1. Introduction

1.1 Background information and research significance

Arsenic (As) has been considered as a target contaminant because of its potential health and regulatory concerns. Due to the carcinogenic effects arsenic contamination of drinking water is a major health concern. Now a days, drinking water is recognized as the major source of arsenic in its most toxic form. However, recent studies indicate additional contamination of the food chain due to irrigation with arsenic contaminated groundwater (Roychowdhury et al. 2002, Chakraborti et al. 2004, Haris et al. 2005). Considering the negative health effects on human, WHO (1993) lowered the guideline value for As in drinking water from 50 μg/L to 10 μg/L. Many countries promulgated 10 μg/L as the maximum contamination level (MCL) in drinking water (US EPA 2000). However, India and Bangladesh still adopt 50 μg/L as the MCL for arsenic in drinking water. Reported incidences of health effects due to exposure to elevated arsenic concentrations from drinking water are available from many countries throughout the world. One of the well documented exposures to arsenic through groundwater is from Taiwan, where people suffered from characteristics symptoms of arsenicosis referred as Black foot disease as a result of drinking arsenic contaminated water for many years. But of these, the most severe outbreaks of arsenic poisoning have been reported from the Bengal Delta including Bangladesh and West Bengal (Eastern India) where millions of people are at risk (Bhattacharjee et al. 1997, Chowdhury et al., 2000). Arsenic contamination in the affected districts of the Bengal Delta is potentially the greatest environmental calamity ever reported (Guha et al. 1998, Karim 2000). Extensive arsenic pollution in groundwater in the Bengal Basin affects both eastern parts of the West Bengal, India and major parts of the Bangladesh (Mandal et al. 1996, Bhattacharya et al. 1997, Dhar et al. 1997, Nickson et al. 1998, Nordstorm et al. 2000). The affected aquifers in the Bengal Basin can be correlated with the Ganga- Brahmaputra holocene stratigraphy and delta sedimentation (Acharyya et al. 2000). Occurrence of arsenic in groundwater, in excess to the permissible limit of 50 μg/L (Indian guideline) in the Ganges-Brahmaputra fluvial plains in India is considered as the world’s biggest natural

Arsenic in groundwater has been reported, mostly in areas formed by recent alluvial sediments, describing Holocene aquifers (<12 thousand years of age) of the Ganga-Brahmaputra fluvial plains (Singh et al. 1996, Chakraborti et al. 2004, Nickson et al. 2007). Almost all the identified arsenic affected areas in Assam and Manipur are in the flood plains of the Brahmaputra and Barak, respectively (Singh et al. 2004, Chakraborti et al. 2004). The Brahmaputra alluvial basin is bounded by lower Himalayan mountains in the north and northeast. High intensity of rainfall in the catchments and plain areas has contributed to high sediment loads, which have developed the valley into a long stretch of recent and old alluvium. Majuli island of the Brahmaputra river in Assam, India, comprises both older and younger alluvium as well as active flood plain deposits of recent age. The stratigraphy of the Majuli island is similar to the stratigraphy of the Brahmaputra Valley on the southern bank of the Brahmaputra as it comprises both older alluvium and newer alluvium at many places. Ironically, all the rivers in the Ganga-Meghna-Brahmaputra (GMB) flood plains that originated from the Himalayas are expected to be arsenic contaminated (Chakraborti et al. 2004). Keeping in mind these aspects a study has been carried out in the Majuli island to know the groundwater arsenic contamination status of this riverine island. The potential source of arsenic in the groundwater requires an understanding of the sediments. Therefore, it is felt necessary to study the borehole sediment samples of the island to find out the chemistry involved in leaching out of arsenic and the mode of occurrence and origin.

Arsenic is a tasteless, odourless and colourless element. The detection of the element is only possible through chemical analysis. Similarly, exposure to low levels of arsenic can not be detected visually since it takes more than 10 years for the common symptoms to develop. The most important biomarkers commonly used to identify or quantify arsenic exposure are total arsenic in hair or nails, and total or speciated metabolites of arsenic in urine. The elimination of arsenic via urine, its concentration in hair and nail acts as reliable indicators of internal exposure. Therefore, the most direct way of determining recent arsenic exposure is measuring its content in urine. However, the chronic arsenic exposure can be detected by measuring its concentration in hair and
nails. Because arsenic has affinity for sulfhydryl groups and it accumulates in hair and nails comprising of high content of keratin (Shapiro 1976, ASTDR 1993, Mushak et al. 1995, Hakala et al. 1995, Kurttio et al. 1998). Additionally, it can give valuable information about the metabolism of arsenic species within the body. Thus, it is essential to quantify arsenic in the biological samples (urine, hair, and nail) to assess health risks associated with arsenic exposure.

The acute toxicity of arsenic poisoning can lead to rapid death, while chronic toxicity symptoms tend to appear only after several years of exposure (Smith et al. 2002). The most commonly observed symptoms of chronic arsenic poisoning are arsenical skin lesions (e.g. melanosis, keratosis), blackfoot disease, and in more severe cases, incidents of gangrene, skin cancer, and lung cancers and fetal death (Astolfi et al. 1981, Smith et al. 1992, Das et al. 1995, Karim 2000). The health effects of arsenic is a function of time of exposure and the most effective way to overcome the adverse health effects of arsenic is prevention of further exposure by providing safe drinking water. There is no effective treatment for arsenic toxicity. Due to the negative health effects of drinking arsenic contaminated water, more stringent standards have been introduced for arsenic. Therefore, the treatment of arsenic from drinking water has attracted growing interest. A lot of research has been carried out with the specific aim of developing cost-effective technology for the removal arsenic from water. Numerous investigations have examined the removal of arsenic from potable water through treatment processes such as precipitation-coagulation, reverse osmosis and ion exchange. The focus of research has now shifted to solve the problem using suitable sorbents to achieve low level of arsenic in drinking water for communities. Adsorption has emerged as one of the most practical methods because it can easily be used in small scale systems. Many researchers are looking into using iron oxides to remove arsenic from drinking water through adsorption by batch and column systems. Using iron oxides of nanosize creates an advantage over bulk iron oxides because of the increased surface area, which allows more sorption sites for removal. The mechanism for sorption of arsenic to nanoscale iron oxides can be understood by adsorption isotherms, surface complexation models, and spectroscopic studies.
1.2 Statement of the problem

Arsenic is a toxic metalloid found in the atmosphere, soils, rocks and water. It is mobilized in the environment due to both natural processes and anthropogenic activities. Naturally, arsenic is introduced into the groundwater through the dissolution of minerals and ores. Groundwater arsenic contamination has far reaching consequences including its ingestion through drinking water and food chain, which are in the form of health hazards. The acute toxicity of arsenic at high concentrations has been reported from many regions of the world including India. Long term exposure to arsenic even at low concentrations have adverse effects on human health. Extensive studies have been done on groundwater arsenic contamination throughout the world. However, limited studies have been carried out on groundwater arsenic contamination in North Eastern states of India. Many more places in North Eastern states are suspected to have possibility of arsenic in groundwater. Although groundwater has been monitored by the Public Health and Engineering Department (PHED), partly in collaboration with UNICEF, in Majuli, detailed finding are yet to be published. Therefore, a more systematic and detail study is needed to asses the magnitude of groundwater contamination in the world’s largest populated river island.

Following the evidences of arsenic exposure through drinking water, remediation of this problem needs the development of the technology with improved materials and systems with high efficiency. Numerous studies have been carried out with the specific aim of developing a cost-effective eco-friendly technology for the removal arsenic from water. Many researchers have looked into the adsorption of arsenic onto iron oxides due to the strong affinity of arsenic to iron oxides. Though in recent times, some attempts were made to study the efficiency of arsenic removal from drinking water using nanoparticles, for the most part these methods are effective in removing arsenic from the drinking water, but some can be expensive due to separation techniques, or produce significant amounts of waste. However, arsenic removal methods so far used requires preoxidation of As(III) to As (V) and pH adjustment to enhance the removal efficiency. However, the reported studies have limitations in terms of high adsorbent doses, high contact time period and absolute removal efficiency. These disadvantages are what continue to make developing a new improved method for arsenic removal from
contaminated water. In the present research, an attempt has been made to develop a novel technology for removal of arsenic from drinking water.

1.3 Research objectives

1. To assess the groundwater arsenic contamination status of Majuli island of Assam by analyzing the hand tubewell water samples.

2. To analyze the groundwater samples for iron and other heavy metals and to find out their correlation with arsenic.

3. To explore and identify the possible sources of arsenic contamination of the study area by analyzing the borehole sediment samples.

4. To analyze arsenic and other heavy metals in the borehole sediment samples and to find out the correlation of arsenic with other heavy metals.

5. To measure the total arsenic concentration in biological samples (hair, nail and urine) of arsenic exposed population of different age group.

6. To develop a surface functionalized ultrafine iron oxide nanoparticles and its application for removal of arsenic from artificially prepared model water and natural groundwater.

7. Separation of spent and excess adsorbents from treated water.

8. To find out probable arsenic mitigation option in the arsenic affected areas of Majuli.