CHAPTER 1

INTRODUCTION

1.0 GENERAL

Water is an essential natural resource for sustaining life. Endurance of life on the earth only is conceivable because of water. Near about 97% of earth’s surface is covered by water. It is very essential source for maintaining the life. There is a large amount of water present on the earth and the whole amount of water reserves is divided into two parts, marine water which covers the 97.4% of total water reserves and fresh water which covers only 2.6%. Over the past few decades, the ever-growing population, urbanization, industrialization and unskilled utilization of water resources have led to degradation of water quality and reduction in per capita availability in various developing countries. Due to various ecological factors either natural or anthropogenic, the groundwater is getting polluted because of deep percolation from intensively cultivated fields, disposal of hazardous wastes from industry, liquid and solid wastes from industries, sewage disposal, surface impoundments etc. (Kass et al., 2005; Amina et al., 2004; Oren et al., 2004; Anwar, 2003). Presence of various hazardous contaminants like fluoride, arsenic, nitrate, sulfate, other heavy metals etc. in underground water has been reported from different parts of India (Liu et al., 2003; Charles et al., 2005; Muhammad et al., 2004; Mulligan et al., 2001). Fluoride belongs to halogen family, the most electronegative element which is the ionic form of fluorine and does not occur in the elemental state in nature because of its high reactivity. In the elemental form, fluorine is a flammable, irritating, and is the most powerful oxidizing agent. Fluoride occurs in two forms in nature viz inorganic fluoride and organic fluoride. There are number of sources from where fluoride is generally generated and added to the environment. The sources of fluoride are characterized into two categories; natural sources which includes the fluorine already present in nature and distributed in Earth’s crust, mainly as the minerals fluorspar, fluorapatite and cryolite (Mamilwar et al., 2012), and anthropogenic sources which includes industrial activities. Further, a number of industrial processes such as coal combustion, steel production, and other manufacturing processes (aluminum, copper and nickel production, phosphate ore processing, phosphate fertilizer production, glass, brick and ceramic manufacturing) etc. also contribute to increase fluoride levels in water.
Generally fluoride found in groundwater is naturally occurring from the breakdown of rocks, soils or weathering and deposition of atmospheric volcanic particles. Fluoride uptake of up to 1 mg/l has beneficial effects on to the plants, animals and human beings. In humans, fluoride exhibits the bone formation, remineralization and protection from demineralization of teeth. Fluoride is extremely effective in protecting cavities and making teeth stronger. Excessive fluoride intake over a long duration of time may result in a serious health problem called fluorosis. The starting phase is known to be dental fluorosis result in dental deformities with the development of yellow colour affecting children in the age of 6-8 years. The next phase is skeletal fluorosis which brings the fluoride deposition in skeletal muscles found in children as well as adults. The most alarming stage of fluorosis is the crippling fluorosis which can have life threatening effects. Different governmental as well as non-governmental associations, such as US EPA, WHO, CPCB, etc, sets the highest permissible limit of fluoride in forms of water. The WHO sets the limit of 1.5 mg/L for drinking water (Bennajah et al., 2010) The limit set by the CPCB for the different forms of water viz 2.0 mg/l for inland surface water.

**Problem Identification**

Due to the detrimental and injurious effects of excess fluoride, there is an urgent prerequisite of methods for its removal from drinking as well as from industry waste water. The methods used for fluoride removal are distillation, membrane separation processes, precipitation, ion exchange and adsorption. The adsorption method complies with the use of physical or the biological adsorbents. Most commonly used adsorbent for treatment is activated carbon.

Further, agro based adsorbents are getting more consideration now a days due to their abundant availability and low cost. Some literatures are available on the removal of fluoride from water using various agro based adsorbents like *Phyllanthus emblica* (Veeraputhiran and Alagumuthu, 2011), *Citrus limonum* (lemon) leaf (Tomar et al., 2014), rice husk ash (Mondal et al., 2012), neem leaf, peepal leaf, khair leaf (Jamode et al., 2004), tamarind fruit shell (Sivasankar et al., 2010) etc. In most of these literatures the concentration of fluoride is in between (1.5-15 mg/l). However, industrial waste water normally contains higher fluoride concentration (Pollution Prevention and Abatement Handbook Phosphate fertilizer plant, World Bank Group.1998) and there is very little literature on the removal of fluoride from water containing fluoride at higher concentration i.e. 20 mg/l. From the literature survey some other facts have been revealed on fluoride removal:

1. Most of the reported results are based on batch scale laboratory experiments
2. There is very little literature on the removal of fluoride from water containing fluoride at higher concentration.
3. Very little work has been found on bacteria which possess the fluoride removal capacity.
4. No modeling of the bio removal process has been reported.
5. Least attempt has been made on continuous study on immobilized natural bioadsorbent in packed bed bioreactor for fluoride removal.
Biotechnology serves as an important tool for the treatment of waste water which involves the development of bioreactors containing biofilms of suitable organisms or use of immobilized microbes. For making adsorption process more feasible and cost effective, there is urgent need of low cost adsorbents with higher adsorption capacities. Therefore, it is required to study the aspects of simultaneous adsorption and bioaccumulation (SABA) of fluoride on immobilized natural bioadsorbents. Hence, the scopes lie with the exploration in the above fields for better understanding of bio-removal and for improved fluoride removal efficiency.

1.2 Objectives

Based on the extensive literature review, objectives for the present study have been formulated as below:

1. Identification of some natural bioadsorbents based on literature and their screening on the basis of experiment.
2. Characterization of the selected (initially screened) bioadsorbents.
3. Adsorption study using selected bioadsorbents in batch reactor to find out optimum process parameters and adsorption capacities as well as to select the most suitable bioadsorbent.
4. Column study using most suitable bioadsorbent.
5. Identification/selection of microorganisms responsible for fluoride removal based on literature.
6. To enhance the resistivity of microorganism towards fluoride.
7. Fluoride removal in batch reactor in bulk phase and in immobilized phase (SABA reactor) for finding out the optimum process conditions and to study the fluoride removal capacities of these processes.
8. Continuous column study using most suitable bioadsorbent and immobilized with the microbes.
9. Comparison of adsorption and SABA process.

1.3 ORGANIZATION OF THESIS

Thesis has been divided into the following chapters:

Introduction, Literature Review, Experimental Set-up, Instrumentation and modeling, Experimental Programme and Data acquisition, Results and Discussion and Conclusion. The organization of the thesis is as follows:

1. **Chapter 1**: Introduces the reader with the sources, effects, toxicity, treatment methods of fluoride, justification of the study and objectives of the present work
2. **Chapter 2**: Comprises overview of the work done by various researchers in fluoride removal by adsorption, bioaccumulation and SABA.
3. **Chapter 3:** Describes Experimental set-up, Instrumentation and Modeling
4. **Chapter 4:** Describes Experimental Programme and Data acquisition
5. **Chapter 5:** Describes Results and Discussion
6. **Chapter 5:** Describes Conclusions based on the results obtained and also describes the Recommendations for future work
7. Publication, Reference and Appendixes are placed at the end