CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1. Research background

Fluorosis has attained an alarming dimension all over the world. "Fluorosis is a slow, progressive, crippling malady, which affects every organ, tissue and cell in the body" (Gopalakrishnan *et al.,* 2012). The Threat of fluorosis has consumed many countries viz: Algeria, Argentina, Australia, China, Egypt, India, Iran, Iraq, Japan, Jordan, Kenya, Libya, Morocco, New Zealand, Pakistan, South Africa, Syria, Tanzania, Thailand, Turkey and USA (WHO, 2006). Conservative estimates by Ayoob and Gupta (2006) uncovered that the population of nearly 200 million from nearly 35 countries were at risk of different forms of "fluorosis". In India, 20 of 32 states are endemic to fluoride (Ayoob and Gupta, 2006) making fluorosis a serious health hazard issue. A few years back Susheela (2001) advised that approximately 62 million people in India suffer from dental, skeletal and non-skeletal fluorosis of which 6 million are children under the age of 14 years.

High prevalence of endemic fluorosis in India is due to the fact that larger portion of the country's water supplies contains a high level of fluoride than the prescribed maximum desirable limits of 1.5 mg/l by BIS (1991) and WHO (1984). About 94% of drinking water needs are sufficed by groundwater (Singh *et al.,* 2011). The fluoride content in this major drinking water source varies between 0 - 86 mg/l in India (Brindha and Elango, 2011). As per WHO report, 20% of the fluoride affected villages in the whole world is in India. After efforts taken by the government to measure the fluoride concentration, collated data released by the Ministry of Drinking Water and Sanitation (MDWS) reveals that drinking water in 14,132 habitations in 19 States still containing fluoride above the permissible levels (The Hindu, 2014). According to the same report, Gujarat ranks 5^{th} among the 19 states in high fluoride content in groundwater. Data available from the ministry of water resources, concerning ground water quality scenario, reveals that 18 of Gujarat's 26 districts (DNA, 2012) i.e. nearly 70% of the districts have fluoride content above the permissible limit. The districts severely affected by fluoride contamination are Mehsana, Patan, and Sabarkantha. In Mehsana district, where relentlessly groundwaters are mining, a comprehensive epidemiological survey revealed that 236 villages out of 559 villages surveyed were reported for the prevalence of fluorosis (WHO, 2006).

Besides drinking water, dietary intake of fluoride through agricultural products grown in fluoride-enriched environments has recently been viewed as an important cause of fluoride-related health problems in many parts of the world (Fung *et al.,* 1999; Jin *et al.,* 2000; Rai *et al.,* 2000; Chandrajith *et al.,* 2007; Yadav *et al.,* 2007; Messaïtfa, 2008; Yi and Cao, 2008; Jha *et al.,* 2009). In some areas where fluorosis is endemic, fluoride ingestion through food constitutes a significant portion of the total daily intake (Kumari *et al.,* 1995; Malde *et al.,* 2011). The continuous use of irrigation water wearing high concentrations of fluoride may lead to its accumulation beyond the critical limits and affect the quality of crops (Specht and MacIntire, 1961). Also, most of the applied fluoride is unable to leach down even after a considerable period (Specht and MacIntire, 1961; Tracy *et al.,* 1984; Peek and Volk, 1985; Robbins, 1986). This fluoride is clutched in the soil surface and contributes significantly to soil fluoride and indirectly to the fluoride concentration in the crop grown over such contaminated soil. Several previous studies conclude that the usage of the fluorinated water for food processing significantly elevates the amount of daily fluoride intake through food (Liu *et al.,* 1995; Fung *et al.,* 1999; Viswanathan *et al.,* 2010).

Fluoride is an essential oligo-element, beneficial for growth, reduction of bone fractures and promoting dental and skeletal development, particularly among children (Messaitfa, 2008; Ozsvath, 2009). However excess fluoride intake can mainly cause fluorosis along with symptoms overlapping with many other disease manifestations. Various study concludes that fluoride interferes basic metabolism of the body (Islam and Patel, 2011), DNA replication (Zhou *et al.,* 2004) and activity of brain (Sinha, 1997). High fluoride can cause arthritis, osteoporosis, brittle bones, cancer, infertility, brain damage, Alzheimer syndrome, kidney poisoning and thyroid disorder (Chinoy, 1991; Sinha, 1997; Fan *et al.,* 2003; Harrison, 2005).

Hence, keeping in mind the toxic effects of fluoride on human health took either through drinking water or through food it is necessary to quantitatively estimate fluoride concentration in groundwater as well as vegetation including the grain crops and vegetables. In addition to this, there was an urgent need to find out an effective and robust technology for the removal of excess fluoride from groundwater. To solve this issue extensive works are being carried out by many workers. The major techniques currently available for defluorination involves: coagulation and precipitation (Saha, 1993; Reardon `and Wang, 2000; Turner *et al.,* 2005; Ayoob *et al.,* 2008; El-Gohary *et al.,* 2010; Gong *et al.,* 2012), membrane processes(Simons, 1993; Karabelas *et al.,* 2001; Ndiaye *et al.,* 2005; Hu and Dickson, 2006; Ayoob *et al.,* 2008; Sehn, 2008; Ghosh *et al.,* 2013; Chakrabortty *et al.,* 2013), electrochemical treatments (Shen *et al.,* 2003; Tahaikt *et al.,* 2006; Fawell *et al.,* 2006; Zuo *et al.,* 2008; Arar *et al.,* 2009; Cui *et al.,* 2012), ion-exchange and its modification (Apambire *et al.,* 1997; Singh *et al.,* 1999; Kodama *et al.,* 2001; Liu *et al.,* 2002; Chubar *et al.,* 2005; Meenakshi and Viswanathan 2007) and adsorption onto various adsorbents (Raichur and Basu 2001; Mohapatra *et al.*, 2004; Maliyekkal *et al.,* 2006; Onyango *et al.,* 2006; Tripathy *et al.*, 2006;). Among all these techniques, adsorption methods have more advantages because it is comparatively cheap, easy approachable, low maintenance and highly effective in removing fluoride from water to the maximum extent (Chauhan *et al.,* 2007; Ayoob and Gupta, 2008; Mohan *et al.,* 2007).

1.2. Statement of Problem

Fluoride is a toxic element found in every compartment of the environment. High concentration of fluoride has become a menace to solve. Naturally occurring fluoride is a common geogenic problem, but anthropogenic activities have catalyzed the dissolution of fluoride in groundwater and thus increased its concentration in nature. High concentration of fluoride has far reaching consequences including its ingestion through drinking water and food chain, which are in the form of health hazard. Extensive studies had been undertaken documenting groundwater as well as vegetation fluoride in India and techniques of defluorination. But limited works are entitled to the Gujarat specifically to North Gujarat. Many government organization like WASMO as well as NGO are working in North-Gujarat, in collaboration with the local community, to reduce fluoride ingression. Mehsana district is one of the mega water depletion zones. Already water is scarce and whatever quantity available is fluoride contaminated.

Therefore, a more systematic and detailed study is needed to assess the magnitude of groundwater contamination. Following the pieces of evidence of fluoride exposure, directly from drinking water and indirectly from irrigation water, remediation of this problem needs the development of the technology with improved materials and systems with high efficiency.

"Present work is delimited to Kheralu Taluka of Mehsana District situated at the South-west end of Aravalli range in North Gujarat".

1.3. Goals of study

First and Foremost goal was to systematically document the magnitude of fluoride contamination in groundwater and health hazards caused due to fluorosis. Thereby building links between fluoride concentration in drinking water and its impact on the community. Thereafter assessment of fluoride concentration in bore-well irrigated field soil and crops/grains will be done for evaluating an impact of secondary sources of fluoride in form of food. Thus by laying out baseline measurements for fluoride encroachment in the society health, this research creates the platform for the future framework for integrating regular health surveys into a fluoride removal program.

The Second goal was to study and develop an optimized model for defluoridation of groundwater of area under study. Previous efforts for implementing sorption and precipitation techniques to treat groundwater fluoride in rural India have eventually failed; also chemically treated plant based biosorbent cannot be utilized for defluorinating drinking water for common people, thus primary target for the present work was to focus on development of biosorbent from seeds of *T. indica* in an untreated manner which is viable, cost-effective and easy to use manner for scalable to communities of any size without modifying any of the parameters.

1.4. Objectives

The Objectives of the present study are as follows:

- Mapping Fluoride in the ground water samples of villages of entire Kheralu Taluka in Mehsana District of Gujarat and selection of most affected villages from the surveyed area.

- Survey of percentage population affected due to high Fluoride concentration in groundwater in the villages of the Kheralu Taluka.

- Determination of Fluoride content in the agricultural soils of the fields from selected villages under study.

- Bioaccumulation of Fluoride in the grains of major crops of the area.

- *In vitro* optimization of *Tamarindus indica* seeds in terms of agitation speed, pH, dose, particle size and agitation time.

- Analysis of groundwater samples of all the affected villages for all the potable water parameters (including Ca^{+2}, Mg^{+2} and Na^{+} ions and other contaminants) with special reference to Fluoride before treatment with *T. indica* seed powder and Application of optimized seed powder to ground water samples of the study villages thereby evaluating the efficiency of the seed powder for fluoride removal followed by post treatment analysis of the Ground water samples (After treating with *T. indica* seeds).

- Recommendation for the use of defluorinated water for different purposes.