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A Review on Feasibility of Conventional Fluoride Removal Techniques in Urban Areas

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Abstract

Present study was carried out to evaluate the feasibility of conventional rural based defluoridation technique - Nalgonda technique, Activated alumina in urban areas. Nalgonda technique is being used extensively due to ease in construction of the reactor, operation & maintenance. This technique is very effective even when the fluoride concentration is above 20 mg/L. However, generation of acid or alkali water, residual aluminum, soluble aluminum fluoride complexes and fluoride contaminated sludge limits its practical applications. Above this, leakage of sulphate as aluminium sulphate with concentration as high as 400 mg/L in treated water, makes it un-potable and caused pitting effect on RCC reservoir/reactor or container. Cement paste is also employed for effective removal of F^- due to high concentration of Ca^{2+} and additional adsorption of the remaining F^- into amorphous calcium phosphate. However lime creates the problem of hardness of effluent water and co-precipitation particle of CaF_2 are too fine to be sedimented without coagulation. Limitation of CaF_2 precipitation also includes it inability to reduce F^- concentration of less than 10- 20 mg/L against permissible limit of 1.5 mg/L. Activated Alumina though showed effective removal of fluoride, slow rate of adsorption, pH adjustment, accumulation of bacteria in the long run inhibits its commercial application. Also sludge generation is one of its main drawbacks. Application of these conventional techniques in urban areas will leads to generation of large amount of fluoride sludge which creates another issue of solid waste management. It will be advisable to set up decentralized locality based fluoride removal treatment unlike high capacity water treatment in urban areas.

Keywords: Defluoridation, Nalgonda technique, Activated alumina, Co-Precipitation.

1. Introduction

Fluorine is the most highly reactive element and exists in water mainly as fluoride ion. Fluoride is highly toxic and is considered as an accumulative toxin (Pillai and Stanley 2002). It is present in ground water coming either from natural sources like weathering and volcanic processes or from wastewater of industries like fertilizer, glass, ceramics, brick, iron works and electroplating (Nigussei et al., 2007). Fluoride has both beneficial and harmful effects on the human health depending upon its level. Among the beneficial effects of fluoride in human body, strengthening of bones and prevention from tooth decay are significant (Fawell et al., 2006). W.H.O has stated that it should be in the range of 0.1 to 0.5ppm. The Indian Standard for fluoride contents is 1 ppm. This shows that the requirement of fluoride content changes and it depends on the geographical condition and the age of human beings. Excess fluorides in drinking water cause dental fluorosis and/or skeletal fluorosis. Removal of fluoride from drinking water, defluoridation, is normally accomplished by adsorptive (including ion exchange) and precipitation processes. Nalgonda Technique was developed by National Environmental Engineering Research Institute (NEERI), Nagpur, India (Bulusu et al., 1979), which involves, the addition in sequence, of an alkali, chlorine and aluminium sulphate or aluminium chloride or both; followed by settling and filtration. Adsorption is also a method used for removal of fluoride in which materials like activated carbon, activated alumina, bone char, or ion-exchange resins are used as adsorbents (McKee and Johnston, 1934). Presently several methods have been practised to remove fluoride from drinking water, however in urban, the application of these techniques has certain drawbacks at the time of implementation.

2. Materials and Method

In the process of Nalgonda Technique, alum (aluminium sulphate) and lime (calcium oxide) are added to and rapidly mixed with the fluoride contaminated water. Induced by a subsequent gentle stirring, “cotton wool”-like flocs develops (aluminium hydroxides) and is subject to removal by simple settling. The main contents of the fluoride are removed along with the flocs through combination of sorption and ion exchange with some of the produced hydroxide groups (Dahi et al., 2006). Activated alumina for defluoridization through adsorption involves preparation at low temperature dehydration. The fluoride uptake capacity of activated alumina depends on the specific grade of activated alumina, the particle size and the water chemistry (pH, alkalinity and fluoride concentrations) (Ganesh et al., 2006; Kumar and Gopal 2000). Bone char used for defluoridation involve sieving of bone char to the average particle diameters of 0.65, 0.79 and 1.29 mm, then washing it with deionized water, drying in a furnace at 100◦ C for 24 h and stored in plastic containers. The concentration of fluoride in an aqueous solution was determined by a potentiometric method.

3. Results and Discussion

Nalgonda techniques, activated carbon, bone char methods used for deflouridation of water are used basically in rural areas, which is community based. Nalgonda process did not achieve a great degree of success in field application as it removes only a smaller portion of fluoride (18–33%) in the form of precipitates and converts a greater portion of ionic fluoride (67–82%) into soluble aluminium fluoride complex ion, and therefore this technology is erroneous. Adoption of Nalgonda technique for defluoridation of water is not desirable due to use of aluminium sulfate as coagulant, the sulfate ion concentration increases tremendously and in few cases, it crosses the maximum permissible limit of 400 mg/L, which causes cathartic effect in human beings. The residual aluminium in excess of 0.2 mg/L in treated water causes dangerous dementia disease as well as pathophysiological, neurobehavioural, structural and biochemical changes. It also affects musculoskeletal, respiratory, cardiovascular, endocrine and reproductive systems. On household scale it is introduced in buckets or drums and at community. For larger communities a waterworks-like flow system is developed, where the various processes of mixing, flocculation and sedimentation are separated indifferent compartments.

Defluoridation using Activated Alumina (AA) has been one of the widely used adsorption/ ion exchange methods water and many reports are available on large-scale installations for townships, requiring supervision and skilled personnel. The quality of treated water from such facilities was assured. However, this approach was not immediately feasible because of increase hardness and surface loading (the ratio of total fluoride concentration to activated alumina dosage). The process is highly selective and is pH specific with low adsorption capacity, poor physical integrity, requires acidification and pretreatment and its effectiveness for fluoride removal reduces after each regeneration.

Bone char, though cost effective with a defluoridation percentage of 62 to 66%, still posses limitations such as harbors of bacteria and hence unhygienic conditions. Without a regular fluoride analysis, nothing indicates when the material is exhausted and the fluoride uptake is ceased. Moreover, the use of bone-char will have psychological effects on consumers. In urban areas, peoples generally use R.O techniques to maintain the fluoride from groundwater source but it proves costly. Thus, these conventional techniques are not that much suitable for the urban areas, we need such a technique having economical cost and easily accessible.

4. Conclusion

The literature survey has indicated that each of the discussed techniques can remove fluoride under specified conditions. The fluoride removal efficiency varies according to many site-specific chemical, geographical and economic conditions, so actual applications may vary from the generalizations made. Any particular process, which is suitable at a particular region, may not meet the requirements at some other place. Nalgonda technique, Activated Alumina, Bone Char is suitable technique for Indian

rural communities. Thus we have to look for urban areas accessible methods for deflouridation which are economical and effective.

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