FLUORIDE AND ARSENIC REMOVAL FROM UNDERGROUND WATER FOR POTABLE USE

by

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Submitted

in fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

HAUZ KHAS, NEW DELHI-110016 (INDIA)

JULY, 2005

CERTIFICATE

This is to certify that the thesis entitled, "**FLUORIDE AND ARSENIC REMOVAL FROM UNDERGROUND WATER FOR POTABLE USE,**" being submitted by Ms. **Meenakshi** to the Indian Institute of Technology, Delhi for the award of Doctor of Philosophy is a record of bonafide research work carried out by her under my guidance and supervision in conformity with the rules and regulations of Indian Institute of Technology, Delhi. The research report and results presented in this thesis have not been submitted, in part or full, to any other university or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

Its my great pleasure to be especially privileged one to receive guidance from my supervisor Prof. R.C. Maheshwari whose academic excellence and constant encouragement steered me through the work all the way. I would seize the opportunity to express my deep sense of gratitude for his valuable analysis, constructive criticism and personal affection which instilled in me immense confidence to continue my research right from the beginning till the accomplishment of the goal. He is much more than a formal research guide to me.

I am specially thankful to Prof. Santosh Satya, Head, Centre for Rural Development and Technology, Indian Institute of Technology, Delhi who extended all possible help, took keen interest and encouraged me always throughout the work.

I express my sincere thanks to all the faculty members of RDAT for their help and co-operation. I am also grateful to all non-teaching staff of RDAT, who has helped me in some way or the other.

I would also like to thank The Institute of Water Technology, Fachhochschule, Braunschweig/Wolfenbuettel, Germany for providing all the necessary lab facilities during my stay in Germany to carry out some of the experiments.

I also extend a note of thanks to Dr. K.K. pant, Department of Civil Engineering, IIT, Delhi for providing the lab facilities and guidance during this study.

I wish to put on records thanks to my friends Parag, Ashutosh, Neetu, Deepak, Lalit, Manish and all others for helping me in completing my thesis.

I would like to thank Mrs. Maheshwari, who has always encouraged me during last 4 years and provided motherly care.

I fail to express my deepest regards and thankfulness for my respected parents, as their contribution in whatever I have achieved till date is beyond expression. It was their love, affection and blessed care that has helped me to move ahead in my difficult times and complete my work successfully. The cute love of my brothers Sandeep Pahwa and Gaurav Pahwa has always lighted my heart.

I have no words to express my feelings for my husband, Dr. Gaurav Arora whose constant support, valuable suggestions and encouragement enabled me not only to finish my work in time but has also given a wide horizon and vision for future. Without his support it would have not been possible to finish this task successfully. Cute and innocent love of Chahat always gave me strength and motivation to move ahead even when it seem hard to move.

Special thanks are due to my parents in law, Bhaiya-Bhabhi and loving Nishtha for being very petient and encouraging during the last phase of my ph. D.

I would like to thank Department of Science and Technology, Ministry of Science and Technology, Govt. of India for providing financial support.

Last but not the least I would thank almighty for providing me strength and wisdom to complete this work.

(Meenakshi)

ABSTRACT

The presence of fluoride and arsenic in groundwater is the most pervasive environmental issue of present time. Both this minerals are of geologic origin and toxic for human health. The permissible limit of fluoride in drinking water is 1.0 mg/l whereas concentrations as high upto 30.0 mg/l have been reported in various parts of world including India. Continuous exposure to excess fluoride leads to dental and skeletal fluorosis. The permissible limit of arsenic is 50 ppb as per Indian and WHO standards and 10 ppb as per USEPA guidelines. It is a potential carcinogen and its deleterious effects on all forms of life are well documented. Various methods used for removal of these minerals include chemical precipitation, ion exchange, adsorption and reverse osmosis. All the techniques suffer from one or the other drawback. Thus attention has been focused on providing some cost effective and efficient solution for these problems. In this study low energy reverse osmosis membrane and nanofiltration membrane for fluoride removal from underground water has been selected on the basis of pore size, molecular weight cut off, material of construction and the geometry of the membrane. The efficiency of both the membranes has been tested using various electrolytes. For arsenic removal, a new adsorbent (Silica ferric complex adsorbent-Sfca) was prepared in the laboratory and its performance was evaluated evaluated and compared with one commercially available adsorbent (Granular Ferric Hydroxide-GFH).

The results of experiments conducted with low energy RO membrane show that even at low pressures, it can provide fluoride free water. In case of high rejection leading to removal of all necessary ions from water, blending of permeate with feed to some extent is recommended

which will reduce the cost of treatment. The experimental results are in very good agreement with the combined film theory-solution diffusion model.

It has been observed that by nanofiltration membrane rejection of fluoride and other monovalent ions is very less while using single electrolyte, whereas in case of mixed electrolyte when fluoride and calcium ions coexist, rejection of fluoride ions is sufficiently high due to precipitation of fluoride as CaF_2 on the membrane surface. But the groundwater rich in fluoride is generally found low in calcium. Therefore NF membrane doesn't serve the purpose.

A new adsorbent, Silica ferric complex adsorbent (Sfca) was prepared in the laboratory and its characterization was done. Adsorption experiments were conducted in batches for optimization of sorption parameters and to study the equilibrium, kinetics and thermodynamics of arsenic adsorption on GFH and laboratory made Sfca. The kinetics of the arsenic was found to be of pseudo first order. It has been observed that though both the adsorbents remove arsenate and arsenite upto 96%, GFH imparts colour to water and gets dissociated in contact with water whereas Sfca provides clear water and does not disintegrate, therefore adsorbent loss is very less. Various operating parameters like contact time, adsorbent dose, pH, initial arsenic concentration, and agitation speed have been optimized for GFH and Sfca. The experimental data showed better correlation with Langmuir isotherm model than with Freundlich model. It has also been observed that adsorption of arsenate and arsenite increased with increase in temperature. Film diffusion step was found rate limiting factor for the adsorption of arsenic on Sfca and GFH. The laboratory made adsorbent was found to be cheap and affordable due to its high adsorption capacity. Its disposal doesn't pose any environmental hazard due to its non-leachable residue.

Fixed bed adsorption study was conducted with Sfca at various bed heights, feed flow rate and initial arsenic concentrations. Breakthrough point and column exhaustion was studied, from which mass transfer zone was determined.

From the results of present study it has been concluded that low energy RO membrane is the option of choice for fluoride removal from underground water and adsorption of arsenic on Sfca can solve the problem of excess arsenic in underground water.

CONTENTS

LIST OF TABLES