Abstract

Water, water, everywhere,
Nor any drop to drink
Samuel Taylor Coleridge

Water is a vital resource for the human society. Rapidly shrinking surface water resources due to over-exploitation and resulted contamination with several chemical and biological agents all over the globe has shifted tremendous pressure on the groundwater resources. Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. Ground water is assumed to be of higher quality unlike surface water sources as it remains unexposed but with the increase in domestic sewage and agricultural and other industrial wastes the natural sources are getting contaminated every now and then. The chronic impact of these chemical contaminants of drinking water is dreadful. Evaluation of water quality is a meaningful topic today. Quality water is vital to the social health and economic well-being of the prairies and its people. Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes and oceans. Thus every effort should be made to achieve drinking water quality as safe as practicable.

The present study has been carried out on “QUALITY OF DRINKING WATER IN KAMRUP DISTRICT, ASSAM, INDIA AND DEFLUORIDATION OF WATER USING BIOADSORBENTS”. The thesis has been divided into six chapters.

Chapter 1: The first chapter begins with an introduction to the subject of investigation, a brief definition, various aspects of water contamination, a review on existing literature on environmental water quality, significance of the study and most importantly the aims and objectives of the study.

The following objectives have been formulated for the present study

- To monitor the physical, chemical and biological quality of drinking water in the study area.
- To study the potability of water.
- To correlate the principal-contaminants with the common-ailments in the district.
- To generate a database for the drinking water quality in the study area.
• Identification of potential pollution sources and evaluation of their nature and extent.
• To find out strategies for protecting the natural quality of drinking water sources for sustainable human development (stress would be given to develop a low cost defluoridation process).

Chapter 2: The second chapter deals with the environmental setting of the study area. A brief idea about its location, topography, climate, rainfall, temperature, humidity, soil, drainage and water bodies, hydrology and ground water, population and general geology of the study area has been provided in this chapter. Kamrup district the capital district of Assam, has been chosen as the study area. It is situated between 25.43 and 26.51 degree north latitude and between 90.36 and 92.12 degree east latitude. The greater parts of the district consists of wide plains, through the lower portion of which the mighty river Brahmaputra makes its way flowing a steady course from east to west. It covers an area of 4345 sq km. and receives an average rainfall of 1500 mm – 2600 mm. The region enjoys a climate of the sub tropical type with semi-dry summer & cold in winter.

Chapter 3: The third chapter illustrates the materials and methodology adopted during the study. For the present study, 184 water samples were collected from forty six sampling stations in Kamrup district spread over two seasons (Winter and Pre monsoon season and Monsoon and Post monsoon season) during 2006-2008. Samples from supply water taps, tube wells, and deep tube wells were collected from the outlets after flushing water for 10–15 min in order to remove the stagnant water. Samples from the ring wells were collected using water sampler. All the samples collected in tight capped high quality sterilized polyethylene bottles were immediately transported to the laboratory under low temperature conditions in iceboxes. The samples were stored in the laboratory at 4 °C until processed/analyzed.

The samples were analyzed for water quality parameters viz., Temperature, pH, Electrical conductivity, Total Solid (TS), Total Dissolved Solids(TDS), Total Suspended Solids(TSS), Turbidity, Dissolved Oxygen (DO), Total Hardness(TH), Calcium Hardness (CH), Magnesium Hardness(MH), Chloride (Cl⁻), Sulphate (SO₄²⁻),
Sodium (Na), Potassium (K), Fluoride (F'), Nitrate (NO₃⁻), Iron (Fe), Copper (Cu), Manganese (Mn), Cadmium (Cd), Lead (Pb), Arsenic (As), Zinc (Zn), and Total coliform bacteria (TC) and Faecal coliform bacteria (FC).

All physico-chemical and bacteriological parameters were determined according to standard protocols (APHA, 1998).

In this study, the tools used for data analysis are mainly experimental, aimed at defining possible relationships, trends, or interactions among the measured variables of interest. The observed parameters are related graphically. Descriptive statistics in the forms of mean, variance (V), standard deviation (SD), standard error (SE), median, range of variation, and percentile at 95%, 75% and 25% (P95%, P75%, P25%) are calculated and summarized in tabular form. The correlation analysis was performed for measured parameters to determine the relationship between these variables. Univariate statistics were used to test distribution normality for each parameter. \( t \)-Test is done under null hypothesis (H⁰) by taking the assumption that the experimental data are consistent with the mean rating given by WHO. Box and Whisker plot, P-P plot and histograms are some of the principal graphical techniques for exploratory Data analysis. SPSS® statistical package (Window Version 10.0) was used for data analysis. All statements reported in this study are at the \( P < 0.05 \) levels.

Chapter 4: The fourth chapter discusses the detail results and the findings of the present investigation.

In the present study the pH values of all the samples are found within the prescribed limit. The values ranged from 6.0 to 7.9; the variation of pH is narrow and in general, the pH is towards the alkaline side. The general appearance of the collected samples of water was seen to be colorless having some odour in some cases. Most of these were seen to have clear appearance. The conductance of water in the study area have values greater than the maximum permissible limit (0.3 mmho cm⁻¹) of USPH and indicates that water is markedly polluted with its reference. Ideally drinking water should have a turbidity of <1 NTU for aesthetic quality as well as for efficient disinfection. But the turbidity value was found within the range between 0.5 – 4.5 NTU. Chloride and sulphate contents above the permissible limits can cause serious health problems to the consumer. Their concentrations in water under study are within the approved WHO guide line values for safe drinking water and no fixed trend of variation among the sampling stations could be ascertained. Total hardness lied
between 9 to 478 mg/l. Calcium concentration was found within the ranged between 4 to 435 mg/l while magnesium concentration range between 0.29 to 114 mg/l. Calcium concentration exceeded permissible WHO standard (75mg/l) almost in 60 water samples.

In the present investigation the fluoride concentration is above the permissible range in more than 70% samples. Iron content of 72 percent of the drinking water sources in the area exceeds the WHO guideline value of 0.3 mg/L, which requires immediate attention.

The present study did not show any high value of sodium and potassium concentration. There was no significant seasonal variation in BOD values. However the monsoon and post monsoon values show some increasing trend. Almost about 84% of the water samples in the present study meets or falls below the current standard for arsenic, which is 0.01 ppm. In about thirty seven of the forty six sampling stations under investigation, the cadmium contents were much above the guideline value of 0.003 ppm as set by WHO. Fourteen sampling stations contain lead above the EPA guideline value of 0.015 ppm. It is observed that twenty four of the forty six sampling stations under investigation, contain manganese either at toxic or alert level. The rest of all the investigated parameters were found to be within the permissible range suggested by WHO and ICMR.

The MPN index of Coliforms shows that all the sampling points were contaminated with coliform group of organisms. The degree of contamination was low in case of PWS compared to other sources of drinking water in the study area.

Statistical analysis of the present investigated data indicates off normal distribution of the studied parameters. This is evident from the difference between mean and median values, positive skewness and the width of the third quartile, which is greater than the first and second quartile. A positive and/or significant correlation has been observed between temperature and total solid, pH with dissolved oxygen and magnesium, EC with chlorine, sulphate and sodium, TS with TDS and TSS, TSS with TH and Ca, Potassium with chlorine and sulphate, sodium with Chlorine, Fluoride, Iron and Potassium concentration in the study area. A negative but significant correlation exists between temperature and DO and TSS and potassium. The statistical values on comparison of calculated | t | value with tabulated t at 5% probability level show that most of the studied water quality parameters are significant implying that the null hypothesis may be rejected.
Chapter 5: The fifth chapter focuses on health effects of fluoride that is affecting the region slowly but steadily. A complete picture on bioavailability of fluoride, its absorption, its sources, and mobility in natural environment has been drawn. This chapter has also been designed to find out strategies for protecting the natural quality of drinking water sources for sustainable human development. Looking at the amount of fluoride concentration in the drinking water sources some locally available adsorbents has been identified and their adsorption capacity has been studied so that they could be used to develop a low cost defluoridation process. Batch experimental runs at room temperature were performed to evaluate the adsorption capacity of neem charcoal from aqueous solutions. Adsorption studies for defluoridation on neem charcoal powder showed that the adsorbent were highly influenced by temperature, pH of the solution, and initial fluoride concentration.

This study also evaluated the effectiveness of betel nut coir charcoal as a potential adsorbent for defluoridation of synthetic aqueous solution following batch method of operation. The efficiency of the adsorbent was measured at different temperature settings with respect to initial fluoride concentration, contact time, and pH of the solution. The process achieved equilibrium at 180 minutes with maximum defluoridation efficiency of 92%. The isotherm can be conformed to either Langmuir and Freundlich model at different temperature. The process follows pseudo 2\text{nd} order rate with both boundary layer effect and pore diffusion mechanism.

Chapter 6: The Sixth is the conclusive chapter which focuses on protective measures that could be employed to improve the drinking water quality in the district. For the greater Guwahati region, developing more comprehensive water supply schemes to supply water from the adjoining Brahmaputra river would be the best alternative towards fulfilling the primary needs of drinking water of the citizens of the district. Apart from this conclusions drawn from the health survey and defluoridation studies have been discussed in detail. A detail bibliography and annexures including a list of publications have been provided to end the thesis.