

## Research Article

## Nitrate Removal in Drinking Water of Godwar Region (Rajasthan)

Sangeeta Parihar<sup>1</sup>, Rajnee<sup>2</sup> and Raaz Maheswari<sup>3</sup>

<sup>1</sup>Department of Chemistry, Jodhpur National University, Namadi, Boranada, Jodhpur, Rajasthan, India.

<sup>2</sup>Department of Physiology, Sardar Patel Medical College, Bikaner, Rajasthan, India.

<sup>3</sup>Department of Chemistry, SBRMBC, Nagaur, Rajasthan, India.

### ABSTRACT

Godwar region is a west part of Rajasthan. Drinking water samples were collected from different sources of this region and biochemical studies was done. The high concentration of nitrate was observed in some sources of desuri and bali tehsils. The toxic limit of nitrate in drinking water is 45mg/ litre but in the various samples it was obtained are in the range of 70 to 472ppm. Nitrate causes methemoglobinemia (blue baby syndrome) and both nitrate and nitrite have potential to form carcinogenic N- nitroso compounds. Experiments have carried out to investigate nitrate removal from the samples using anion exchange resins. This resin is capable of treating 40 liter of highly contaminated water sample with 100 ppm nitrate to safe drinking limit.

**Keywords:** Godwar, Water Samples, Nitrate, Ion-exchange resin.

### INTRODUCTION

Quite recently the groundwater department of Government of Rajasthan has reported the alarmingly high concentration of nitrate. Gupta and Jain from Ground Water Board (GWB) Jodhpur, Rajasthan (India) have reported in a paper presented at national conference on water resources at Roorke<sup>5</sup>, very high concentration of nitrate in a number of districts of the state. This comprehensive survey of nitrate contamination in drinking water from 15 selected districts of Rajasthan was carried out in 1995. The nitrate level in 5000 samples was determined and classified into four categories viz. up to 50ppm, 50-100ppm, 100-250ppm and 250ppm,.

Waters high in nitrates, over 10ppm, cause "blue babies". Two health hazards are identified with nitrate-contaminated waters; induction of methemoglobinemia (oxygen deprivation), especially in infants and possible formation of carcinogenic nitrosamines<sup>2,4</sup>. Acute toxicity of nitrate is caused by its rapid reduction to nitrite in the stomach. The nitrite then converts hemoglobin (blood pigment that carries oxygen) to methemoglobin, Methemoglobin does not act as an oxygen

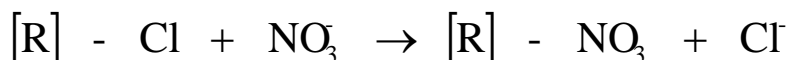
carrier, a consequently anoxia and death may be caused<sup>8-9</sup>.

Nitrate is a stable and highly soluble ion with low potential for co-precipitation or adsorption. These properties make it difficult to remove using conventional water treatment technologies such as lime softening and filtration. More sophisticated technologies viz. chemical denitrification, ion exchange, reverse osmosis, electro dialysis, catalysis denitrification and biological denitrification can be used to remove nitrates from drinking water. Ion-exchange can provide an attractive alternative, especially for small and average size facilities. Ion-exchange is considered suitable for ground water that relatively free of dissolved organic matter. The presence of organic matter can cause fouling of ion-exchange resins and reverse osmosis membranes. The low TDS water (500 mg/L) can be effectively treated using the ion-exchange process if the sulphate concentration is less than 300 mg/L for nitrate removal from water containing more than 1000mg/L TDS, Electro dialysis and Reverse osmosis, Capacitative deionization would be more effective, full scale application of Electro

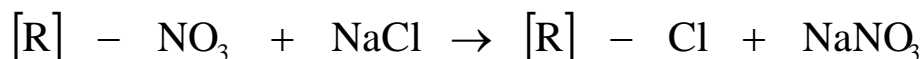
dialysis appears unlikely in the near future for economic reasons<sup>10</sup>.

### EXPERIMENTAL

The ion-exchange process involves passage of nitrate laden water through a



The exhausted resin is regenerated using a concentrated solution of sodium chloride or sodium bicarbonate.



Typically, the increasing order of ion selectivity for on ion exchange resin is bicarbonate, chloride, and nitrate than sulphate. Treatment of high sulphate water with typical resin is difficult because the nitrate removal capacity of the resin is reduced by the sulphate ions. The use of the resins with nitrates preference over sulphate ions would be beneficial. Resins with a higher selectivity for nitrate can be produced by increasing the number of carbon atoms around ammonium nitrogen in the resin structure. The increasing order of ion selectivity for such resins changes to bicarbonate, chloride, and sulphate than nitrate. The nitrate to sulphate selectivity increases from 100 to 1000 when ethyl group in place of methyl groups surrounds ammonium nitrogen. Clifford and weber<sup>6</sup> (1978) observed that sulphate selectivity can be reduced by increasing the distance between ion exchange sites, and nitrate selectivity can be increased by increasing the matrix and functional group hydrophobicity. The increased selectivity for nitrates has been attributed to steric strains in the resins that results from higher steric requirements of alkyl groups and the higher capability of nitrate to reduce the steric strains over sulphate. Guter<sup>7</sup> noted that compared to trimethyl amine resins triethyl amine resins increased the bed life by 62% when treating water containing 1.5m eq/ L nitrate and 6.5 m eq/ L

resin bed containing strong base anion (SBA) exchange resins on which nitrate ions are exchanged for chloride ions until the resins exchange capacity is exhausted.

Regenerate usage is also decreased by 25.50%, thus reducing the cost of the ion exchange process. Use of nitrate selective resins also reduces nitrate peaking, which occurs with conventional resin due to sulphate displacement of nitrate.

### METHOD OF REMOVAL OF NITRATE ION

The twenty sampling stations were selected for seasonal studies in godwar region. Nitrate contamination in drinking water samples of station – 8: Bawari – Desuri, near police station, Station – 9: Hand pump, near the railway station, phalana city, Station – 13: Hand pump, Devtara, near railway crossing, Phalana city, station – 14: Hand pump, Doodaria, Desuri, Station – 15: Hand pump, Kabristan, Desuri and Station – 16, Godawada dam, Narlai, Desuri obtained are in the range of 70 to 472ppm.

### MATERIAL AND METHODS

#### Material (Ion exchange resin)

The anion exchange resin Tulsion A-36MP (Tulsion exchange, India) are manufactured under the technical collaboration of ionic chemical company, a division sybron corporation USA. The characteristics of this macroporous strong base type II resin are given below:

#### RESIN: A: 36MP (MACRO POROUS STRONG BASE TYPE II RESIN)

Tulsion  
Type

: A-36 MP  
: Strong base

Matrix structure	: Polyesterene Co-polymer
Functional group	: Quaternary Ammonium Type II
Ionic form supplied	: chloride
Screen size v/s Mesh	: 16-50 $\mu$
Particle size	: 0.3-1.2 $\mu$
Stability maximum Temp $^{\circ}$ F/ $^{\circ}$ C	: 140/60
pH range	: 0-14
Total exchange capacity	
(a) as per gm/lit as CaCO <sub>3</sub>	: 26.4
(b) as Meq/ml	: 1.3
Moisture content %	: 49
Reversible swelling	: Cl $\rightarrow$ OH <sup>-</sup> 9 moist spherical leads
Features	: macroporous strong base type II anion exchange resin having high regeneration efficiency and resistant to organic fouling
Application	: Multiple bed deionization and dealkalization
Free chlorines	: Nil
Iron and heavy metals	: less than 0.05 to 0.1 mg/L
Turbidity	: less than 2 to 5 units

This resin was found to be suitable for removal of nitrate.

### REMOVAL OF NITRATE BY ION EXCHANGE METHOD

The ion exchange process<sup>1,3</sup> involves passage of nitrate laden water through resin bed containing strong base anion are exchanged for chloride ions until the resins exchange capacity regenerated using a concentrated solution of sodium chloride.

#### Experiment -1

##### Determination of the exchange capacity of the ion exchange resin

The manufacturers of A-36 MP anion exchange resin have specified the exchange capacity to be 26.4gm CaCO<sub>3</sub>/liter i.e. 1.32meq/ml. Since the resin capacity does remains constant and is alter after every regeneration. The exchange capacity of the resin to be used in the experiment was determined. The resin was regenerated by soaking 295 mℓ resin in one thousand ml 1.0N NaCl for 6 hours. The resin was filtered and packed into an 11 inches long column with 2-inch diameter. Now the column was washed with distilled water, by passing distilled water at the rate of 3 mℓ/min. The effluent was checked for the presence of chloride ions. The resin was considered to be fit for experiment, when the effluent was free

from chloride ion on testing with silver nitrate.

A standard 1.0 N nitrate solution was prepared by dispersing 85gm NaNO<sub>3</sub> in 1000 mℓ water. These 1000ml nitrate solution was passed through the resin and effluent was collected. The effluent was analyzed for the chloride by titrating it with 0.11N AgNO<sub>3</sub>. It was observed that 10 mℓ of effluent consumed 26.0 mℓ 0.11AgNO<sub>3</sub>.

#### Experiment -2

After determining the exchange capacity of the resin, the stepwise nitrate removal was studies to optimize the condition for removal of nitrate.

Resin: Macroporous strong base type  
Resin volume: 295 ml resin was packed in 11" long column and 2" diameter.

### RESULTS AND DISCUSSION

**Experiment 2(a)** a series of experiments were carried out by passing water sample of station -15 (Hand pump, Kabristan, Desuri) and Station - 16, (Godawada dam, Narlai, Desuri) containing 79.0ppm and 72.0ppm nitrate through the column at flow rate of 10 mℓ /min. the residual nitrate concentration was found to be 5-6 ppm which much below to acceptable unit 40ppm. It was also found that, when 40

litre of the water sample was passed, the residual nitrate concentration was 30ppm and 29ppm, the results are shown in Table – 1 & Figure 1 & 2. These results clearly demonstrate that this resin is capable of treating 40 liter of highly contaminated water sample with 100ppm nitrate to safe drinking limit.

In another set of **experiment 2(b)**, the saturation capacity was determined. For this purpose, water samples of station – 8: Bawari, Desuri, near police station, Station – 9: Hand pump, near the railway station, phalana city, Station – 13: Hand pump, Devtara, near railway crossing, Phalana city and station – 14: Hand pump, Doodaria, Desuri, of 352, 358, 379 & 472ppm nitrate respectively were passed through the column. The nitrate present in the sample was monitored after every 2 litre sample water. The results are reported in Table – 2 & Figure 3, 4, 5 and

6. It is observed that when 25 litres of water sample of station – 8: Bawari – Desuri, near police station, Station – 9: Hand pump, near the railway station, phalana city, Station – 13: Hand pump, Devtara, near railway crossing, Phalana city and station – 14: Hand pump, Doodaria, Desuri, was passed, the residual nitrate were 320, 322, 335 & 425 ppm respectively. It is further observed that upto 24 litres of the water sample of station – 8: Bawari – Desuri, near police station, Station – 9: Hand pump, near the railway station, phalana city, Station – 13: Hand pump, Devtara, near railway crossing, Phalana city and station – 14: Hand pump, Doodaria, Desuri, the resin functions well and produce the treated water with nitrate concentration of 85ppm in station 8.88ppm in station 9.98ppm in station 13 & 112ppm in station 14.

**Table 1: Concentration of Nitrate in sample of station-15 and station16**

S. No.	Volume of effluent passed (litre)	Concentration of NO <sub>3</sub> <sup>-</sup> (ppm)	
		At Station-15	At Station-16
1	2	6.0	5.8
2	4	5.4	5.2
3	6	5.0	4.8
4	8	4.8	4.5
5	10	5.7	5.1
6	12	7	6
7	14	12	11
8	16	14	13
9	18	16	15
10	20	20	19
11	22	22	21
12	25	25	24
13	30	26	25
14	35	28	27
15	40	30	29

**Table 2: Concentration of Nitrate in sample of station – 8, 9, 13, 14**

S. No.	Volume of effluent passed (litre)	Concentration of NO <sub>3</sub> <sup>-</sup> (ppm)			
		At Station-8	At Station-9	At Station-13	At Station-14
1	2	28	29	31	39
2	4	25	26	28	36
3	6	22	23	25	33
4	8	19	20	23	30
5	10	23	24	28	37
6	12	27	28	32	41
7	14	31	31	37	46
8	16	35	36	42	51
9	18	36	37	43	52
10	20	39	40	46	55
11	21	56	57	67	77
12	22	58	60	68	78
13	23	70	72	83	95
14	24	85	88	98	112
15	25	320	322	335	425

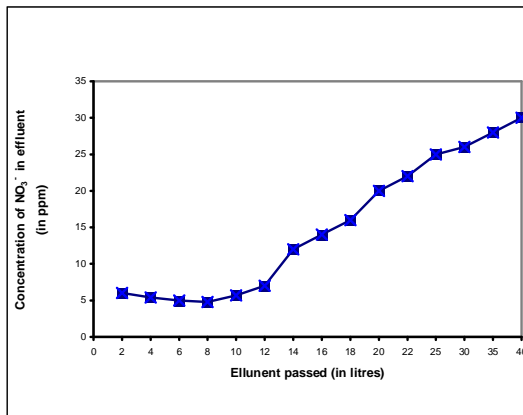


Fig. 1: Concentration of Nitrate in sample of station -15

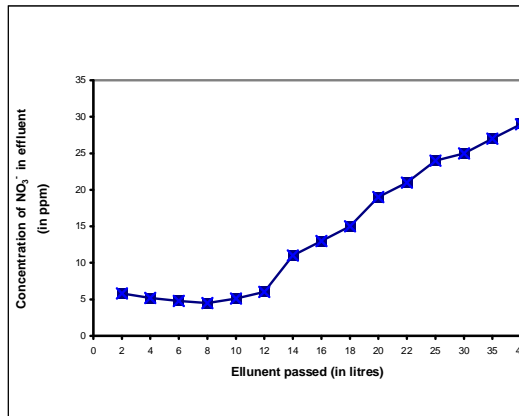


Fig. 2: Concentration of Nitrate in sample of station -16

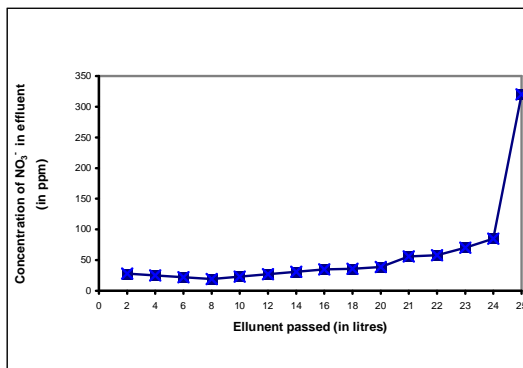


Fig. 3: Concentration of Nitrate in sample of station -8

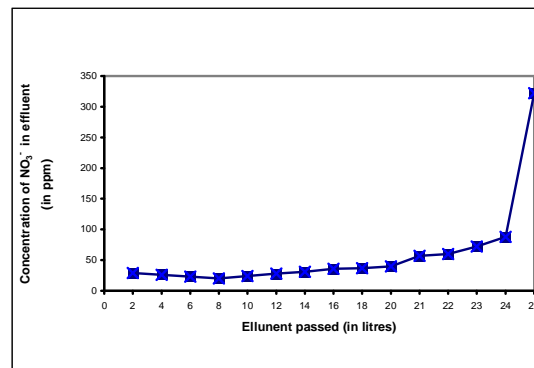


Fig. 4: Concentration of Nitrate in sample of station -9

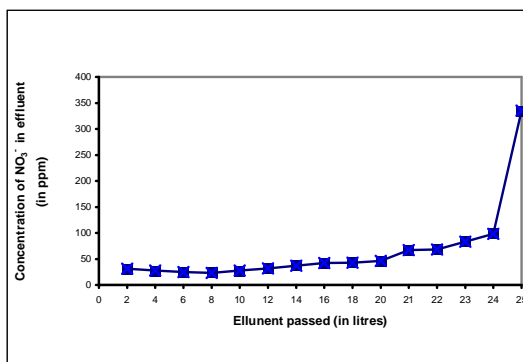


Fig. 5: Concentration of Nitrate in sample of station -13

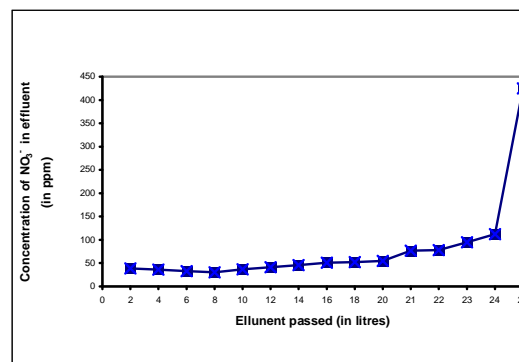


Fig. 6: Concentration of Nitrate in sample of station -14

## CONCLUSION

The nitrate content in the water as reported in this study ranged from 472 mg/L to 2.18 mg/L and most of them have had health risks in large consumption.

The anion exchange resin Tulsion A-36 MP (Tulsion exchanges, India) was used for removal of nitrate in sample of station - 15 (Hand pump, Kabristan, Desuri) and Station - 16, (Godawada dam, Narlai,

Desuri), station – 8: Bawari, Desuri, near police station, Station – 9: Hand pump, near the railway station, phalana city, Station – 13: Hand pump, Devtara, near railway crossing, Phalana city and station – 14: Hand pump, Doodaria, Desuri.

Desirable limit of Nitrate (as  $\text{NO}_3^-$ ) mg/L is 45, beyond this methemoglobinemia takes place. In some water samples during the survey period it is much higher than the limit. Since it is not always possible in large scale to identify whether the nitrate content in waters are within the limit, it is highly advisable to reduce the consumption of water nearby extensive agricultural field where nitrogeous fertilizers are frequently used. Moreover, optimum use of nitrogeous fertilizer for controlling the nitrate contaminations in waters is essential.

#### REFERENCES

1. Wild A. Nature. 1977;268:197-198.
2. Croll BT and Hayes CR. Envir. Pollution. 1988;50:163-187.
3. Terbulance APS. Water SA. 1991;17(1):77-82.
4. Bauchard DC, William NK and Surampalli RY. J. AWWA. 1992; 84(9): 85-90.
5. Gupta SC and Jain GS.. National Conference on water resources at Roorkee (India), 1995;200-207.
6. Clifford D and Weber Jr. WJ. VS. US Environmental Protection Agency (EPA), Cincinnati, Ohio, 1978600/2,78-052.
7. Guter GA.. U.S. Environmental Protection Agency (EPA), Cincinnati, Ohio, 1982;600/2,82-042
8. Maheshwari R. Water Engineering News, September. 2006;10(5):7-9.
9. Maheshwari R, Singh U and Rani B. Everything About Water. 2011;110-118
10. Maheshwari R. Water Digest. 2007;2(3):84 – 87.