6.0 SUMMARY AND SUGGESTIONS

6.1 SUMMARY OF SORPTION REACTION

The present study involved investigation of Bauxite, Cerium hydrate, Lanthanum oxide and gamma Alumina for removal of fluoride from water by adsorption process. The results reveal high sorptive capacity of Lanthanum oxide, Cerium hydrate and gamma Alumina and hence their usefulness as sorbents for removal of fluoride from water. Acid treatment of Bauxite enhanced its sorption capacity significantly from 15% to 86% and hence acid treated Bauxite is also equally useful as a sorbent.

Agitated, non-flow batch adsorption experiments indicate that adsorption is almost instantaneous accomplishing almost 80-90% within 10-15 minutes. The rate of adsorption then reduces gradually and approaches equilibrium. Near total removal i.e., 97-100% is achieved in an equilibrium time of 1-2 hours by all the sorbents.

Equilibrium isothermal sorption experiment suggested sorbent dosages of 15gL⁻¹, 4gL⁻¹, 10gL⁻¹ and 20gL⁻¹ for Treated Bauxite, Cerium hydrate, Lanthanum oxide and gamma Alumina respectively accomplishing a removal of 97%, 100%, 99% and 98% in the same order. Experiments conducted by varying sorbate concentration in the range of 2.0 mgL⁻¹ to 20 mgL⁻¹ and isothermal equilibrium adsorption data indicated adsorption to be multilayer sorption. With isothermal adsorption data fitting well into the BET model further denoting multilayer adsorption. Sorption curves suggest a strong interaction between the sorbate and sorbent. Desorption and Regeneration studies further support adsorption to be of the type chemisorption with strong interactions between the sorbent and sorbate molecules.
Concentration and time dependence of equilibrium adsorption data denote pore diffusion as the rate limiting though the sorbate molecules experience some resistance due to diffusion through the surface film overcoming boundary layer resistance. The pH sorption edges typically denote anionic sorption with almost total removal at acidic pH values and up to pH 9.5 and as the pH was increased beyond, removal reduced drastically to around 40-50%, the change occurring within 1.5 pH units. It may therefore be inferred that adsorption process based on these sorbents would have practical utility as the pH of the fluoride bearing ground waters will be seldom higher than pH 9.50.

Presence of cations in water have negligible influence (sorptive capacity reduced by 2-5%) while presence of anions exerted considerable influence especially beyond a certain concentration. Sulphates, carbonates and bicarbonates at concentrations equal to or greater than 150 mgL⁻¹, 300 mgL⁻¹ and 50 mgL⁻¹ reduced removals by 70 to 85%. This may perhaps be due to competition for sorption or preferential sorption.

Adsorption studies were conducted with tap water (ground water) spiked with fluoride and results indicate an overall reduction in sorption capacities of up to 30% due to presence of a variety of anions and cations.

Upflow fixed-bed continuous flow column studies conducted with three sorbents employing three different sorbent dosages (column bed depths) at three different flow rates indicated applicability of the sorbents in continuous flow process. Breakthrough curves for all the sorbents yielded typical 'S' shaped curves and there was a gradual shift in service time and breakthrough time. Bohart-Adams model was used to design the columns at different flow rates. The calculated values of 'No' (adsorptive capacity) and 'K' (reaction rate constant) of the above model are found to decrease and increase respectively, with increase in flow rate from 20mL/min to 30mL/min.
To elucidate sorbent-sorbate interactions, virgin (original, unloaded, before sorption) and sorbed (loaded, after sorption) sorbents were subjected to Infrared spectral and X-Ray Diffraction analysis. Infrared spectral studies indicate participation of surface functional groups like carboxyl, phenolic and hydroxide in the sorption reaction leading to a sort of chemical bonding and chemisorption. However, X-Ray Diffraction analysis indicate shift and variation in ‘D’ and ‘Imax’ values suggesting structural and/or chemical changes. However, these aspects need further detailed investigation.

6.2 SUGGESTIONS FOR FURTHER WORK

Present study revealed high potential of materials like Treated Bauxite, Lanthanum oxide, Cerium hydrate and gamma Alumina for sorptive removal of fluoride from synthetic test fluoride solution and also indicated their potential for use in field applications. However, further detailed studies are needed in order to develop a technology for field application especially in rural and small communities.

1. Since all the sorbents are fine powders, their use in adsorber columns give rise to several problems like non-uniform flow, formation of lumps/balls, piping in the bed and at the walls (periphery), escape of sorbent material along with the flow. Pelletisation or granulation may overcome such problems and hence further studies in this direction would improve their field application.

2. Investigations on candle type or capsule modules by filling the powder sorbents for domestic and community application would improve their practical applications.

3. Development of simple, do-it-yourself regeneration and recycling/scrapping methodologies would improve the economic feasibility.

4. Detailed instrumental analyses like EDAX, Elemental Analysis, XRF, SEM, etc., would provide more and conclusive information regarding fluoride sorbent interactions.