

# Nitrate Removal from Groundwater by Electrodialysis

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Removal of nitrate from groundwater by electrodialysis was carried out for one year, using a monovalent anion permselective ion exchange membrane. The nitrate was efficiently removed and there was no any deterioration in membrane performance.

Keywords: electrodialysis, nitrate removal, groundwater, monovalent anion permselective membrane.

## 1. INTRODUCTION

The concentration of nitrate has been greatly increasing in groundwater because of excess use of artificial fertilizers. This is a serious problem because nitrate is harmful to human health. According to Japanese Law of "City Water", the concentration of nitrate in drinking water should be below 10 mg/L of nitrogen. To remove nitrate in groundwater, various methods have been proposed and tried: anaerobic biological digesters, ion exchange, reverse osmosis, electrodialysis (1, 2), etc.

This work reports the results of continuous removal of nitrate by electrodialysis from groundwater containing 10 mg/L of nitrogen for a year.

## 2. EXPERIMENTAL

Cation exchange membrane, NEOSEPTA CMX and anion exchange membrane NEOSEPTA ACS, produced by Tokuyama Corp., were used throughout experiment. Electrodialysis was carried out at room temperature using Labo-cell (effective membrane area: 0.84m<sup>2</sup> - 0.12 m<sup>2</sup> x 7 units) and a flow sheet of electrodialysis system is shown in Fig. 1. The polarity reversal (EDR) was performed every one hour throughout this

experiment. Constant voltage was applied to electrodes. Other experimental conditions are shown as follows:

- 1) period: from April 1997 to March 1998, continuous operation;
- 2) feed water: groundwater of which the composition is shown in Table I
- 3) Flow rate of water: 6cm/sec

When the removal rate of nitrate was below 75%, feed water were passed through the cell once. On the other hand, when the removal rate was more than 75%, the feed water was partially circulated. The diluate and concentrate water were collected separately and their ionic composition was analyzed. Voltage drop of the cell, electrical

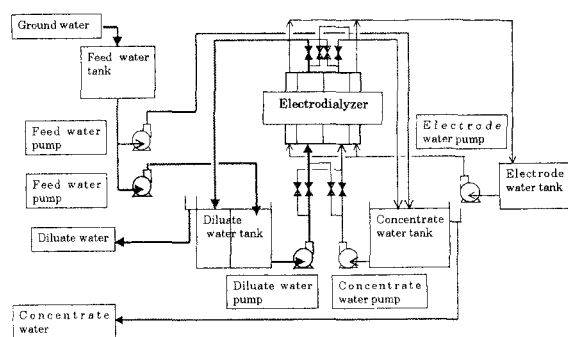


Fig 1 FLOW SHEET OF ELECTRODIALYSIS (CIRCULATION PROCESS)

current, electrical conductivity, pH and temperature of the waters were automatically recorded on a recorder. Removal rate was performed until 90%, 75% and 65% of nitrate in the water to evaluate the electrodialysis process.

3. RESULTS AND DISCUSSION

Table I shows typical composition of feed, diluate and concentrate water. The results show that there are significant differences in transport properties between ionic species. Table II also shows removal rate of each ionic species, which was different from ions. Though nitrate and chloride ions were removed as like expected, most of sulfate ions remained in the diluate water. This is based on that NEOSEPTA ACS membrane has monovalent anion permselectivity. In this case, about 65% of nitrate and about 1.9% of sulfate was removed with electric conductivity of the feed water decreased by 42%. Namely, nitrate and chloride ions were effectively removed using the monovalent anion permselective membrane, NEOSEPTA ACS. Fig. 2 shows the relationship between the concentration of nitrate and electric conductivity of diluate desalinated water. Because the concentration of nitrate is linearly related to the conductivity, the concentration of the ions can be estimated by measuring electric conductivity of the diluate water. Fig. 3 shows the change in electric conductivity during one-year operation.

Table II Removal rate of each species

Nitrate-N preset removal rate( % )	65	75	90
Nitrate-N ( % )	65.4	75.1	91.8
Chloride ( % )	55.4	62.7	87.8
Sulfate ( % )	1.9	2.1	8.6
Conductivity ( % )	42.2	50.0	71.7
TDS ( % )	47.1	53.9	67.4

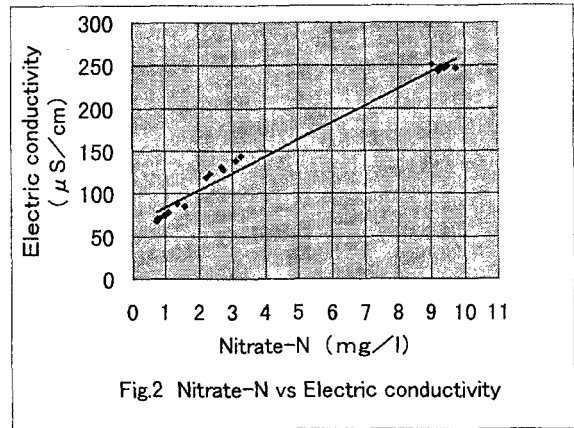


Fig.2 Nitrate-N vs Electric conductivity

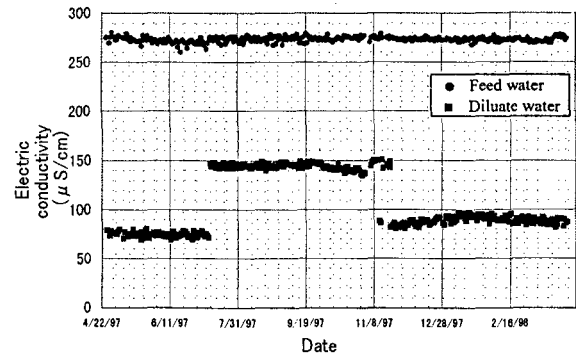


Fig.3 Operation data of feed water and diluate water electric conductivity

Table I Typical composition of feed, diluate and concentrate water

Nitrate-N preset removal rate ( % )	65			75			90		
	Feed water	Diluate water	Concentrate water	Feed water	Diluate water	Concentrate water	Feed water	Diluate water	Concentrate water
Nitrate-N (mg/l)	9.42	3.26	100	9.31	2.32	102	9.39	0.77	84.2
pH	6.6	6.5	7.2	6.7	6.5	7.3	6.6	6.7	7.7
Conductivity( μ S/cm)	249	144	1840	248	124	1720	247	70	1940
Sodium (mg/l)	15.1	12.4	53.5	15.6	12.4	63.4	14.7	8.6	83.7
Chloride (mg/l)	18.4	8.2	225	16.9	6.3	155	17.2	2.1	243
Sulfate (mg/l)	15.5	15.2	22.7	14.4	14.1	21.6	14.0	12.8	25.6
Hardness (mg/l)	74.0	36.0	711	77.2	27.7	770	75.7	10.8	727
TDS (mg/l)	170	90	1800	167	77	1410	178	58	1380

Operation was carried out at the rate of 90% nitrate removal during the first two months and then the rate was decreased to be 75% for 4 months. Thereafter, the rate was increased in 90%. Electric conductivity of feed water, electrical current and cell voltage during this operation was the same as those of the first two months operation as shown in Fig. 3,4. Electrodialysis was continuously carried out for one year, in which electrical current was reversibly applied for every one-hour (EDR). Any chemicals, cleaning procedure of electro dialyzer and membranes were not necessary during electrodialysis. Also there was no scaling on the membrane surfaces after disassembling the electro dialyzer. Fig. 5 shows the relationship between the rate of nitrate removal and the amount of diluate water. Naturally, when the rate of nitrate removal was high, the amount of diluate water was small. From this Figure, the rate of nitrate removal should be decided according to requirements.

#### 4. CONCLUSIONS

The nitrate was efficiently removed by electrodialysis for a year, using a monovalent anion permselective ion exchange membrane. EDR method was effective, any chemicals, cleaning procedure of electro dialyzer and membranes were not necessary during electrodialysis. Also there was no scaling on the membrane surfaces after disassembling the electro dialyzer.

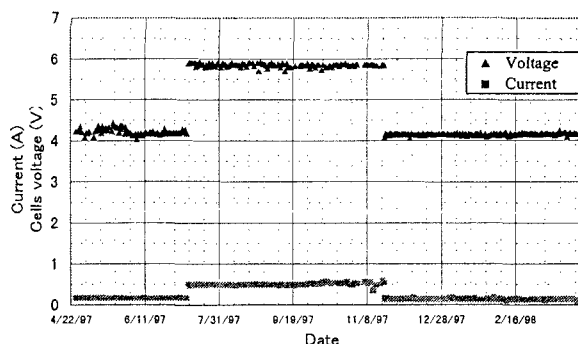


Fig.4 Operation data of current and voltage

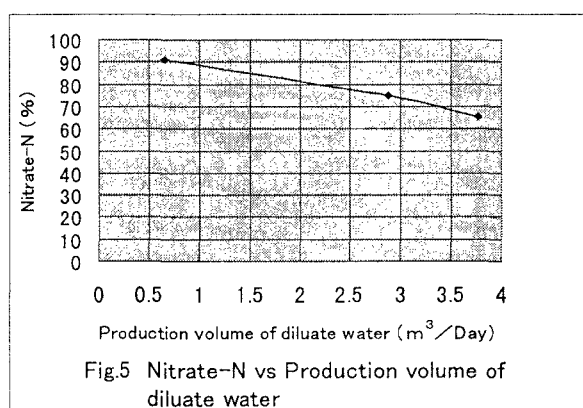


Fig.5 Nitrate-N vs Production volume of diluate water

#### 5. REFERENCES

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