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Removal of Fluoride from Ground Water using Pineapple peel as Biosorbent

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Abstract

Fluoride is a naturally occuring compound derived from fluorine. It occurs naturally in public water system as a results of runoff from weathering of fluoride containing rocks and soils. It is toxic in high conc. Due to high toxicity of fluoride to mankind, there is urgent need to treat fluoride contaminated drinking water to make it safe for human use. Here we use pineapple peel powder as a biosorbent for fluoride removal from groundwater. The fluoride removal efficiency of pineapple peel powder was investigated by Batch wise adsorption experiment. The effect of various parameters on the %age removal of flouride was studied. e.g. contact time, adsorbent dose, pH.

Keywords : Pineapple peel, Biosorption, fluoride, contact time, Adsorption

Introduction :

Water is one of the most important elements for all forms of life. Safe drinking water is primary need of every human being. Pure water is not available to all. Water may be contaminated by natural sources or industrial effluents. One such contaminant is fluoride. Fluoride contamination is ground water is one of serious problem world wide [1]. Fluorine is most electronegative of all the elements which mean that it has a strong tendency to acquire negative charge and in solution form fluoride ion [2]. Fluoride enters into groundwater due to dissolution from rocks/minerals like topaz,fluorite,fluorspar,cryolite etc. available at the aquifer bottom [3]. The fluoride content in the ground water is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, pH, temperature and concentration of calcium and bicarbonate ions in water [4]. Besides the natural geological sources, various industries are also contributing for fluoride enrichment in groundwater [5]. The industries which dischrage waste water containing high fluoride concentrations include glass and ceramic production, semiconductor manufacturing, electroplating, coal fired power stations etc. the effluents of these industries have higher fluoride concentrations than natural water [6]. Depending on the concentration, the impact of fluoride in drinking water can be beneficial or detrimental to mankind. Fluoride is beneficial in human body for calcification of dental enamel and maintainance of healthy bones.

Presence of fluoride beyond the permissible limit > 1.5 ppm in drinking water is harmful and not suitable [7]. Fluoride in drinking water has a profound effect on teeth and bones. Up to a small level (1–1.5 mg/L) this strenghthens the enamel of teeth. Concentrations in the range of 1.5–4 mg/l result in dental fluorosis and with prolonged exposure and higher fluoride concentrations (4-10 mg/L) progresses to skeletal fluorosis [8]. Elevated fluoride conc. in the ground water occurs in various parts of world [9]. Besides the drinking water, fluoride can also enter into the human body through food, industrial exposure, drugs, cosmetics etc. [10]. Elevated fluoride conc. Can induce birth, reproduction, immunological effects [11]. It can interfere with carbohydrates, proteins,vitamins and mineral metabolism [12]. There are many methods available for removal of fluoride from water such as coagulation, Ionexchange, dialysis, reverse osmosis etc. [13]. From these all methods adsorption is most simple process. Adsorption methos is mainly used because it is cost effective, easy to operate and eco-friendly nature [14].

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Biosorption method involves low cost adsorbents, like horse gram powder, ragi powder, multhani matti, red mud, calcined clay, concrete, chalk powder, activated coconut shell carbon, coffee husk etc. are some of the different materials used for removal of fluoride from water.

In this paper, the fluoride removal by pineapple peel powder has been investigated and effects of various parameters on the percentage removal of fluoride has been studied.

Health Impacts of Fluoride

Though a small amount of it is beneficial for human health for preventing dental carries. It is harmful when present in excess. In dental fluorosis there are opaque white patches on the teeth and in advance stages there is production of brown to black staining on teeth. Dental fluorosis is mostly found in children up to the age of 12 years [15].

In skeletal fluorosis there is increase in bone density leading to the thickness of long bones and calcification of ligaments. The symptoms include mild rheumatic/ arthritic pain in joints and muscles to severe pain in the cervical spine region along with stiffness and rigidity of the joints. High level of fluoride is major cause of weakening of bones and increase in wrist fracture [16].

Fluoride causes reduced intelligence, impaired memory and reduced IQ level. Fluoride may also affect foetal brain development [17]. The chronic ingestion of fluoride can have non-carcinogenic effects on the kidney and there can be possiblity in kidney stone [18].

EXPERIMENTAL METHODOLOGY

Materials : First, a stock solution of 100 mg/litre concentration of fluoride was prepared by dissolving 221 mg of anhydrous sodium fluoride in one litre water [19]. and desired concentration of working solutiosn were then prepared from the stock solution. Sulphuric acid (0.1N) and sodium hydroxide (0.1N) were used for adjusting the pH values either to acidic or alkaline conditions.

Pineapple fruit peel was collected from the local market. The peels were washed thoroughly with water for removing the dust, dried and finally crushed. After drying and crushing, it is sieved through sieve.

Batch Adsorption Experiment

In batch adsorption experiment, the 50 ml of sample having 5 mg/l of initial fluoride concentration had been taken in a conical flask of volume 100 ml containing definite quantity of bio-adsorbent, which was agitated [20]. After the agitation the conical flask was allowed to stand for some time for the setting of the adsorbent.

The sample solution was filtered through Whatman no. 42 filter paper and the filtrate was analyzed for determining the fluoride concentration through SPADNS photometric method using UV-spectrophotometer at wavelength of 570 nm.

Spectrophotometric Method

In this method SPADNS reacts with zirconium ion to form a red colored complex. Further, fluoride reacts with this complex and discolors the red color of the complex. Now the variation in the adsorbance can be determined by using a spectrophotometer.

Results and Discussions

Effect of pH

pH is one of the important parameter that affects the biosorption of fluoride. Fig. (1) shows that plot of %age fluoride removal against varying pH range 2–10. The nature of graphs shows that maximum adsorption of fluoride occurs at pH 4.

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Dose of adsorbent in gm	pH	Initial fluoride (mg/l)	Final fluoride (mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.5	2	5	1.75	3.25	65
0.5	4	5	0.75	4.25	85
0.5	6	5	1.25	3.75	75
0.5	8	5	3.00	2.00	40
0.5	10	5	2.78	2.22	44.5

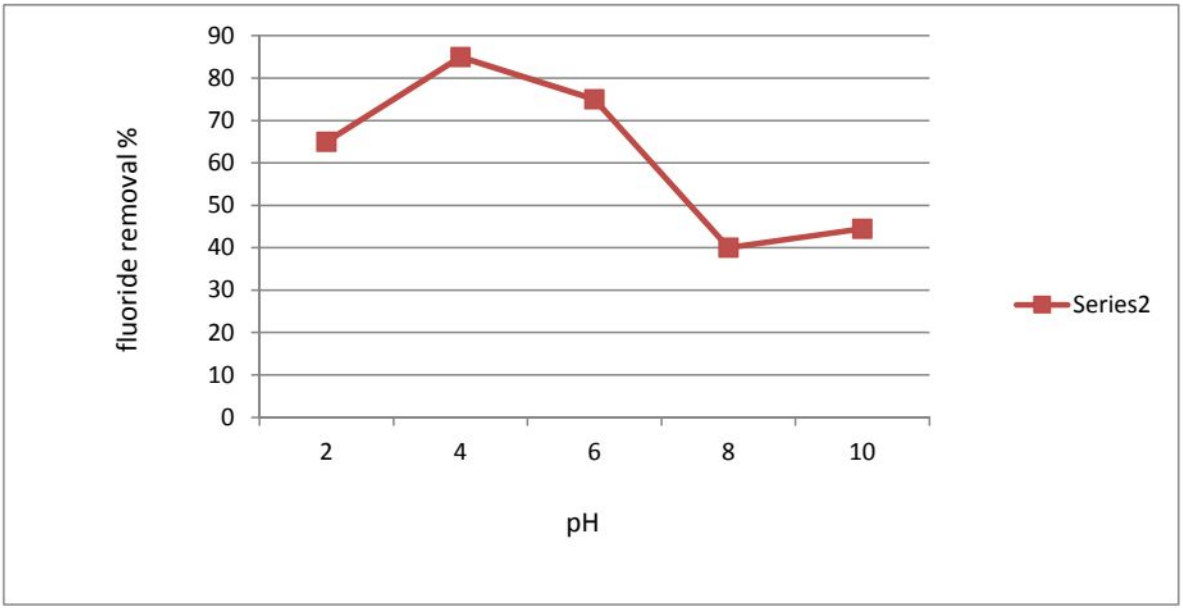

Fig. 1 : Effect of pH on adsorption of fluoride on pineapple peel

Effect of Contact Time :

The study of the effect of contact time was conducted by agitating 0.5 gm peel powder in 50 ml of fluoride solution containing 5 mg/l fluoride conc. Fig. 2 shows that %age of removal of fluoride increase first by increasing contact time from 20 min. to 50 min. than it attains equilibrium state. This result may be shown due to the presence of more active sites initially and after the fluoride accumulation and saturation of the sites, it attains equilibrium.

Dose of adsorbent in gm	Contact Time (in Min)	Initial fluoride (mg/l)	Final fluoride (mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.5	20	5	2.25	2.75	55
0.5	30	5	2.1	2.9	58
0.5	40	5	2.0	3.0	60
0.5	50	5	1.6	3.4	68
0.5	60	5	1.6	3.4	68

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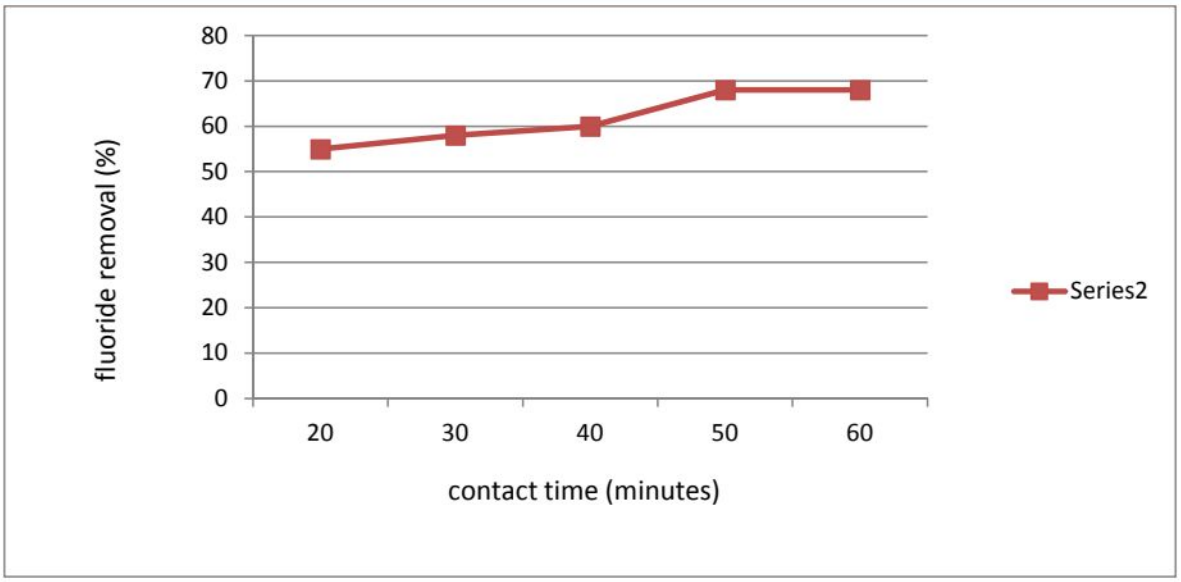

Fig. 2 : Effect of contact time on adsorption of fluoride on pineapple peel

Effect of adsorbent dose :

To study the effect of biosorbent dose, the experiments are performed at various doses of biosorbent between 0.2–1.2 g in 50 ml Fluoride solution having initial conc. of 5 mg/l. The percentage removal of fluoride has been increased with dose of biosorbent, then decreases to some extent because more active sites are available for adsorption in initial stage.

Dose of adsorbent in gm	Initial fluoride (mg/l)	Final fluoride (mg/l)	Reduction in fluoride (mg/l)	% removal efficiency
0.2	5	1.45	3.55	71
0.4	5	1.2	3.8	76
0.6	5	1	4	80
0.8	5	0.7	4.3	86
1	5	0.46	4.55	90.9
1.2	5	0.55	4.45	89

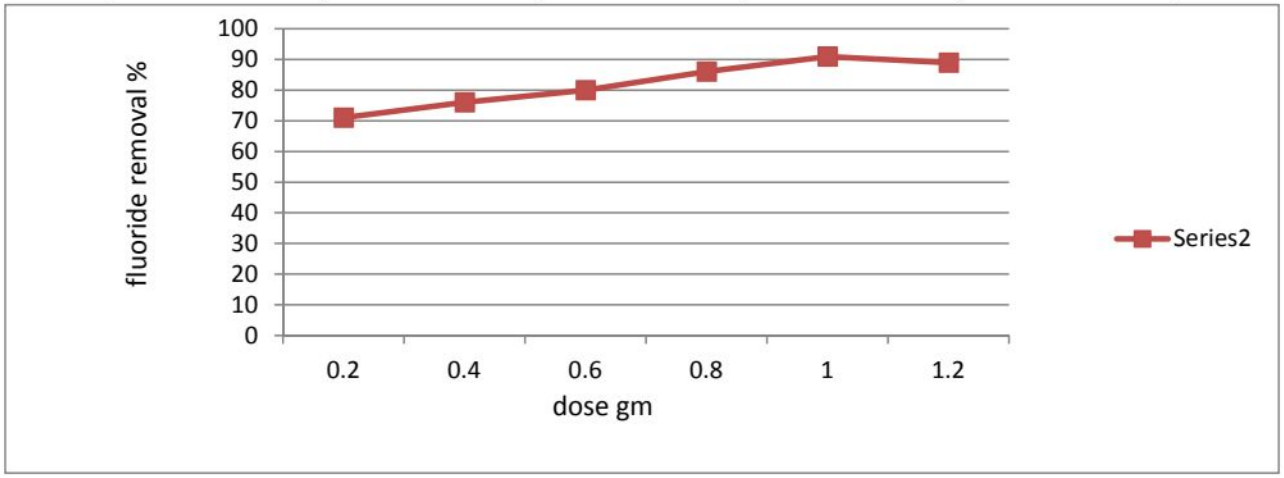

Fig. 3 : Effect of Biosorbent dose on adsorption of fluoride on pineapple peel

Conclusion :

- The study shows that pineapple peel is suitable adsorbent for removal of fluoride from water.
- Removal percentage of fluoride by pineapple was found maximum at pH 4.
- Removal percentage of fluoride by pineapple was found maximum at adsorbent dose of 1 gm.
- Removal percentage of fluoride by pineapple was found maximum when contact time was 50 minutes.

Thus the use of pineapple peel as a low cost biosorbent for fluoride removal was proved to be economic.

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