

# Defluoridation of Water by Montmorillonite Minerals

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**Abstract-** Prolonged use of fluoride contamination in drinking water more than permissible limit of 1.5 ppm causes dental and skeletal fluorosis. Though a number of adsorbents for removal of fluoride eg. Brick red powder, active charcoal, bone charcoal, fine powders of agriculture solid wastes are available, montmorillonite minerals may be used as a low cost technology for defluoridation. Montmorillonite minerals give blue colour with benzidine solution and have a 2 : 1 or TOT structure i.e one octahedral sheet is sandwiched between two tetrahedral sheets. The residual negative charge is balanced by K<sup>+</sup>, Na<sup>+</sup>, Mg<sup>2+</sup> or Ca<sup>2+</sup> ions. Montmorillonite minerals having high cation exchange capacity and large surface area have been found effective for defluoridation. Percentage removal of fluoride increased with time. Defluoridation by montmorillonite minerals takes place partly by adsorption and ion exchange. Kinetic studies revealed that defluoridation followed first order reaction. Adsorption by montmorillonite minerals is spontaneous and endothermic in nature.

**Keywords-** Skeletal fluorosis, Montmorillonite, Defluoridation, Ion exchange, Adsorption.

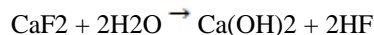
## I. INTRODUCTION

Fluoride contamination in ground water has become a common problem in many states of India in general and in some villages of Jagdishpur Anchal of Bhagalpur district in particular. Prolonged use of excess fluoride in drinking water causes dental and skeletal fluorosis<sup>1</sup>. Patients suffering from skeletal and dental fluorosis have been seen in Kola Khurd village of Jagdishpur Anchal which drew the attention of researchers. Fluoride contamination in ground water may be attributed to two factors:

Natural

Anthropogenic.

The natural factor is the presence of fluoride bearing minerals in the hills i.e. fluorapatite, fluor spar. These type of minerals come in contact with water and fluoride ion is released in water<sup>2-3</sup>.



At low pH HF is found in water. In addition to natural source, fluoride passes into water through insecticides, disinfectants and preservatives used in agriculture sector. Use of phosphatic fertilizers, manufacture of super phosphates and aluminium extraction processes are also responsible for entry of fluoride in ground water<sup>4-6</sup>.

Montmorillonite minerals are smectite group of minerals widely spread in different parts of the world e.g. France, Japan and U.S.A and in Rajasthan and Jharkhand in India. These montmorillonite minerals have good swelling power and high cation exchange capacity than the minerals of other part of India. Owing to these properties, montmorillonite minerals have various industrial uses e.g. capping of holes, bonding and plastigizing agents, softening of hard water and removal of heavy metals. Adsorption of heavy metals or fluorides takes place partly due to adsorption and partly due to ion exchange<sup>7-9</sup>. The structure of montmorillonite may be explained as TOT i.e. 2 : 1 or it can be said that one octahedral unit is sandwiched by two tetrahedral units. Negative charge remains in the lattice of montmorillonite unit as a result of substitution of divalent cation by trivalent cation and the negative charge of interlayer is neutralized by K<sup>+</sup>, Na<sup>+</sup>, Mg<sup>2+</sup> and Ca<sup>2+</sup>. As a result of these exchangeable ions, montmorillonite minerals have the capacity to remove fluoride ion also. Main constituents of montmorillonite minerals are SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>. Na<sub>2</sub>O, K<sub>2</sub>O, FeO, Fe<sub>2</sub>O<sub>3</sub>, MnO and traces of TiO are also present in this mineral. Removal of fluoride by montmorillonite minerals have gained superiority over removal by activated charcoal, bone charcoal and agriculture solid wastes because these can give odour and bad taste to the treated water<sup>10-11</sup>. Kinetic studies revealed the fact that adsorption follows first order kinetics and thermodynamic studies showed that process is endothermic in nature. Type of adsorption isotherms determines whether adsorption is mono

layer or multilayer % removal is determined by the formula given below – % removal =  $\frac{C_i - C_e}{C_i} \times 100$

## II. EXPERIMENTAL

Stock solution of 10 mg/L fluoride is prepared by dissolving 22.1 mg anhydrous NaF in one litre distilled water and 2 mg/L fluoride is prepared from dilution of the stock. 100 ml 2ppm NaF solution is treated with 1g, 2g and 3g

powder up to 1 hour and 1 g montmorillonite powder is treated with 100 ml 2 ppm NaF solution up to 1 hour, 2 hour and 3 hour. The residual concentration is measured by SPADNS dye method and Ion selective electrodes present in the laboratory. The results have been again confirmed by U.V double beam spectro photometer pharo 300. Montmorillonite minerals after collection is washed with deionized water, dried in oven at 100°C and then powdered to 300 mesh sieve.

III. RESULT AND DISCUSSION

Table 1 - shows the residual concentrations of F- after 1 hour, 2 hours and 3 hours.

Table 1 :Concentration of F – ion after treatment with 1 gm of montmorillonite.

| Sl.No. | Montmorillonite sample | Time   | Initial Concn of F – ion ( in ppm) | Residual Concentration | % removal |
|--------|------------------------|--------|------------------------------------|------------------------|-----------|
| 1      | RHB4                   | 1 hour | 2                                  | 1.4                    | 30 %      |
| 2      | RHB4                   | 2 hour | 2                                  | 1.2                    | 40 %      |
| 3      | RHB4                   | 3 hour | 2                                  | 1.0                    | 50 %      |

Table 2 - concentration of F – ion after treatment with differement masses of montmorillonite mineral up to 1 hour.

| Sl.No. | Montmorillonite sample | Mass | Initial Concn of F – ion ( in ppm) | Residual Concentration of F – ion ( in ppm) | % removal |
|--------|------------------------|------|------------------------------------|---|-----------|
| 1      | RHB4                   | 1 gm | 2                                  | 1.4   | 30 %      |
| 2      | RHB4                   | 2 gm | 2                                  | 1.6   | 20 %      |
| 3      | RHB4                   | 3 gm | 2                                  | 1.6   | 20 %      |

Table 3 - Values of qt and Ct

| Sl.No. | Montmorillonite sample | Ct  | qt   | $\frac{Ct}{qt}$ |
|--------|------------------------|-----|------|-----------------|
| 1      | RHB4                   | 1.4 | 0.06 | 23.33           |
| 2      | RHB4                   | 1.2 | 0.08 | 15              |
| 3      | RHB4                   | 1.0 | 0.1  | 10              |

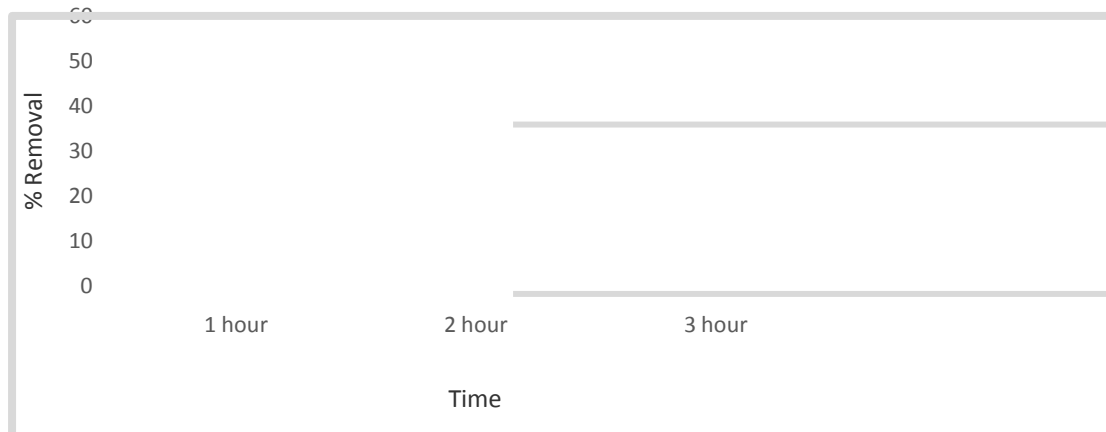


Figure 1 - % remoalof F – ion vs time

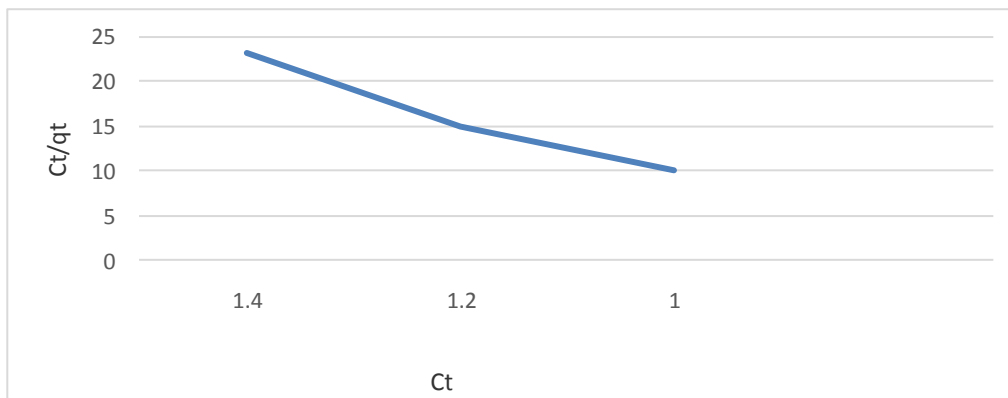


Figure 2 : Plot of  $\frac{C_t}{q_t}$  Vs  $C_t$

Table 1 clearly shows that maximum percentage of removal of fluoride is 50 % when 1 gm montmorillonite sample is treated with 2 ppm F – solution up to 3 hours. When 3 gm montmorillonite sample is added to 100 ml 2 ppm solution up to 1 hour the removal percentage decreases to 20 % i.e release of F –ions takes place with increase dose. Rate of adsorption studied for fluoride removed increases linearly it is crystal clear that removal of F – needs 3 hours from 1 gm montmorillonite sample.  $q_t$  is given as –

$$q_t = \frac{C_i - C_t}{m} \times V$$

Where,

$C_i$  = initial concentration

$C_t$  = Concentration at any time  $t$

$V$  = Volume of solution in litre

$m$  = Mass of montmorillonite mineral

A plot of  $\frac{C_t}{q_t}$  vs  $C_t$  shows that Langmuir adsorption isotherm is being followed monolayer adsorption is taking place.

#### IV. CONCLUSION

Experimental results reveal that maximum removal of fluoride is up to 50 % and important observation is that adsorption is monolayer and first order kinetics is followed. Preferred model of isotherm is Langmuir isotherm.

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