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RESEARCH ARTICLE

A REVIEW PAPER ON REMOVAL OF FLUORINE FROM DRINKING WATER

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ABSTRACT

This paper depicts the removal of fluorine from drinking water accomplished by different adsorbents and techniques. In the human system this fluoride has a dual personality, a destructive effect (greater than 1.5 ppm – dental & skeletal fluorosis) and a beneficial effect (upto1.0ppm – carries prevention and health promotion). WHO (World Health organization) recommends that maximum fluorine content in drinking water should be up to 1.5 ppm in India. Large population in India suffers from dental and skeletal flourosis due to high fluoride concentration. The study reveals at what extent the low cost adsorbents and separation techniques are beneficial for the defluoridation of water.

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INTRODUCTION

Water is the major medium of fluoride intake by humans. Fluoride in drinking water can be either beneficial or detrimental to health, depending on its concentration. Ground water is the major source of freshwater on the earth. Groundwater containing dissolved ions beyond the permissible limit is harmful and not suitable for domestic use. Fluoride beyond desirable amounts (0.6 to 1.5mg/l) in groundwater is a major problem in many parts of the world. The fluorides belong to the halogen group of minerals and are natural constituents of the environment [1]. One million people are affected by fluorosis in nalgonda district, Andhra Pradesh [2]. 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 [1]. The popular technologies for the removal of fluoride from water include: coagulation followed by precipitation, membrane processes, ion exchange and adsorption [1]. Various low cost materials like kaolinite, bentonite, charfines, lignite and nirmali seeds were investigated to assess their capacity for removal of fluorides from water by batch adsorption studies [11]. In recent years, considerable attention has been focused on the study of fluoride removal using natural, synthetic, and biomass materials such as activated alumina, fly ash, alum sludge, chitosan beads, red mud, zeolite, calcite, hydrated cement, attapulgite, and acid-treated spent bleaching earth [2].

Study has indicated that materials like nirmali seeds and lignite are not effective (removal 6 to 8%) ; whereas removal by kaolinite clay was slightly higher (18.2%). Charfines and bentonite exhibited highest removal capacity of 38 and 46%, respectively, at optimum system conditions. Chemical pretreatment of charfines did not result in enhanced removal of fluoride from water [11]. The process of adsorption by Zr–Mn composite material followed Freundlich as well as Langmuir isotherms but is favorable to Freundlich isotherm that provides best fit to the experimental data. The results obtained showed that adsorption on the Zr–Mn composite material could be an effective method for the removal of fluoride [13]. Also defluoridastion of water using limestone is carried out with preacidification of acetic acid and citric acid [4]. Activated carbon is a good adsorbent to remove fluoride as it has a large surface area and hence a large surface for the adsorption of fluoride [5]. Also three low cost agricultural biomass based adsorbents namely: activated bagasse carbon (ABC), sawdust raw (SDR), and wheat straw raw (WSR) are also used for water defluoridation at neutral PH range.

Effect of different low cost adsorbents

Freshly fired brick pieces are used for the removal of fluoride in domestic defluoridation units. The brick bed in the unit is layered on the top with charred coconut shells and pebbles. Water is passed through the unit in an up flow mode. It is reported that efficiency depends on the quality of the freshly burnt bricks.

Percentage removal of Fluoride with different adsorbents [2]

Sr No	Adsorbents	Initial concentration of fluoride in mg/l	Final concentration of fluoride in mg/l	Amount adsorbed in mg/l	% removal
1	Chalk powder	12	1.6	10.4	86
2	Pine apple peel powder	12	1.6	10.4	86
3	Orange peel powder	12	2.5	9.5	79
4	Horse gram seed powder	12	3	9	75
5	Red mud	12	3.4	8.6	71
6	Ragi seed powder	12	4.2	7.8	65
7	Multhani mati	12	5.2	6.8	56
8	concrete	12	5.6	6.4	53

The unit could be used for 25-40 days, when withdrawal of defluoridated water per day was around 8 liters and raw water fluoride concentration was 5 mg/l. Activated carbon prepared from various raw materials (rice husk, wheat husk) exhibits good fluoride uptake capacity. But the adsorption process is highly pH dependent and is effective at pH less than 3.0 and there is little removal at neutral pH of 7.0. A maximum of 83 percent removal could be accomplished by rice husk and attains almost an equilibrium condition in nearly 180 minutes (3 hours) [8]. Ragi seeds are the low cost material act as a bioadsorbent and it consist of proteins, fat, and fiber. These components are responsible for fluoride adsorption from aqueous solution. Chalk is the form of Calcium carbonate with minor amount of silt and clay As Calcium carbonate decomposes only at 900°C, the adsorption taking place Chalk powder due to certain porosity adsorbs fluoride from aqueous solution. Orange peel chemical composition as well as some trace elements, ascorbic acid, carotenoids dietary fiber, total polyphenols and their antiradical efficiency, using the 2,2-diphenyl-1-picrylhidracyl (DPPH) were assessed in the dried peels of orange (Citrus sinensis), due to certain porosity of orange peel powder adsorbs fluoride from aqueous solution. Addition of citric acid to crushed limestone lowers the concentration of fluorine from 10 mg/l to 2 mg/l and that of acetic acid lowers from 10 mg/l to 1.5 mg/l [4].

Methods for defluorodation of water

Coagulation and precipitation method

Lime and alum are the most usually utilized coagulants for Nalgonda technique for defluoridation of water. Expansion of lime prompts precipitation of fluoride as insoluble calcium fluoride and raises the pH value upto 11 – 12. As the lime leaves a leftover of 8.0 mg F^-/l, it is constantly connected with alum treatment to guarantee the best possible fluoride removal. The process produces water with leftover fluoride somewhere around 1 and 1.5 mg/l [3].

Membrane process

Reverse Osmosis (RO)

RO is a physical process in which the anions are removed by applying pressure on the feed water to direct it through the semi permeable membrane. RO works at higher pressure with more prominent rejection of dissolved solids. The membrane rejects the ions taking into account the size and electrical charge. RO membrane process is the reverse of natural osmosis as a consequence of applied hydraulic pressure to the high concentration side of the solution, it forces solvent filter through the membrane, against a pressure gradient into the lower-concentration solution.

In RO, utilizing a mechanical pump, pressure is applied to a solution via one side of the semi-permeable membrane to overcome inalienable osmotic pressure. The process likewise removes soluble and particulate matter, incorporating salt from seawater in desalination [14]. In the 80’s, RO membrane separation technique was effectively connected for the treatment of industrial wastewater particularly for the removal and recovery of fluoride from its effluents. More than 90% of fluoride can be removed regardless of initial fluoride concentration using RO membrane separation process [3].

Nano filtration membrane process

Nanofiltration (NF) is the later innovation among all the membrane processes utilized for defluoridation of water. The essential contrast in the middle of NF and RO membrane separation is that NF has somewhat bigger pores than those utilized for reverse osmosis and offer less resistance to entry of both solvent and of solute. As a outcome, pressures needed are much lower, energy prerequisites are less, removal of solute is substantially less thorought, and flow are faster [21]. Nanofiltration membrane removes essentially the larger dissolved solids when contrasted the RO making the process more prudent. Notwithstanding over, the permeability of nanofiltration membrane is higher than RO membrane, making the performance of NF in desalination more best for some brackish water [22]. In RO membrane separation 99% of salt present in water was rejected prompting the disposal of all the fluoride ion while NF membrane separation process give incomplete defluoridation of water and optimal fluoride concentration in water can be accomplished by changing the operation conditions.

Dialysis

Dialysis separates solutes by transport of the solutes through a membrane instead of utilizing a membrane to hold the solutes while water goes through it as in reverse osmosis and nanofiltration. The membrane pores are a great deal less prohibitive than those for nanofiltration, and the solute can be driven through by either the Donnan effect or a connected electric field.

Electro dialysis

Electro-dialysis is the removal of ionic components from aqueous solutions through ion exchange membranes under the driving force of an electric. Electro-dialysis is like reverse osmosis, except current, rather than pressure, to separate ionic contaminants from water. In any case, electro-dialysis is not suitable for rural because of use of electricity. Adhikary et al. have treated defluoridation of brackish water having fluoride upto 10 ppm with TDS upto 5000 ppm with an energy necessity of < 1 KWh/Kg of salt removed and brought it to reasonable firthest reaches of 600 ppm TDS and 1.5 ppm fluoride.

Ion-exchange process

Fluoride can be removed from water supplies with a strongly fundamental anion-exchange resin containing quaternary ammonium functional groups. The fluoride ions substitute the chloride ions of the resin. This process proceeds until every one of the sites on the resin are possessed. The resin is then backwashed with water that is supersaturated with dissolved sodium chloride salt. New chloride ions then substitute the fluoride ions promping recharge of the resin and beginning the process once more. The driving force for the substitution of chloride ions from the resin is the stronger electronegativity of the fluoride ions. High productivity (90-95 % fluoride removal) [3].

Conclusion

This paper provides an overview of various low cost adsorbents used for the effective removal of fluoride from water. Most of the adsorbents performance is depend on the pH and temperature. The removal capacity increases by increasing dose of the adsorbent and decreasing size of the adsorbent. The new treated adsorbents are also available and hope that it will encourage even more rapid and extensive developments for the treatment of fluoride. Present studies shows that concrete has the capacity to remove fluoride at lower concentration only. The adsorption capacity is low when compare to other adsorbents. This review has endeavored to cover an extensive variety of procedures which have been utilized so far for the removal of fluoride from the drinking water and industrial wastewater.

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