United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-81-115 Oct. 1981

EPA

Project Summary

Inorganic Contaminant Removal from Drinking Water by Reverse Osmosis

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The removal of inorganic contaminants from drinking water was studied using two reverse osmosis (RO) treatment systems. A high pressure (400 psi) and low pressure system (200 psi), each having a rated capacity of 1.82 L/sec (28.9 gpm) of product water, were used to evaluate their capability for removing various inorganic contaminants. A groundwater was spiked with varying concentrations of fluoride, nitrate, arsenic III, and arsenic V, and runs of 2 to 5 days were conducted to determine rejections. Removal data were also collected on the natural constituents in the feed water of total dissolved solids, hardness, calcium, magnesium, chloride, sodium, and sulfate.

For all contaminants and natural constituents measured, the high pressure system operated at 265 to 359 psig more effectively removed the inorganic contaminants than did the low pressure system operated at 163 to 187 psig. High pressure system removals ranged from 80 to 99 percent; low pressure, from 10 to 85 percent. Percent removals varied with the ion measured, but the order, from best to worst, was about the same for each system. The order for the high pressure system was: (1) arsenic V, (2) fluoride, (3) nitrate, and (4) arsenic III. For the low pressure system: (1) arsenic V, (2) fluoride, (3) arsenic III, and (4) nitrate. Percent removal was also independent of the initial concentration.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

RO has been used successfully for desalting sea water and brackish waters for many years. Compared with other drinking water treatment methods, its relatively high cost has limited its application in this field. Technological advances, however, have generated considerable interest for use on drinking waters with high total dissolved solids and on those having specific contaminants that cannot be easily removed by other methods.

One major advantage of RO is its effectiveness to remove almost all inorganic substances. Information is generally available on the rejection capabilities for the common natural constituents in drinking water, such as sodium, chloride, or sulfate, but lacking on the rejection of specific contaminants such as arsenic and selenium.

This study was undertaken to develop data on removing the inorganic contaminants included in EPA National Interim Primary Drinking Water Regulations by RO. Tests were conducted using two parallel pilot plant RO systems: (1) a low pressure (200 psi) system housing low rejection mem-

branes and (2) a high pressure (400 psi) system with high rejection membranes. Test runs lasting from 1 to 5 days were carried out by spiking a natural groundwater with known concentrations of contaminants and measuring their removal by each RO system. Removal data were also obtained on some of the natural constituents in the feed water such as total dissolved solids, calcium, magnesium, chloride, sodium, and sulfate. The results of the first series of tests for the removal of fluoride, nitrate, arsenic III, and arsenic V are reported in this first progress report.

Results

Because of several problems, unrelated to the RO systems, the two systems were operated under three slightly different sets of operating conditions (pressure). The test data on the natural substances suggest, however, that these changes did not significantly influence the performance of the systems for removing the spiked contaminants.

As was anticipated, the test data show a very significant difference in the capabilities between the two RO systems for removing all spiked and natural constituents monitored. The low pressure system, which requires about one-half the energy used by the high pressure system, achieved rejections of about 50 percent or less than that achieved by the high pressure system. Data also show that rejection of the contaminants on a percent basis was independent of the feed concentration and the order of effectiveness for removing spiked and natural constituents was nearly the same for each system (Table 1).

Table 1. Percentage Removal of Natural and Spiked Constituents Monitored

Constituents	Reverse Osmosis Systems, % Removal	
	High Pressure	Low Pressure
Natural		
Sulfate	>99	82 - 84
Magnesium	96 - 98	63 - 67
Calcium	96 - 98	64 - 67
Total Hardness	97 - 98	64 - 66
Radium-226	97	62
Total Dissolved Solids	93 - 96	45 - 52
Chloride	87 - 95	42 - 45
Sodium	88 - 93	36 - 44
Spiked		
Arsenic V	91 - 98	77 - 81
Fluoride	90 - 93	56 - 62
Nitrate	76 - 80	6 - 24
Arsenic III	63 - 70	12 - 35

Conclusions

The investigation clearly indicated that the high pressure system was significantly more effective for removing all substances measured. The low pressure system achieved a very wide range of removals and was very ineffective for removing nitrate and arsenic III.

Because of its low rejection characteristics, the low pressure system is only effective on source water having contaminant concentrations slightly above the maximum contaminant levels (MCL). The high pressure system, although it requires about twice the energy, is much more effective, and blending of feed and product waters could be accomplished to affect the difference in energy costs.

The full report was submitted in fulfillment of Cooperative Agreement No. RC-805207 by Charlotte Harbor Water Association, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

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***Thomas J. Sorg** is the EPA Project Officer (see below).*
The complete report, entitled "Inorganic Contaminant Removal from Drinking Water by Reverse Osmosis," (Order No. PB 81-224 420; Cost: $8.00, subject to change) will be available only from:
National Technical Information Service
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Springfield, VA 22161
Telephone: 703-487-4650
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