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Retention of herbicides and pesticides in relation to aging of RO membranes

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Abstract

Amsterdam Water Supply (AWS) intends to increase the capacity of the Leiduin production plant. In the existing plant (capacity 70×10^6 m^3/y) pretreated Rhine River water was infiltrated in the dune area west of Amsterdam for artificial recharge and after a residence time of approximately 100 days extracted and posttreated to achieve drinking water quality. In the extension (capacity 13×10^6 m^3/y) the pretreated (coagulation, sedimentation, filtration) Rhine River water was not infiltrated in the dunes, but was treated directly without soil passage. First, an additional pretreatment (ozonation, biological activated carbon filtration and slow sand filtration) was carried out, and finally reverse osmosis (RO) was used for desalination, hardness removal, disinfection and removal of pesticides and others micro-pollutants. Former research on removal of pesticides has already showed a removal of >99.5% with the ozonation/BACF preceding RO. To prove high retention of RO membranes as a second barrier and to examine the influence of aging of the membranes, several dosing experiments were carried out by AWS and Kiwa. During the period before March 1997, Toray SU710L membranes were used. From then on Fluid Systems 4821ULP membranes have been used in the RO pilot plant. The RO feed flow is 9 m^3/h and the recovery is 85%. To compare the removal of pesticides and herbicides with the two different applied RO membranes, six dosing experiments were carried out: two with the Toray membranes and four with the Fluid Systems membranes. A cocktail of pesticides was dosed with a feed concentration of approximately 5 μg/l. The results of the test showed an equal retention for bentazon, DNOC and pirimicarb for both types of membranes. The removal of metamitron and metribuzin was substantially higher with the Fluid Systems membranes. As a result, it was concluded that RO is a second barrier for pesticides in this treatment concept as biological activated carbon filtration in the first barrier. Retention of the Fluid Systems membranes is higher than the retention of the Toray membranes. After 3 years of operation with the Fluid Systems membranes, no pesticide retention decline was observed.

Keywords: RO membranes; Retention; Pesticides; Membrane aging; Dosing experiments

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1. Introduction

Amsterdam Water Supply (AWS) intends to increase the capacity of the Leiduin production plant. In the existing plant (capacity 70×10^6 m^3/y) pretreated Rhine River water was infiltrated into the dune area west of Amsterdam for artificial recharge, and after a residence time of approximately 100 days was extracted and posttreated to achieve drinking water quality. In the extension (capacity 13×10^6 m^3/y) the pretreated Rhine River water was not infiltrated into the dunes, but was treated directly without soil passage. First, additional pretreatment was carried out, and finally reverse osmosis (RO) was used for desalination, hardness removal, disinfection and removal of pesticides and other micro-pollutants.

Rhine River water is pretreated by coagulation and rapid sand filtration. Subsequently, ozonation, biological activated carbon filtration and slow sand filtration was carried out, followed by RO as final treatment step. Former research on removal of pesticides showed a removal of >99.5% with the ozonation/BACF preceding the RO [1]. With peak dosing experiments a mix of diuron, isoproturon, bentazon, atrazin, simazin, DNOC, pirimicarb, metamitron, metribuzin, MCPA and mecoprop was added to the feed water with concentrations of approximately 20 μg/l each. In these experiments removal of pesticides and organic micro-pollutants by ozone-biological activated carbon filtration and RO was researched.

Figs. 1 and 2 show a decrease in concentrations in the pretreatment before RO. It is clear that after biological activated carbon filtration all the pesticides are removed. After ozonation most of the pesticides are already removed for the most part. As a consequence, the dosing of pesticides must be done in the feed of the RO.

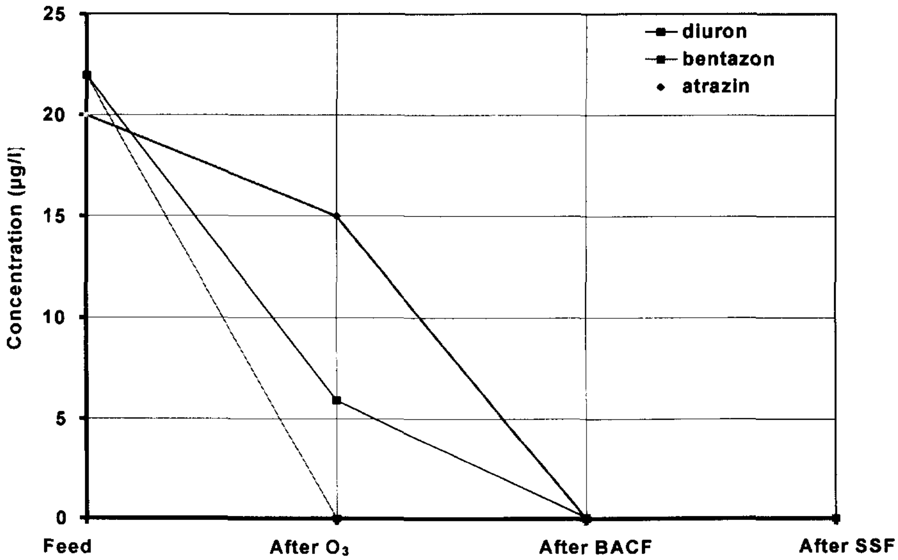

Fig. 1. Removal of the pesticides diuron, bentazon and atrazin by ozonation, biological activated carbon filtration and slow sand filtration.

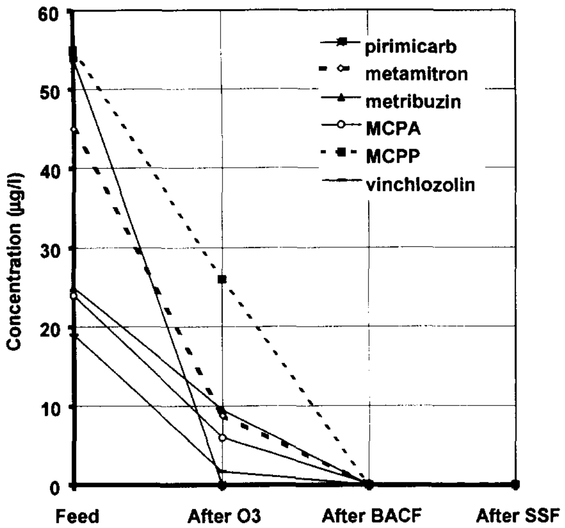

Fig. 2. Removal of pirimicarb, metamitron, metribuzin, MCPA, MCPP and vinchlozolin by ozonation, biological activated carbon filtration and slow and filtration

2. Pesticides

To prove the high retention of RO membranes as a second barrier and to examine the influence of aging of the membranes, several dosing experiments were carried out by AWS and Kiwa. During the period before March 1997, Toray SU 710L membranes were used. Since then Fluid Systems 4821 ULP membranes have been used in the RO pilot plant. The feed flow of the RO was 9 m^3/h and the recovery 85%. More details have been previously described [1,2]. Since the beginning using the Fluid Systems 4821 ULP membranes from 19 March 1997, the membranes have been cleaned six times (see Table 1).

To compare the removal of pesticides and herbicides with the two different applied RO membranes, six dosing experiments were carried out: two with the Toray membranes and four with the Fluid Systems membranes. Only bentazon and DNOC were dosed in both periods. The same cocktail as described above was dosed with feed concentrations of approximately 5 µg/l. The results of the tests with the Fluid System membranes are shown in Fig. 3. The total duration time of the experiment with the Fluid System membranes was 894 days or 2.5 years.

Table 1
Pesticide retention

	Experiment					
	July 1994	August 1994	August 1997	April 1998	October 1998	August 1999
Membrane	Toray SU-710L		Fluid Systems 4821 ULP			
Recovery, %	90	86	86		85	85
Retention, %						
Diuron	87	89				
Isoproturon	97					
Atrazin	99	99				
Simazin		98				
Bentazon	99	99	99	99	99	100
DNOC		97	95	96	96	96
Pirimicarb			99	99	99	
Metamitron			89	95	94	94
metribuzin			98	99	99	100
MCPA			99	99	99	97
Mecoprop			99	99	99	97

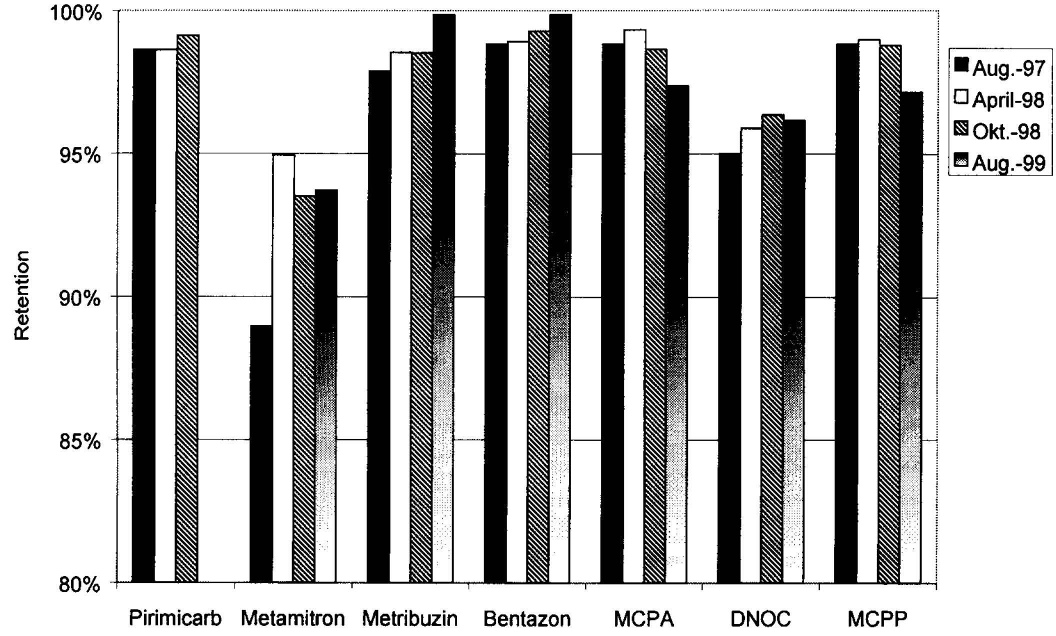

Fig. 3. Development of pesticide retention with the Fluid System ULP membranes.

The results of the test are an equal retention for bentazon, DNOC and pirimicarb for both types of membranes (see Table 1 and Fig. 3). The removal of metamitron and metribuzin is substantially higher with the ultra-low-pressure Fluid Systems membranes.

It can be concluded that RO is a second barrier for pesticides in this treatment concept with biological activated carbon filtration as a first barrier. Retention of the Fluid Systems membranes is higher than that of the Toray membranes. After 3 years of operation with the Fluid Systems membranes, no pesticide retention decline was observed.

4. Removal of sodium, chloride and electric conductivity

The removal of sodium, chloride and electric conductivity by the RO installation is given in Fig. 4, which shows that the retention of sodium is strongly influenced by temperature. For chloride and electric conductivity the temperature influence is less. Retention in 1999 was almost as high as in 1997.

References

[1] J.P. van der Hoek and P.A.C. Bonné, Removal of pesticides and organic micropollutants with the pilot plant WOKOL and retention of RO membranes in the pilot plant WL-RO1, The Netherlands, Leiduin, Amsterdam Water Supply, 1994 [in Dutch].

[2] J.P. van der Hoek, Possibilities extension production capacity, Abstract, End Report, Amsterdam Water Supply, 2000 [in Dutch].

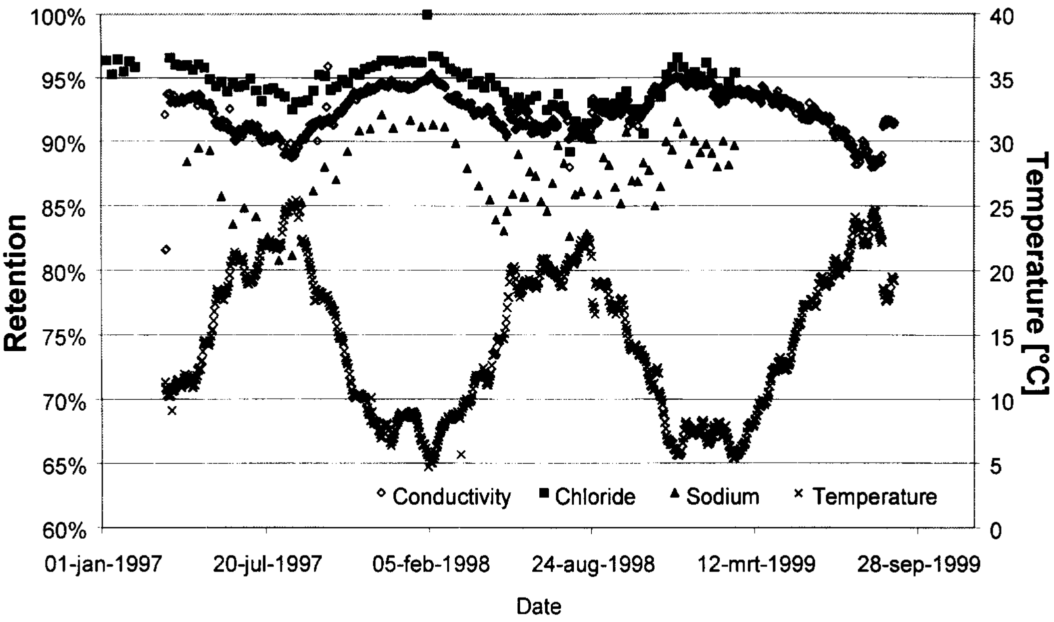

Fig. 4. Removal of sodium, chloride and electric conductivity in the RO installation.