



Defluoridation of Drinking Water in India

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ABSTRACT

Water supply is a daily necessity and key factor in human health and well being. The International Standards for Drinking Water (WHO, 1.9 –7.1) status that water intended for human consumption must be free from organisms and from concentrations of chemical substance that may be a hazard to health, in addition, supplies of drinking water should be as pleasant to drink as circumstance permit. Fluorosis, a slow, progressive, crippling malady known to be prevalent in district in 15 centers city's areas. It caused by the intake of water contaminated with fluoride beyond the tolerable limits of 1.5 ppm. India is not the only country, but several other are severely affected by the problem of fluorosis; which includes U.S.A., Morocco, Algeria, Libya, Egypt, Jordan, Turkey, Iraq, Iran, Pakistan, Kenya, South Africa, China, Australia, New Zealand, Japan and Thailand etc. The concentration of fluoride is critical for dental health in children too high a concentration of fluoride in drinking water can result in dental and skeletal fluorosis in children, but a small amount is essential for the prevention of dental caries. The desirable concentration varies with average ambient temperatures varies with a average ambient temperature; 0.9-1.7 mg/L at 10°C, 0.7-1.2 mg/L at 20°C and 6-0.8 mg/L at 30°C, all concentrations, expressed as F. Physiological properties of fluoride have been well documented. In higher doses it may result in the manifestation of certain abnormalities, including; motting of teeth, kidney damage and skeletal aberrations ranging from stiffness to a permanent skeletal, aberrations ranging from stiffness to permanent, crippling skeletal rigidity. Maximum ill effects detected in the neck, spine, knee, pelvic, shoulder and small joints of hand and feet, producing pain and rigidity around the affected areas, restriction the movement. In several cases of fluorosis, complete rigidity of joints in crippling deformity.

Keywords: Water supply, drinking water, fluoride, physiological properties.

INTRODUCTION

In recent past, evidences convincing soft tissue involvement by fluoride have lead to certain vital information on fluoride action on red blood cells as result of which the shape of the RBCs get changed, which in turns are destroyed by the body leading to low haemoglobin level. Acute abdominal pain, diarrhea, constipation blood in stool, tenderness in stomach, feeling of nausea, mouth sores, loss of appetite are several gastro-intestinal problems associated with fluorosis, along with neurological manifestations, like,

nervousness, depression, tingling sensation in fingers and toes; excessive thirst and tendency to urinate frequently. Sometime very painful skin rashes do occur, which are allergic manifestation of excess fluoride ingestion.

PROPERTIES OF FLUORINE

It is estimated to be the 13th most abundant element in the earth's crust. Fluoride attracts calcium ions of bone and teeth to form calciumfluoro-roaptite crystals. Fluoride causes a multiplicity of ill-effects on enzymes or proteins and even on DNA molecule.

Table-1.

Quality parameter	Suggested level of standards
pH	6.5 – 8.5
Dissolved oxygen	>2
Arsenic	<0.05
Lead	<0.05
Chromium (hexavalent)	<0.05
Cyanide	<0.2
Phenolic substances	<0.002
Chlorides	<1000
Total dissolved solids	<4000
E. coli count	0-10/100 ml
Turbidity	>5 unit – 25 unit
Salinity	<4000
Hardness (CO ₃ ⁻ and HCO ₃ ⁻ of Ca ⁺⁺ and Mg ⁺⁺)	>50 (Soft) <100 (hard)
Organic matter (vegetable origin)	2000
Iron	>0.04-200
NaCl	400

FLUORIDE CONTAMINATION

Water, food, air medicament and cosmetics are the chief sources of fluoride contamination. Water and food mainly agricultural crops contaminated with fluoride as the earth's crust in India, is heavily loaded with fluoride containing minerals/salts. Geological survey of India reveals that Fluorite, Topaz, Appetite, Rock phosphate and phosphatic nodule, Phosphorites are widely spread which contains high percentage of fluoride, and leaches out which contaminates water and soil. The intake of fluoride from water ranges from 2.2 to 7.3 mg (0.5 to 0.32 mg/kg body weight). Fluoride contents in different food items has been studied in details by various investigators (Nanda and Kapoor, 1971; Sengupta and Pa, 1971; Lakdawala and Puneekar, 1973; Nanda, 1972).

High alkalinity low calcium content in drinking water and diet deficit in vitamins and mienrals are the main cause of fluorosis afflictions. Incidence of tooth depay is reduced when fluoride concentration in the water ranges from 0.7-1.5 mg/L (Goohart and Shils, Culp and Culp, 1974), air temperature also affects this fluoride contents of the water (USPHSDWS, 1962).

Drug containing fluoride: Sodium fluoride is known to cause skeletal fluorosis, used in the treatment for Osteoporosis. Ottosclerosis and Dental Caries, Uninterrupted and prolonged use of fluoride contamination can lead to histologically pronounced signs of skeletal fluorosis (Baud *et al.*, 1982).

Industrial fluorosis: Industries that use fluoride are aluminium, steel, enamel, pottery, glass, brick, phosphate fertilizer, welding, Refrigeration, Rust removal, Oil refinery, Plastic, Pharmaceutical, Tooth-paste, Chemical and Automobile etc., which uses fluoride as raw material in the manufacturing process of fluoride arises as a by product or end product.

Fluoride – laden wastewater is discharged into the environment by pesticide, disinfectant, wood preservation, metal, and glass manufacturers (Wu, 1978). The greatest amount of fluoride discharge into the environment occurs during the mining of phosphate rock when silicon tetrafluoride is freed and released is freed and released or leached into nearby waters (Staeble, 1974; Marier, 1963; Lundbergs, 1975).

TREATMENT TECHNIQUES

Best water supply is one which needs no treatment at all. The trouble with treatment is that needs looking after. If the treatment process, however simple it may be, does not receive adequate attention, it will not function properly. Inadequate attention may, in fact, lead to a positive danger to public health. Treatment largely consists of preparing good water by removal of undesirable substance by various processes. Control measures include supply of water with fluoride within permissible limit of 1.5 ppm either providing alternative soruces free from fluoride or treating fluoride contaminated water with the help of treatment process, such as Nalgonda technique or activated alumina process.

Over the past decade, much research has been carried out on fluoride removal from drinking water in the country, and several practical methods have been presented (Xu, 1984): activated aluminin adsorption, bone chart adsorption, chemical precipitation, electrocoagulation and electrodialysis. Defluoridation methods can be divided into 2 broad categories, namely (i) techniques based on the addition of chemicals, and (ii) those based on ion-exchange or adsorption principles (Benefield *et al.*, 1982; Schoemann and Botha, 1985).

Treatment techniques which have proven effective or have reported potential for fluoride reduction are coagulation/flocculation ion-exchange, reverse osmosis, and reversible sorption onto activated alumina (Bellen *et al.*). The removal technique which has proven to be most effective is ion-exchange using activated alumina (Sorg, 1978). Activated alumina treatment is a sorption process with ion-exchange as the primary driving forces.

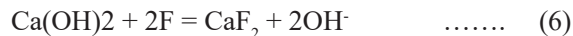
With activated alumina

High selectivity of alumina for fluoride ions over other anions in water, results high defluoridation capacity of

alumina. Defluoridation takes place via adsorption process following the Langmuir isotherm (Wu and Nitya, 1978a and 1979b). Defluoridation by alumina is influenced by the hardness of water, the presence of silicon and boron compounds and the pH of the water. Cl and SO₄ do not affect the defluoridation capacity of alumina. The pH of the solution should preferably be between 5 and 6 (Schoemann and Macleod, 1987; Choi and Chen, 1979; Wu, 1978; Mazounie and Mauchet, 1984), because at pH >7 silicate and hydroxyl ions become stronger competitors than fluoride ions. The following steps can be identified in the process of defluoridation by activated alumina:

1. Acidifying: Alumina. H₂O + H₂SO₄ = Alumina. H₂SO₄ + H₂O
2. Ion exchange: Alumina.H₂SO₄ + 2F⁻ = Alumina. H₂F₂SO₄²⁻
3. Regeneration: Alumina.H₂F₂ + 3NaOH = Alumina.NaOH + 2 NaF + 2H₂O
4. Neutralisation : 2Alumina.NaOH + 3H₂SO₄ = Alumina.H₂SO₄ + Na₄SO₄ + 2H₂O

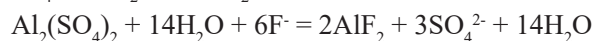
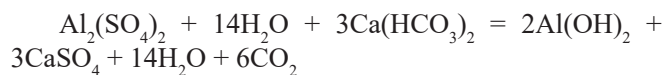
With lime: Addition of lime to the water containing fluoride results in the precipitation of insoluble calcium fluoride according to the following reaction:



To ensure proper fluoride removal, lime treatment should be used in conjugation with other processes, for example coagulation with other processes, for example coagulation with alum.

With alum : Chemical precipitation of fluoride by the use of multivalent metal ions has been investigated by many researchers studied the use of filter alum for reduction of fluorides from drinking water but the method was not popularized because the requirement of alum dose was high Nawlakhe (1974).

Defluoridation is very much effective if alum is used with lime in a two step process. The first step is precipitation cause by dosing with lime; while second step is coagulation due to the addition of alum; which can be expressed by the following reactions :



The best defluoridation is accomplished at pH between 5.5 and 7.5. All the 4 methods of defluoridation depends upon the pH of solution, therefore, utmost care must be taken in controlling the pH of solution.

CONCLUSION

The fluoride removal mechanism is a typical chemisorption which is different from the one used for activated alumina. Adsorption rate was considerable faster at the beginning of the adsorption process, followed by a much slower porous diffusion process. The adsorption was much more suitable for treating high temperature geothermal water with high fluoride content. It also had the advantage of reducing turbidity, decolourizing, and removing iron from drinking water.

The effect of temperature on the adsorbent performance showed that the mechanism of the fluoride removal of the new activated adsorbent is typical chemisorption, which is different from that for activated alumina alone. When influent contact the adsorbent in a slightly acidic medium, complex reaction takes place between a part of the activated alumina bonded to the surface of silica gel and fluoride ions in the influent. The fluoraluminates produced (ratio of every species with the fluoride content and pH of influent) will bead-sorbed by unreacted activated alumina and fluorophillic silica gel (Pitter, 1985). The reactions are quite fast but they need a high activation energy to drive the chemisorption. Therefore, the adsorption proceeds much better at elevated temperature. The process of adsorption after reaction, especially the process of diffusion of fluoride ions into micropores of the adsorbent; is rather slow consequently, it becomes the rate controlling stop of the whole adsorption process.

It appears that the single most important factor affecting the fluoride is the alkalinity of the water. The optimum pH for fluoride removal was shown to be about 6, above pH 6 and below 4, fluoride removal starts to decrease.

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