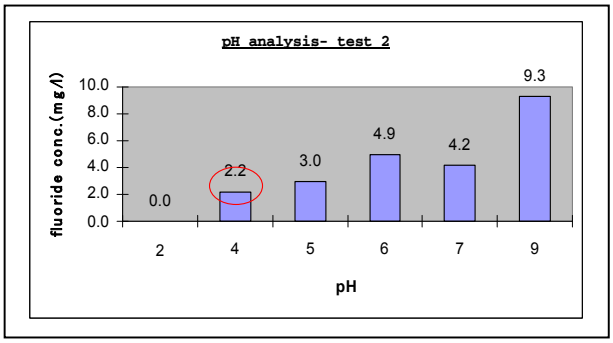

Figure 5. pH analysis graph

We did not choose pH 2 as it was very acidic. Hence pH 4 was chosen

C. Time analysis

In this test, the pH and alumina obtained was kept constant in all the beakers and measured for different time intervals. It was then filtered after that time interval and concentration of fluoride was found out using spectrometer.

TABLE V.

Time (s)	ABS	Volume taken(ml)	Fluoride content(mg/l)
10	0.210	2.0	7.7
20	0.153	2.0	5.6
30	0.149	2.25	4.9
40	0.172	5.0	2.5
60	0.228	4.5	3.7
90	0.266	10.0	1.0

Time analysis of Indian samples

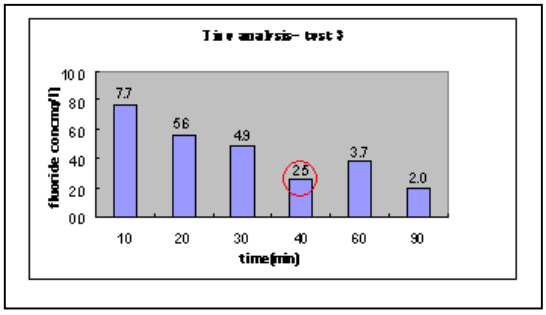

Figure 6. Time analysis graph

Although the fluoride content after 90 minutes of operation was the least, which was 2 mg/l, the operation time of 40 minutes was chosen considering optimum machine power and costs involved. The fluoride content for 40 minutes of operating time was found out to be 2.5mg/l .

D. Conformation test

TABLE VI

Ph =4 Alumina=40g Time=40 min	**ABS**	**Volume taken(ml)**	**Fluoride content**
Trial	0.283	10	2.1

Fluoride content considering optimum value of alumina, Ph and time of operation.

This shows that the fluoride content has been efficiently decreased from 16.2 mg/l to 2.1mg/l with 40g alumina , pH as 4 and 40 minutes as time of operation.

IV. CONCLUSION

The analysis of fluoride was carried out with and without pre-treatment to obtain comparative results between the two. The analysis of fluorides with the former gave accurate results than the latter as the metal ions were removed in the former, giving us precise results.

The reduction of fluoride content in water was successfully reduced to 2.1mg/l from 16.2mg/l through an efficient method using spectrometer in which 40g alumina, pH of 4 and 40minutes These conditions were found to be optimal for the obtained fluoride reduction.

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