

**FLUORIDE AND ARSENIC REMOVAL FROM UNDERGROUND
WATER FOR POTABLE USE**

by

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CENTRE FOR RURAL DEVELOPMENT AND TECHNOLOGY

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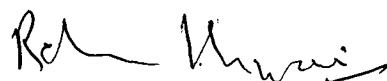
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CERTIFICATE

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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ABSTRACT

The presence of fluoride and arsenic in groundwater is the most pervasive environmental issue of present time. Both these 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 as up to 30.0 mg/l have been reported in various parts of the 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 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.

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