HEALTH, SAFETY AND ENVIRONMENTAL CONSIDERATIONS

Y. Magara
Urban Environment Engineering, School of Engineering, Hokkaido University, Japan

S. Iso
Tokyo Kyuei Co. Ltd., Japan

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Summary

There are still many unsolved problems regarding the effects on marine organisms of brine discharged into the sea. After constructing seawater desalination plants, therefore, it is important to carry out monitoring and fully grasp the effects on marine organisms.

1. Health Hazards of Reverse Osmosis Water Desalination

1.1. Quality of Production Water

The World Health Organisation (WHO) revised the drinking water quality guidelines (hereafter DWQG) and recommended them to membrane countries in 1993. The guidelines recommended the concentration of constituents that would not result in any significance risk to consumers' health over a lifetime of consumption. WHO is also encouraging the establishment of a national drinking water quality standard based on the drinking water quality guidelines. This will need to take account of a variety of geographical, socio-economic, dietary, and other conditions affecting potential exposure to contaminants (WHO 1993). Based on the recommendation of WHO drinking water quality guidelines, many countries have developed their own national drinking water quality standard.

Countries and regions which suffer from a shortage of fresh water resources have developed sea and brackish water desalination plants to supply drinking water and other domestic consumption water. Desalinated water by reverse osmosis (RO) process carries no risk of microbiological pathogens because the membrane acts as a complete barrier to them.

Since seawater contains many varieties of inorganic constituents which are listed in WHO (DWQG) and Japanese Drinking Water Quality Standard (hereafter DWQS; Magara, Kunikane and Ito 1994), it is necessary to confirm the extent of those constituents remaining in RO filtrate. Okinawa prefectural waterworks in Japan are going to operate a 40 000 m^3 day^{-1} seawater desalination plant by RO process. In the feasibility studies of this plant the comprehensive experiment was implemented (Magara 1994).

The performance of RO process from the point of the rejection of inorganic constituents was studied, and the results are shown in Table 1. The study used a polyamide-type membrane under a pressure of 62 $kgf\ cm^{-2}$ at 28.6°C of seawater. The recovery ratio of fresh water under the test condition was 40 per cent. Most of the inorganic constituents except boron and bromide were rejected more successfully than the design salt rejection ratio, i.e. 99 per cent, as shown in Table 1. The RO filtrate meets WHO DWQG and DWQS (although boron has caused testicular atrophy in short- and long-term animal studies and does not meet the guidelines).

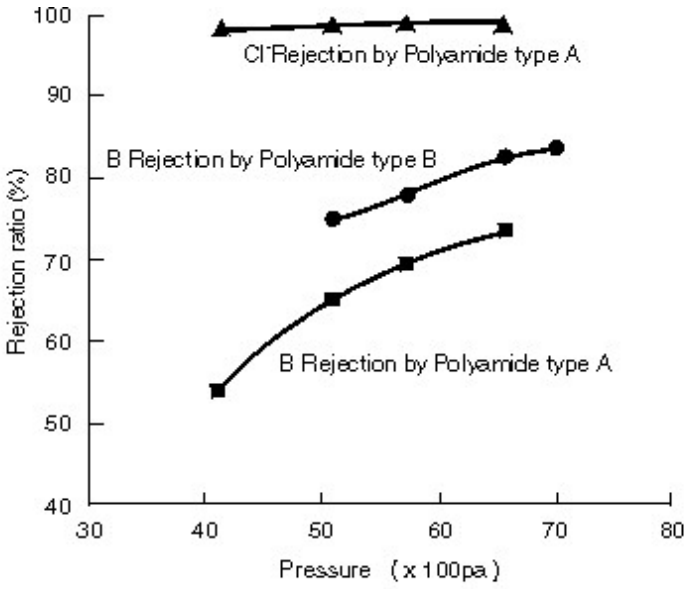
Mineral	**Seawater**	**WHO, DWOG**	**JPN, DWQS**	**RO water**	**1% of seawater**
B	4.5×10^{3}	3.0×10^{2}	2.0×10^{2}	1.3×10^{3}	4.5×10^{2}
F	1.4×10^{3}	1.5×10^{3}	8.0×10^{2}	<D.L	
Na	1.1×10^{7}	2.0×10^{5}	2.0×10^{5}	6.6×10^{4}	1.1×10^{5}
Ca	4.2×10^{5}	-	3.0×10^{5}*	5.7×10^{3}*	4.2×10^{3}*
Mg	1.3×10^{6}	-			
Al	2.0	2.0×10^{2}	2.0×10^{2}	<D.L	
Cl	2.0×10^{7}	-	2.0×10^{5}	1.1×10^{3}	2.0×10^{5}
Cr	2.0×10^{-3}	5.0×10^{1}	5.0×10^{1}	<D.L	
Mn	5.0×10^{-4}	5.0×10^{2}	5.0×10^{2}	<D.L	
Fe	2.0	-	3.0×10^{2}	<D.L	
Ni	5.0×10^{-1}	2.0×10^{1}	1.0×10^{1}	<D.L	
Cu	2.0×10^{-1}	2.0×10^{3}	1.0×10^{3}	<D.L	
Zn	4.0×10^{-1}	-	1.0×10^{3}	<D.L	
As	2.3×10^{-1}	1.0×10^{1}	1.0×10^{1}	<D.L	
Se	1.1×10^{-1}	1.0×10^{1}	1.0×10^{1}	<D.L	
Br	6.8×10^{4}	2.5×10^{1}**	-	5.0×10^{2}	6.8×10^{2}
Cd	8.0×10^{-2}	3.0	1.0×10^{1}	<D.L	
Sb	2.0×10^{-3}	5.0	2.0	<D.L	
Ba	1.4×10^{1}	7×10^{2}	-	<D.L	
Hg	4.0×10^{-2}	1.0	5.0×10^{1}	<D.L	
Pb	3.0×10^{-1}	1.0×10^{1}	5.0×10^{1}	<D.L	

Note: * as hardness; **as bromate.

Table 1. Concentration of inorganic constituents in seawater, RO filtrate and related standards ($\mu g\ l^{-1}$).

In order to make clear the rejection of boron by RO process, the rejection ratios of

chloride ion and boron under a variety of driving pressure conditions were conducted as shown in Figure 1. As shown in the figure, the rejection of boron and other dissolved inorganic matter has not yet been identified. As RO filtrate is the single drinking water source, it is necessary to control boron by other measures such as two stage RO process and ion exchange process to reduce the health risk from boron.



(The recovery rate of type A and type B is about 40% and 20%, respectively)

Figure 1. Rejection of chloride (Cl) and boron (B).

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