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An Emerging Technique For Deflouridation Of Water - A Nanotechnology

Narayana J.
[a]*Department of P.G. Studies & Research in Environmental Science, Kuvempu University, Jnana Sahyadri, Shankaraghatta, 577 451, Karnataka, India*

Abstract: *The de-fluoridation of simulated known concentration of fluoride solution (3 to 5 ppm) was studied using $Al(OH)_3$ nano particles (0.5 gm/100 mL) as adsorbentsby a simple magnetic extraction method.Selective ion electrode method was adopted to analyze reduction of fluoride concentration in simulated solution before and after treatment. The result reveals that, the absorbance for the samples have been noticeable reduction in fluoride. Also it is evident that as the increase in fluoride content the reduction percentage also accelerated. The study showed 24.50 % reduction in absorbance for sample having fluoride 3ppm fluoride content, 21.93% reduction for 3.5ppm, 13.64% reduction for 4ppm fluoride concentration, 11.07% reduction for 4ppm fluoride concentration and 7.62% reduction in absorbance for the sample containing 5ppm of fluoride.*
Keywords: *de-fluoridation; nano particles; ion electrode*

I. Introduction

More than 103 million people around the world live in areas where optimal fluoride concentrations occur naturally. In small amounts of fluoride is beneficial as it is believed to impart stability to bone and enamel, there by preventing dental carries and osteoporosis to some extent but its higher concentration is highly toxic to humans and animals alike. The permissible limit of fluoride in drinking water as recomended by WHO is 1.5 ppm. Chronic exposure to fluoride above the permissible limits causes a disease called "Fluorosis" which is an important clinical and public health problem in several parts of the world. This disease manifests itself in three forms, namely, dental, skeletal, and non-skeletal fluorosis. Even though extensive studies have been conducted, there seems to be no effective cure for these diseases, therefore, it is desirable to drink water having a fluoride concentration less than certain value. So it is essential to consider remedial measures of fluoride in potable water to control fluorosis. This paper deals with an overall, effective and low cost technique for defluoridation of water using nanotechnology.

Some study have already conducted using nanopartical for defluoridation in potable water. Fe3O4 nanopartical (Fe_3O_4 or $Al(OH)_3$ NPS was used (1) to remove excessive fluoride from aqueous solution. The main factors which affecting in removal fluoride are pH of the solution, temperature, adsorption time, initial fluoride concentration and co-existing anions. All the results suggested that the $Fe_3O_4Al(OH)_3$ NPS (2) having strong affinity to fluoride and it could be excellent adsorbent for fluoride contaminated H_2O treatment. Fluoride ions can also removed electrochemically from a solution using a combined electro-coagulation and electro-floatation process (3). For an influence fluoride concentration of 15 mg/L a value after time precipitation, the effluent fluoride concentration can be lower than 2 mg/L when the pH in the coagulation cell is around 6, charge loading is at 4.98 F/M3 water and the residence time is 20 min. Even lower effluent concentration can be achieved if 50 mg/L of Fe^{3+} or Mg^{2+} are added into the coagulation unit. Reduce fluorine by electrodialysis from brackish water containing 3000 ppm of total dissolved solids (TDS) and 3 ppm of fluoride (4). Tthe percentage of fluoride removal has increased with the increase of contact time and dose of adsorbent (5). Defluoridation of ground water using low grade Assam coal has an adsorbent is studied by batch sorption experiments (6). There is no adverse change in the physico-chemical properties of treated water. Also Fe-Al-Ce trimetal oxide amorphous structure was successfully developed for fluoride adsorption (7) . Nano MgO was used to removing fluoride from drinking water (8).

In the present study we explore the use of novel magnetic nanosized adsorbent using hydrous aluminum oxide embedded with Fe_3O_4 nanoparticle (Fe_3O_4@$Al(OH)_3$ nps), was prepared and applied to remove excessive fluoride from aqueous solution.This adsorbent combines the advantages of magnetic nanoparticle and hydrous aluminum oxide floc with magnetic separability and high affinity toward fluoride, which provides distinctive merits including easy preparation, high adsorption capacity, easy isolation from sample solutions by the application of an external magnetic field. The adsorption capacity calculated by Langmuir equation was 88.48mg−1 at pH 6.5.

II. Materials and methodology

Chemicals used in this study were of analytical grade. Aluminium nitrate nonahydrate ($Al(NO_3)_3$. $9H_2O$), ferric chlorde ($FeCl_3$. $6H_2O$), ferrosu chloride ($FeCl_2$. $4H_2O$). A stock solution of 1000 mg/L flurodie was prepared from sodium fluride using distilled water. Required concentration of the sample was prepared by serial dilutions from the sock solution.

Sample preparation

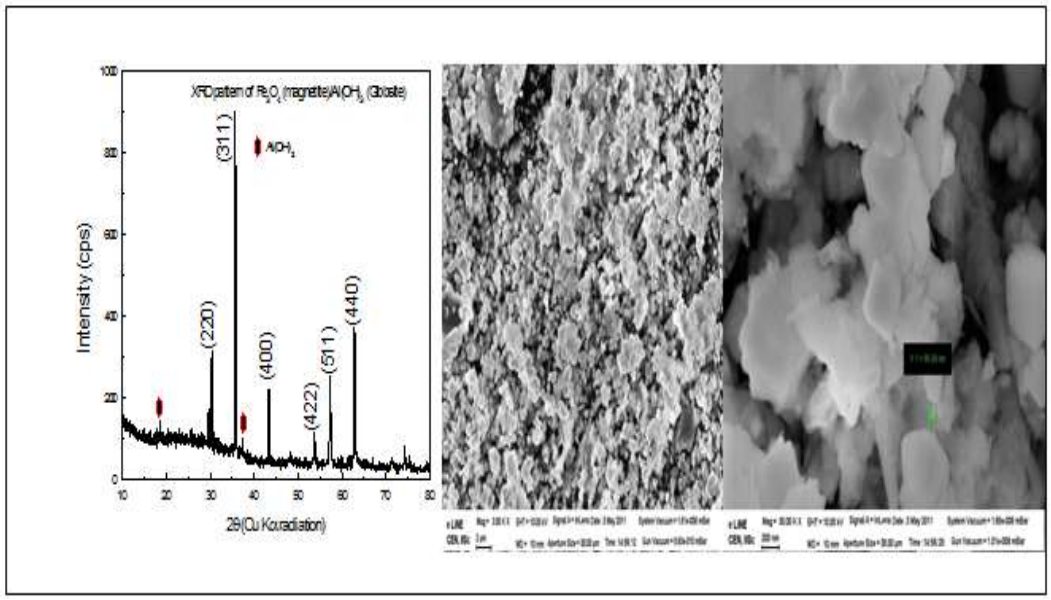
For the study purpose the water samples are prepared in the laboratory. 5 samples were prepared by dissolving known quantites of sodium fluoride using deionised water. The range selected for laboratory test includes namely 3.0ppm, 3.5ppm, 4ppm, 4.5ppm, 5ppm and samples are subjected to analysis using Ion Selective Electrode Method before and after defluoridation process.

Preparation of magnetic adsorbents

5.5 ml of H_2SO_4, 196 gm of ammonium ferrous sulphate and 50.55 gm of KNO_3 were dissolved in 500 ml of distilled water Then the solution was added drop-wise into 100 ml of 1 M NaOH solution under vigorous stirring using non-magnetic stirrer at 80ºc. Kept the sample on water bath for digestion about 6 hrs at 80ºc.After 6 hrs digestion wash the particle with deionized water fro several times. Filtered the sample and dried in oven at 90ºc for 12 hrs. The dried particles are dispersed in 200 ml of deionized water and 100 ml of aluminium nitrate 1(M) to the suspended particle solution and the pH value of the mixture was adjusted to 8.0 by addition of 2(M) NaOH within one hour.

Characterization of magnetic adsorbents:

To enlighten the characteristics of nanoparticles that are used for the present study, Scanning Electron Microscopic Image (SEM) and X-Ray-Diffraction (XRD) as shown below.



Standard solution prepared by diluting the appropriate quantities of the fluoride stock (1000mg/L) solution to 100 ml with distilled water. The de-fluoridation procedure using Fe_3O_4 or $Al(OH)_3$ nano particles as adsorbents allowed rapid separation by a simple magnetic extraction method. The initial fluoride concentration ranging in 3 to 5 mg/L 0.5 gm of Fe_3O_4 or $Al(OH)_3$ nano particles suspension was added into 100 ml of fluoride water under vigorous stirring using non magnetic stirrer under 1 hours, after a few seconds, the magnetic rod nano particles deposited at the bottom of the bottle. The supernatant liquid was filtered using filter paper, then analyzed for the remaining fluoride concentration with selective ion electrode method.

III. Result And Discussions

Figure 1: Absorption of sample with and without application nanotechnology

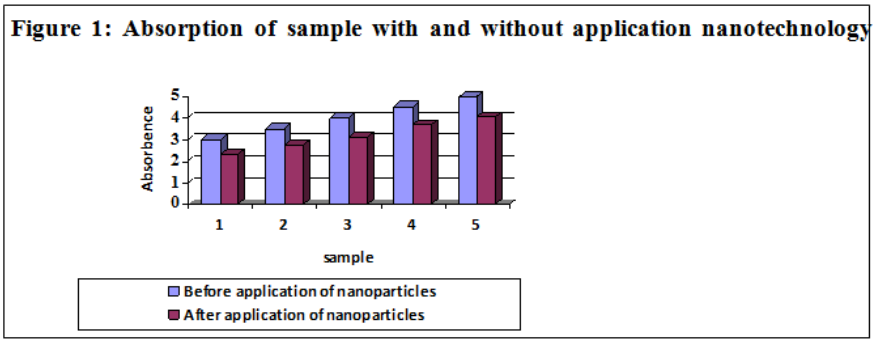
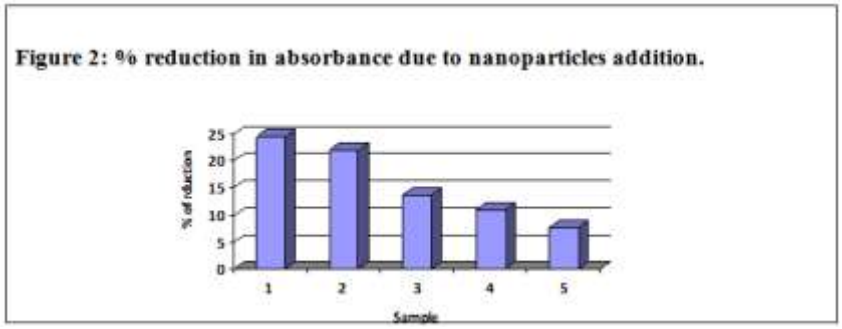


Figure 1 reveals that the absorbance of the samples has been noticeable reduction in fluoride. The study showed 24.50 % reduction in absorbance for sample having fluoride 3ppm fluoride content, 21.93% reduction for 3.5ppm, 13.64% reduction for 4ppm fluoride concentration, 11.07% reduction for 4ppm fluoride concentration and 7.62% reduction in absorbance for the sample containing 5ppm of fluoride.

Figure 2: % reduction in absorbance due to nanoparticles addition.



Though the present study is limited to only particular range of variation in fluoride content , it can be evidently seen that nanotechnology is not only a modern technique emerging and can be easily employed as one of the defluoridation methods along with conventional one. Therefore studies still need to carry for removal of fluoride in water.

IV. Conclusions

Through this experimental study it has been observed that as the process involves magnetic separation is a very simple technique and not much skill is required. No fabrication work of special units or reactors are involved and also cost effective. In the experimental it has been evidenced seen that maximum reduction of fluoride can be achieved by this technique. Merits of our method were three-fold because high adsorption capacity and high affinity toward fluoride. Sorbents have higher surface area as well as shorter diffusion route and the $Al(OH)_3$ surface layer of Fe_3O_4@$Al(OH)_3$,NPS possesses, having specific affinity toward fluoride. Therefore, satisfactory results can be achieved by using less amount sorbents than traditional micron-size particle sorbents. This treatment method also less time-consuming and exhibits great potential in treatment of large volume of water. Easy preparation of nanoparticle chemicals can meet the need of practical application for treatment of large volume high-fluoride contaminated water.

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