

FATE OF NITRILOTRIACETIC ACID DURING GROUNDWATER RECHARGE

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ABSTRACT

Experiments were carried out during 1½ year in a pilot plant in order to study

- the degradation of nitrilotriacetic acid (NTA: substitute for phosphate in detergents) during artificial groundwater recharge.
- the possible mobilization of heavy metals from the soil of the aquifer as a result of the formation of NTA-metal complexes.

From the results can be concluded that complete removal of NTA during percolation can be expected for concentrations of up to 2 mg NTA/l in the surface water used for recharging, even during the period of low water temperatures and under anaerobic conditions. The mobilization of trace elements from the aquifer during the percolation of water containing these low concentrations of NTA was not detected and is considered to be improbable.

INTRODUCTION

Nitrilotriacetic acid (NTA) has been considered as a substitute for phosphates in synthetic detergent. This will lead to the presence of NTA in municipal waste water and in fresh water sources. A substantial part of surface water for drinking water supply in The Netherlands is recharged into the dune area. Therefore, the fate of NTA during the artificial recharge is of special interest.

Theoretical Aspects

A number of previous studies have shown that NTA is biodegraded fairly rapidly under aerobic conditions and at higher temperature. However, conflicting findings have been reported about the effect of low water temperature and/or low redox-potential on the rate of NTA biodegradation.

Another serious concern about the environmental impact of NTA arises from the possible mobilisation of heavy metals from the bottom sediments of inland waters and from the soil during percolation of water containing NTA as a result of the formation of NTA-metal complexes.

MATERIALS AND METHODS

The study was carried out in the pilot plant which consisted of two recharge filters, each 6.5 m high and 2 m in diameter. One filter was filled with dune sand and the other with sand from the Veluwe area in the central part of The Netherlands. NTA was injected in recharge water to obtain a final concentration of 1 mg NTA/l. The detention time of water in the sand bed was about 6 days.

RESULTS

a. Period November 1976 - March 1977

Recharge under aerobic conditions.

Dosing of NTA was started 3 November 1976. Figure 1 shows that NTA was first detected in the effluent after about two weeks of recharge and disappeared from the effluent of the Veluwe filter after 6 - 8 weeks.

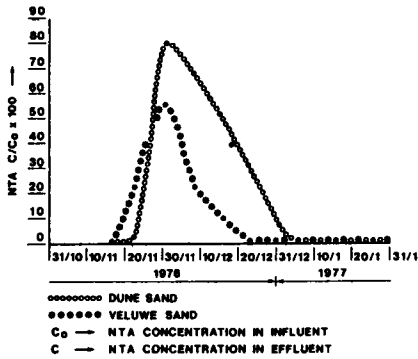


Fig. 1. Variation of NTA concentration during passage through the recharge filters under aerobic condition

The paths of the breakthrough curves indicate that only during the first 3 weeks sorption played a role in NTA removal. After the acclimatisation time of 6 - 8 weeks no more NTA was detected in the effluents of the filters, even during the period with a water temperature of 3 - 5°C.

b. Period March - November 1977

Recharge under anaerobic conditions.

Due to the relatively low concentrations of organic matter and ammonia in the recharge water it was necessary to dose a reductant (Glucose) in order to achieve anaerobic conditions in the sand beds. Under the anaerobic conditions in the sand beds the NTA concentrations in the effluent remained lower than the detection level.

Changes in concentrations of the trace elements during the recharge are presented in Table 1. The figures of this table show that there was a substantial removal of Zn and some removal of Al, Cr, Cu and Ni, no removal of Pb and a slight increase in Cd. Because of the slight increase in Cd concentration in both effluents after recharge

and because no changes of Cd concentrations during the percolation through sand were observed during the tests with the recharge of water without NTA, mobilisation of Cd by NTA was assumed as a potential factor.

Table 1

Trace elements in the influent and the effluent of the recharge filters
N = number of samples; \bar{X} = arithmetic mean; Sx = standard deviation

| Element ($\mu\text{g/l}$) | Influent | | | Effluent Dune filter | | | Effluent Veluwe filter | | |
|--------------------------------|----------|-----------|------|----------------------|-----------|-------|------------------------|-----------|-------|
| | N | \bar{X} | Sx | N | \bar{X} | Sx | N | \bar{X} | Sx |
| Al | 18 | 24.2 | 14.6 | 17 | 18.9 | 11.4 | 18 | 18.0 | 14.4 |
| Cr | 18 | 3.1 | 1.62 | 18 | 1.0 | 0.53 | 18 | 0.65 | 0.41 |
| Cu | 19 | 4.7 | 4.33 | 19 | 2.4 | 1.12 | 19 | 2.7 | 1.25 |
| Ni | 18 | 3.4 | 1.34 | 19 | 2.2 | 0.85 | 19 | 2.5 | 1.5 |
| Pb | 19 | 1.9 | 1.10 | 19 | 1.8 | 1.17 | 19 | 1.8 | 1.15 |
| Zn | 10 | 76 | 88.9 | 18 | 16 | 7.0 | 19 | 13 | 8.2 |
| Cd ¹⁾ | 19 | 0.20 | 0.21 | 19 | 0.35 | 0.16 | 19 | 0.30 | 0.17 |
| Cd ²⁾ | 8 | 0.1 | 0 | 8 | 0.225 | 0.046 | 8 | 0.175 | 0.046 |
| Cd ³⁾ | 10 | 0.30 | 0.09 | 10 | 0.26 | 0.10 | 8 | 0.25 | 0.09 |

1) Period 28/02 - 25/10/1977

2) Period 25/10 - 13/12/1977

3) Period 10/01 - 08/05/1978

To prove this, dosing of NTA was stopped for two months (25 October - 13 December '77), the increase in Cd concentrations after recharge continued (see table 1). However, during the last period of the experiments during the recharge of water with 2 mg NTA/l (10 January - 8 May 1978) a decrease of Cd concentration after the recharge was detected. The conclusion from these facts is that it seems unlikely that the Cd increase was caused by NTA.

c. Period December 1977 - May 1978

Recharge under anaerobic conditions at low temperature.

NTA could not be detected in the effluents of the recharge tanks despite the low water temperature (4 - 7°C) and anaerobic conditions. From mid February 1978 the NTA concentration of the influent water was increased to 2 mg/l. This increase had no influence on the removal and the NTA concentrations of the effluents remained lower than the detection limit.

CONCLUSIONS

This study supports the following conclusions:

- Complete removal of NTA at concentrations of up to 2 mg NTA/l can be expected during artificial recharge of surface water into sandy soil under aerobic and slightly anaerobic conditions in the aquifer, which is a situation prevailing in the groundwater recharge practice in The Netherlands. This complete degradation can also be achieved at low water temperatures (3 - 5°C).
- The mobilisation of trace elements from the recharge aquifer as a result of percolation of water containing NTA up to a concentration 2 mg NTA/l is improbable.

REFERENCES

- 1 Hrubec, J. and Van Delft W.; Behaviour of nitrilotriacetic acid during groundwater recharge. Water Research 15 (1981): 121-128.