

Synopsis of the Thesis Entitled

**INVESTIGATION OF GROUNDWATER COMPOSITION
IN FOUR DISTRICTS OF GUJARAT WITH EMPHASIS
ON MANAGEMENT OF URANIUM
AND FLUORIDE**

*To be submitted to
The Maharaja Sayajirao University of Baroda
For the Degree of*

**DOCTOR OF PHILOSOPHY
In
ENVIRONMENTAL SCIENCE**

By

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Introduction

Groundwater is an essential natural resource to every aspect of our lives and our environment. About two-third of the world's population depends for its water supply on groundwater resources. With a gradually increasing population, many of the available groundwater systems in the world are ever more under stress of exploitation and contamination. Recently many studies have reported observation of dropping groundwater tables, depletion of groundwater reserves, deterioration of groundwater quality, degradation of nature reserves and ecosystems, and land subsidence. In India, groundwater is the most dependable source for clean and fresh water. In India ground water is in major parts of the country is potable. However, water quality issues are reported from various parts of the country. Higher levels of the constituents like Arsenic, Fluoride, Iron, Uranium and Salinity in ground water are due to the natural geological phenomena, but day by day human activities accelerate the concentration of these contaminants in groundwater. Man-made activities like mining, disposal of industrial wastes and untreated domestic wastes are responsible for contamination with pollutants like nitrate and some heavy metals. Uranium is an emerging pollutant in groundwater across the world. Trace quantities of uranium is present in the earth crust since beginning of the earth. Under conducive solubility conditions, uranium is dissolved in the groundwater. Apart from this, anthropogenic activities such as exploration of minerals, mining, industrial activities fossils fuel uses and municipal waste releases may enhance its level in the environment, which causes chemical and radiological effect which ultimately leads to various human health hazards such as kidney, bone, liver, the reproductive system, lung and nervous systems. Fluoride is also one of most significant water constituents, because of its dual nature on human being. It is one of the geogenic occurring pollutants at higher levels in groundwater of many parts of India including Gujarat. and has gained the serious attention of many researchers. Fluoride is beneficial for human being (beneficial effect on teeth and bones) when it presents at low concentration in drinking water, but excess amount (above 1.5 ppm of WHO limit) of fluoride in drinking water poses a number of adverse health effects like fluorosis, skeleton fluorosis, hypertension, and nervous system damage etc.

So, the effective removal of fluoride and uranium from water is an important issue due to their health hazards. It is well known that most of the groundwater of India including Gujarat is affected by fluoride so it become necessary to treat the fluoride contaminated water. These issues emphasize the importance of developing bio-degradable, reliable, eco-friendly and cost-effective techniques for the removal of pollutants from water which is still a big challenge. In

order to treat the water pollutants, numerous effective techniques have been developed till date. A combination of techniques have been reported from various researchers for the treatment of water such as phytoremediation, bioaugmentation, photo degradation, ion exchange, dichlorination, activated alumina, membrane filtration, modified coagulation/filtration, and enhanced lime softening. However, most of these technologies require sophisticated technical systems and hence, these are not currently applied on a broad scale. The most common and useful technologies that have been utilized are based on oxidation, co-precipitation and adsorption onto coagulated flocs, and adsorption onto sorptive media as these technologies are cost-effective. Amongst them, adsorption has been found most feasible and most cost-effective, most flexibility and simplicity of design, ease of operation and the lack of the possibility of producing secondary harmful products.

keeping in view, the aforementioned issues the thesis was entitled “**Investigation of Groundwater Composition in Four Districts of Gujarat with Emphasis on Management of Uranium and Fluoride**” which consisted **five** chapters.

Chapter 1

First chapter gives a detailed literature review related to groundwater monitoring pollution and sources, with emphasize on uranium and fluoride contamination. It also gives details on fabrication, synthesis, and optimization of adsorbents for the removal of uranium and fluoride from aqueous solution followed by the objectives

The objectives of research:

- Monitor and map the Groundwater composition in Anand, Bharuch, Narmada and Vadodara districts of Gujarat.
- Use Advanced statistical methods to interpret the data
- Study potential of DTPA modified chitosan and water melon rind biochar for removal of uranium.
- Study Lanthanum modified biochar and zirconium cholate as adsorbents for fluoride

Chapter 2

Chapter 2: Groundwater monitoring and water quality assessment: describes the details of selection of study area, location, hydrogeology, collection of samples, methods of analysis of physico-chemical analysis of water samples, statistical and spatial analysis of samples. The methodology adapted was described.

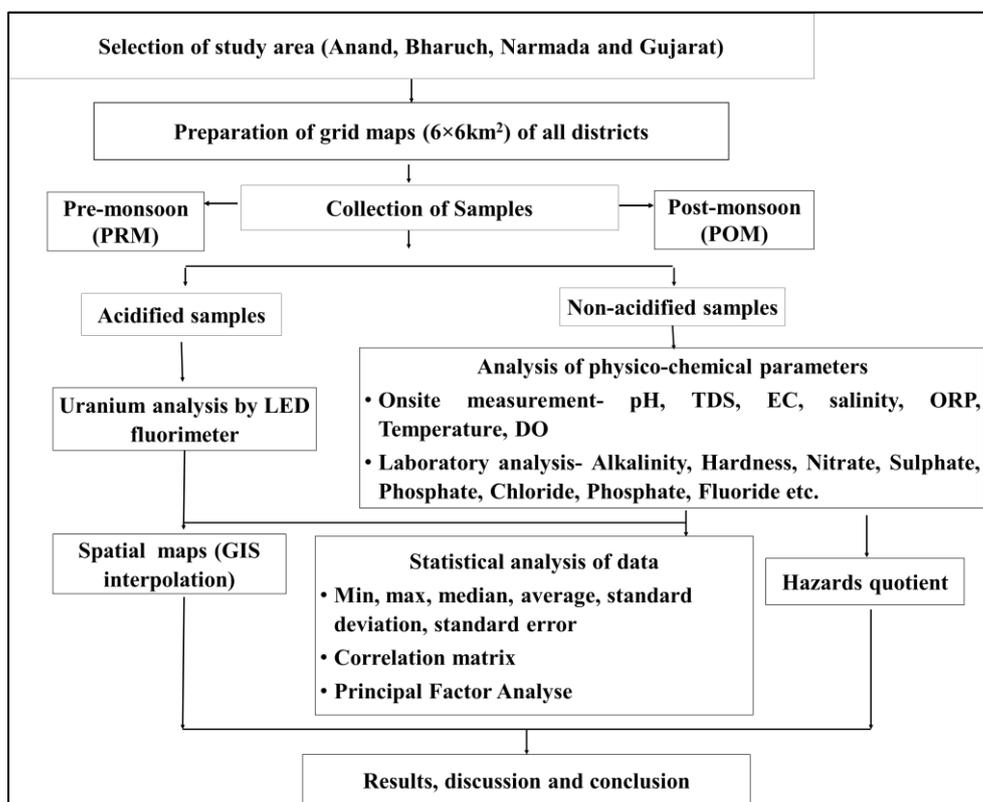


Fig. 1 Methodology used for monitoring and assessment of groundwater quality.

The water samples were collected and analysed in Anand, Vadodara, Narmada and Bharuch districts during both pre and post monsoon seasons and were analysed by advanced statistical techniques. The results are presented in this chapter.

Table 1 summarizes the results for groundwater of Anand

Parameters	Pre-monsoon				Post-monsoon			
	Min	Max	Avg	Median	Min	Max	Avg	Median
pH	6.96	8.77	7.75	7.70	6.26	10.22	8.12	7.93
TDS (ppm)	186.6	2859.0	783.61	643.9	179.4	2451	748.2	616.85
F ⁻ (ppm)	0.05	2.74	0.36	0.24	0.12	2.11	0.48	0.38
Cl ⁻ (ppm)	29.99	1433.56	217.95	105.97	21.27	1283.6	210.43	79.19
NO ₃ ⁻ (ppm)	0.50	54.49	10.00	5.55	0.89	73.75	21.35	22.66
SO ₄ ²⁻ (ppm)	1.08	274.90	53.41	31.44	2.91	199.27	45.02	27.58
PO ₄ ³⁻ (ppm)	0.10	0.18	0.10	0.10	0.1	0.2	0.1	0.1
U (ppb)	0.10	23.85	10.14	10.18	0.1	26.44	12.68	13.23
TH (ppm)	60.00	800.00	289.77	260.00	66.1	718.6	304.45	264.21
Ca ²⁺ (ppm)	20.00	300.00	92.80	80.00	16.01	332.3	109.6	102.09
Mg ²⁺ (ppm)	40.00	572.00	196.98	160.00	36.03	582.5	194.85	161.14
TA (ppm)	130.11	750.65	379.01	370.32	130.00	650.00	360.61	360.00
HCO ₃ ⁻ (ppm)	130.11	750.65	363.95	370.32	130	650	360.12	360

The spatial analyst modeling tool (ArcGIS) was used, to predict unknown concentration of water quality parameters from known sample spot of the geographical area under study, based on interpolation method (Figs. 2 and 3). It is to be noted that the value points that are close to the sampling point are comparable than value points that are farther away based on weighted distance.

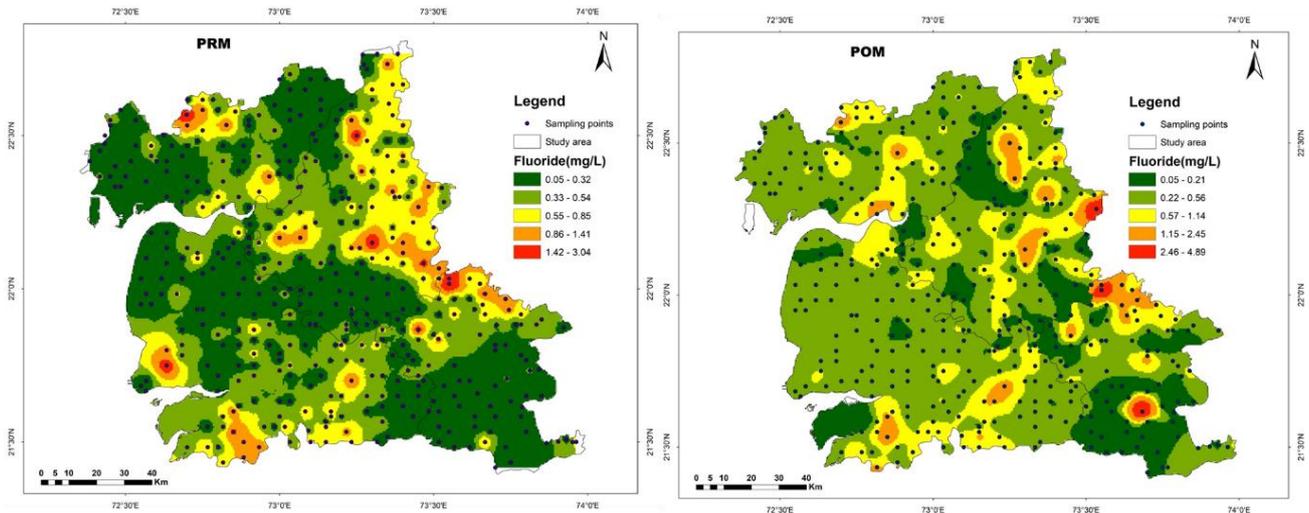


Fig. 2 Spatial distribution of fluoride across study area

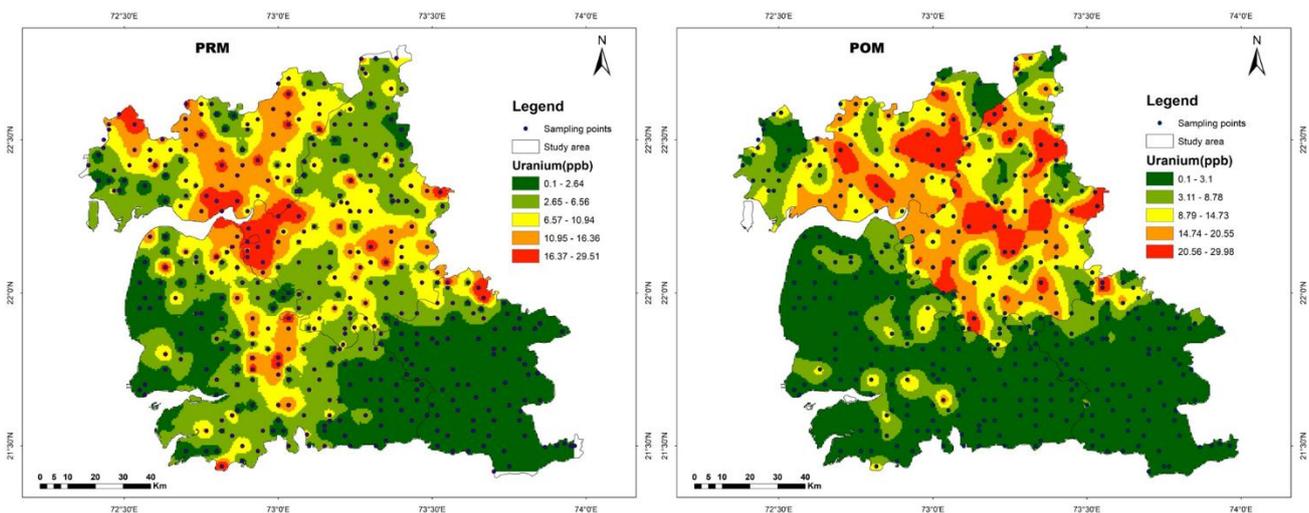


Fig. 3 Spatial distribution of uranium across study area

Chapter 3

The preparation, characterization and application of chitosan DTPA (Diethylenetriamine pentaacetic acid) and water melon rind biochar for removal of Uranium are described in section A and section B of this chapter

Chapter 3A: Synthesis of chitosan-DTPA for removal of uranium from aqueous solution.

This section discussed the synthetic methodology of CH-DTPA and probable crosslinking of chitosan and DTPA.

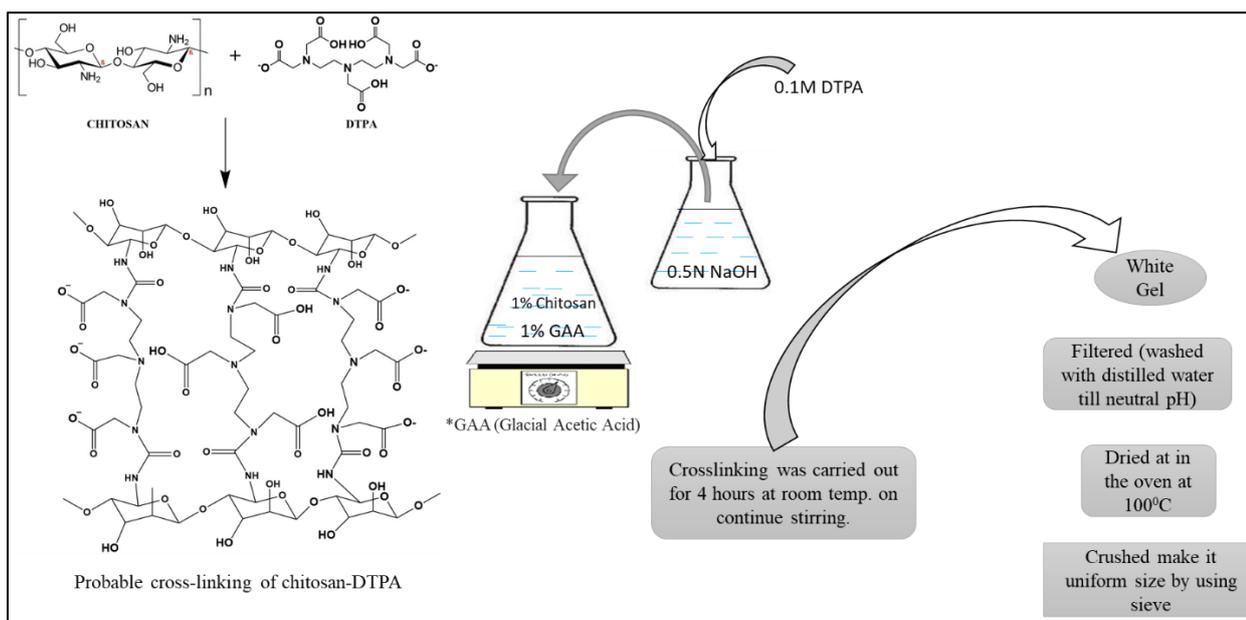


Fig. 4 Fabrication and synthesis of CH-DTPA

The Chitosan-DTPA characteristics elucidated using SEM (Scanning electron microscope), Energy-dispersive X-ray analysis (EDAX), FTIR (Fourier transform infrared) spectroscopy, XRD (X-ray Diffraction), XPS (X-Ray photoelectron spectroscopy), TGA (Thermogravimetric analysis) was reported.

The optimal conditions for the removal of U (Fig.5) and the mechanism of its removal elucidated using different isotherm and kinetic models are described. The adsorption-desorption cycles performed to evaluate desorption and regeneration of adsorbent are detailed and its adsorptive potential in comparison to literature reported chitosan derivatives is critically discussed in this chapter. The applicability of CH-DTPA to real water samples was demonstrated.

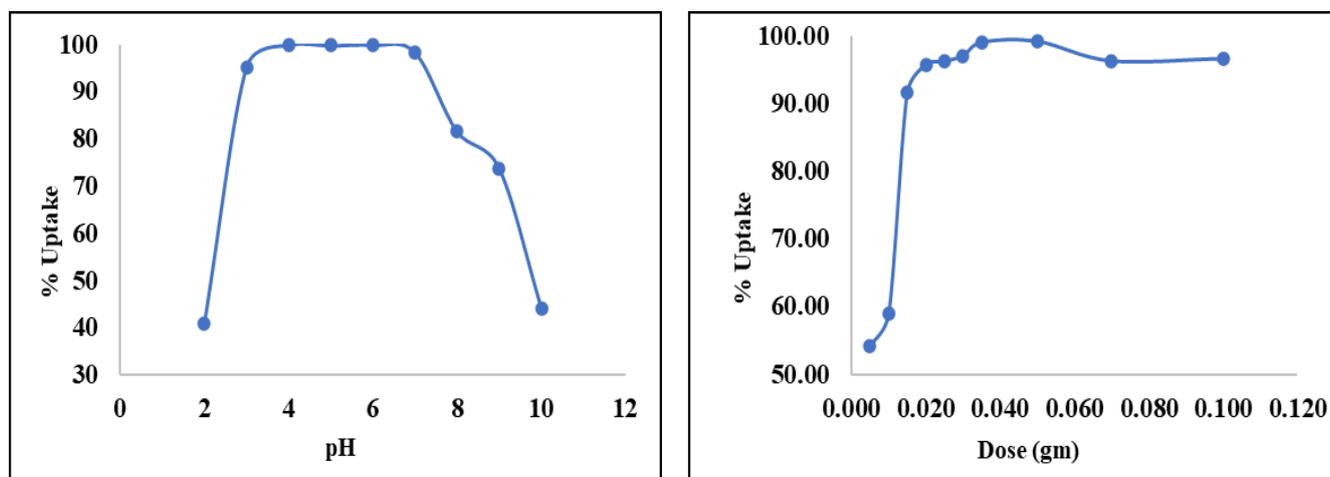


Fig. 5 Optimization of pH and dose for CH-DTPA

Chapter 3B: Synthesis of biochar from watermelon rind for removal of uranium from aqueous solution:

The methodology of preparation of biochar from watermelon rind (WMB) and the characteristics of the material deduced through analysis by SEM, EDAX, FTIR spectroscopy, XRD, XPS and TGA techniques are reported in this chapter.

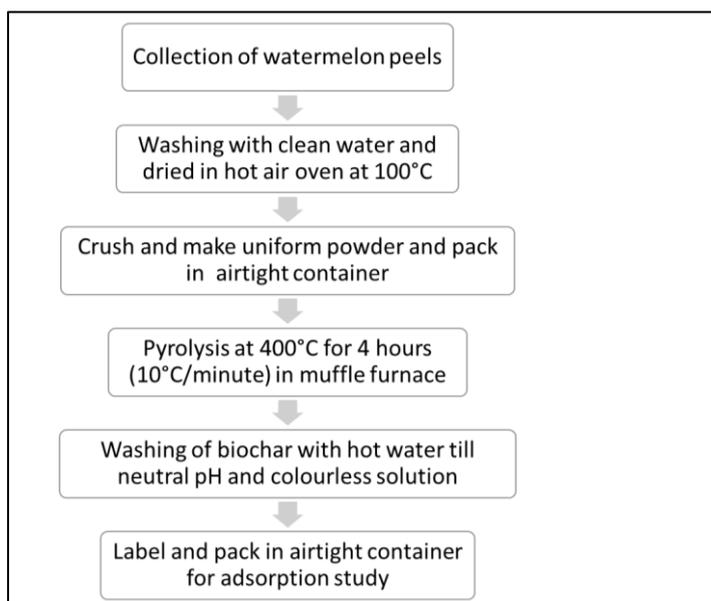


Fig. 6. Synthesis of WMB

The optimised conditions for uranium removal with WMB as well as the mechanism elucidated through fitting of isotherm and kinetic models to the adsorption data are further discussed. The applicability of the adsorbent towards real water samples and its performance in comparison to other literature reported biochars has been critically discussed.

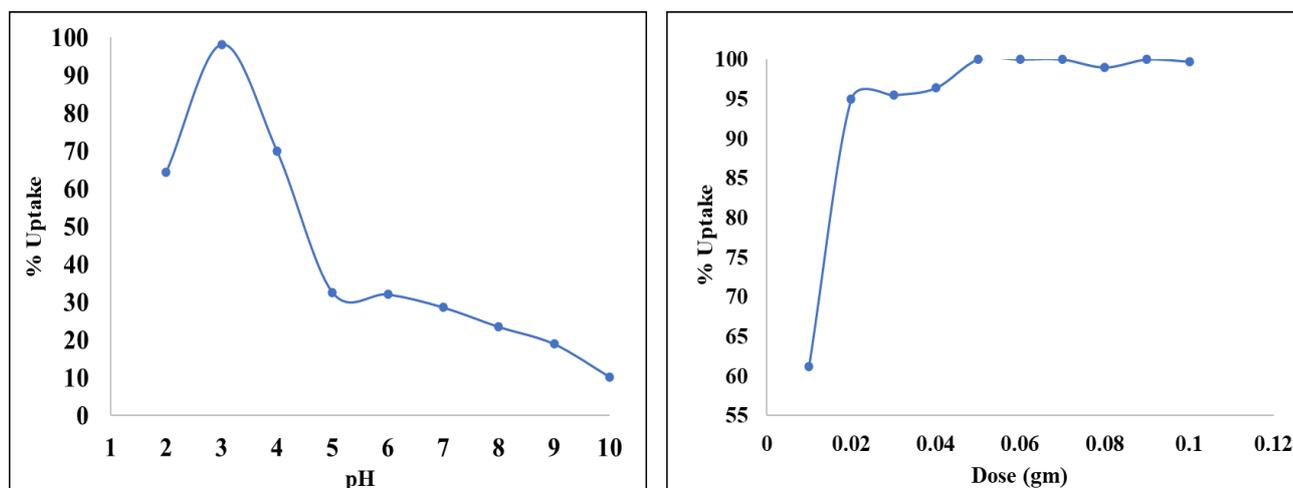


Fig. 7 Optimization of pH and dose for WMB

Chapter 4

Synthesis of adsorbents for the removal of fluoride from aqueous solutions:

This chapter describes the preparation of Lanthanum impregnated biochar and Zirconium cholate as adsorbents for Fluoride removal from aqueous solution in section A and B respectively

Chapter 4A: Preparation and synthesis of Lanthanum impregnated biochar (WMB-LN) for the removal of fluoride from aqueous solution: The chapter will discuss synthetic methodology for preparation of WMB-LN (Figure 8) and its characterization using SEM, EDAX, FTIR spectroscopy, XRD, XPS, and TGA techniques.

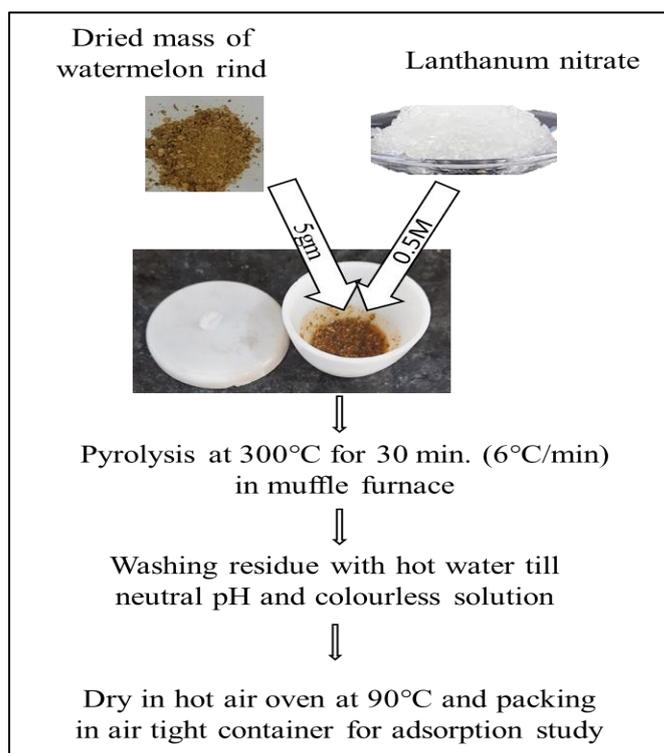


Fig. 8. Synthesis of lanthanum impregnated biochar

The results of isotherm and kinetic models studied and the best to the adsorption data under optimal conditions as well as the plausible mechanism involved are further discussed (Fig. 9). The potential of adsorbent to be recycled and its adsorption potential in comparison to that of other adsorbents reported in the literature were critically investigated.

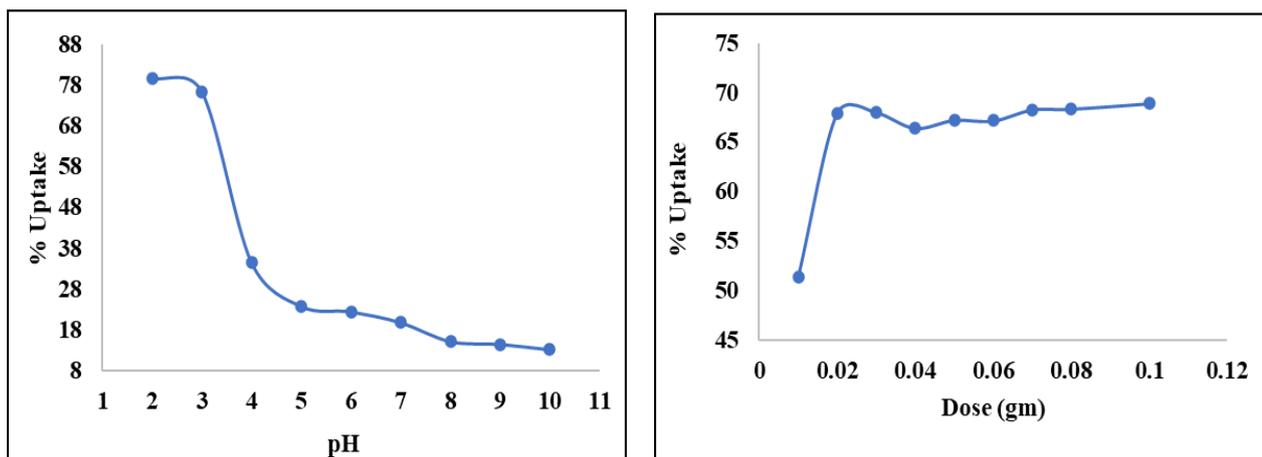


Fig. 9 Optimization of pH and dose for WMB-LN

Chapter 4B: Preparation and synthesis of Zr-Cholate (Zr-CH) for the removal of fluoride from aqueous solution

This chapter discusses the details of synthesis of Zr-CH from zirconium chloride and sodium cholate followed by its potential for remediation of fluoride from aqueous solution. The characteristics of Zr-CH using SEM, EDAX, FTIR spectroscopy, XRD, XPS and TGA are reported.

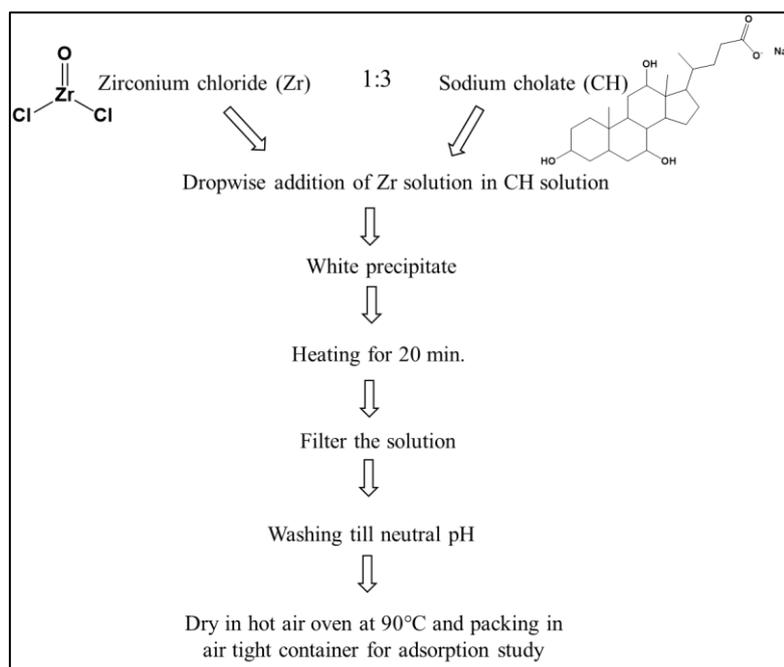


Fig.10. Synthetic Methodology for preparation Zr-CH

The optimum conditions for removal of fluoride using Zr-CH (Fig. 11) and the plausible mechanism of removal by fitting adsorption data to isotherm and kinetic models are described. The recyclability and applicability of Zr-CH to real water samples is further discussed as well as its performance relative to literature reported adsorbents.

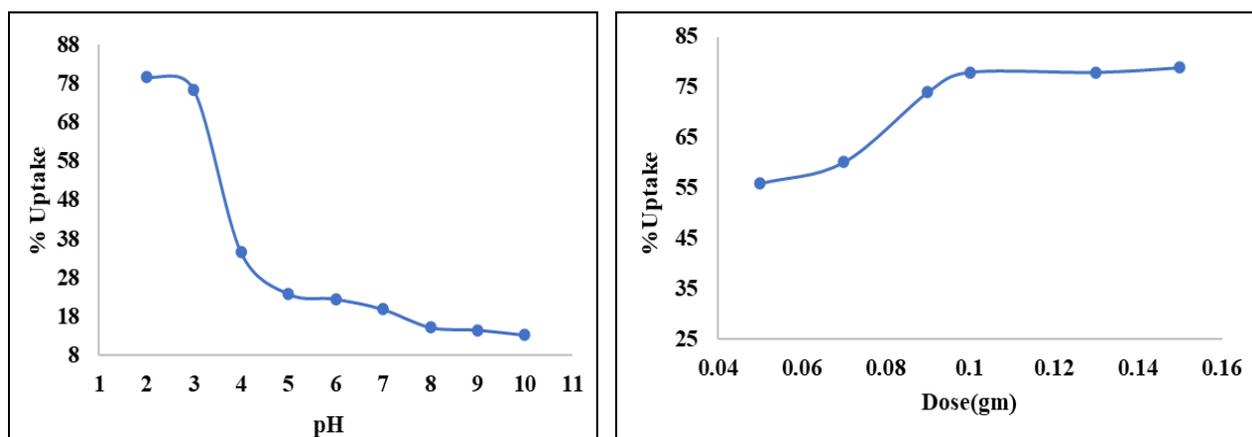


Fig. 11 Optimization of pH and dose for Zr-CH

Chapter 5

The fifth chapter summarizes the important conclusions of our study with future scope of the study.

Publications

- **Patel, D.**, Jindal, M. K., Pamidimukkala, P. S. & Chakraborty, D. 2023. Gamma radiation dose rate distribution in the Anand, Bharuch, Vadodara, and Narmada districts of Gujarat, India. *Environ Sci Pollut Res Int*.
- **Patel, D.**, Pamidimukkala, P., Chakraborty, D. & Yadav, A. 2022. Bharuch District, Gujarat, India: Factor analysis and geographical distribution of water quality characteristics. *Environmental Nanotechnology, Monitoring & Management*, 18, 100732.

Oral/poster presentation

- Paper presented on entitled “Pre- and Post-monsoon variation of uranium and associated water quality parameters in Narmada district of Gujarat” in Twentieth National Symposium on Environment (NSE-20) at IIT-Gandhinagar, 13th -15th Dec 2018 (poster).
- Paper presented on entitled “Spatial Distribution of Uranium in drinking water of Tilakwada Tehsil and its removal using chitosan-based derivative” in National Symposium on Advance in Chemical Research (ACR-2019) at MSU, Baroda, 24th Feb 2019 (poster).
- Paper presented on entitled “Monitoring of uranium and fluoride in drinking water of Bharuch district of Gujarat” in National seminar on Interdisciplinary Approaches in Environmental Sciences (IAES-01) at MSU, Baroda, 18th -19th Jan 2020 (oral).
- Paper presented on entitled “Monitoring of fluoride along with some physico-chemical parameters in Anand, Vadodara and Bharuch districts of Gujarat state” in international

conference on Eco health and Environmental Sustainability (ICEES-2020) at Navrachana University, Vadodara, 24th-26th Feb 2020 (oral).

- Paper presented on entitled “Spatial distribution of uranium and fluoride in groundwater sources of Anand district in Gujarat, India” in international conference on technologies for smart green connected societies 2021 at ICTSGS, SPAST Foundation, 29th-30th Nov, 2021 (online-poster).
- Paper presented on entitled “Terrestrial Radiation Dose Rate Distribution in the Four Districts of Gujarat, India” in International Conference on Radiation Awareness and Detection in Natural Environment at Dolphin (PG) Institute of Biomedical and Natural Sciences, Dehradun, 2nd – 4th March 2023 (oral).

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