Membrane Separation Technology:
Lifting Japan's Water-linked Environment Business

By Association of Membrane Separation Technology of Japan

1. Origin of Environmental Business

Japan has 40 years of experience in developing elemental technologies that have led to establish core technologies overcoming a variety of environmental problems such as air/water pollution and noise, aggravated in the wake of the nation's industrial development. Japanese environmental efforts that began by coping with the negative side – environmental deterioration – eventually turned to the positive side, leading to the active development of environment-friendly core technologies by corporations that saw business opportunities in this sector. Today, Japan is seeking to contribute to the international community by developing and spreading the core technologies as environmental business on a global basis.

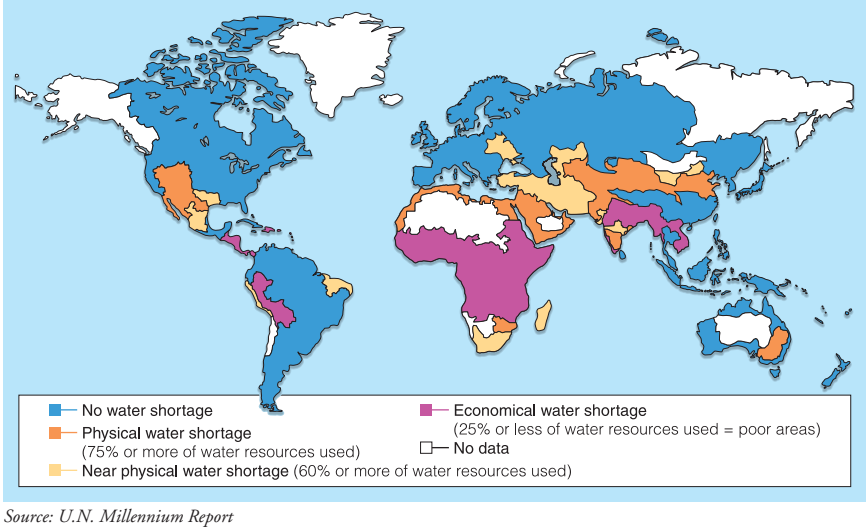
Generally, environmental business by definition includes a host of businesses ranging from products and services with less environmental load to environmental preservation technologies and systems. This report will introduce Japan's contribution to the international community in the area of membrane separation technology as a part of Japan's core state-of-the-art technologies in connection with water-related environmental business.

2. Water-related Environmental Problems

Global population growth has resulted in greater demand for water for daily life, agricultural water for increased food production and industrial water for socioeconomic activities. Total water demand registered a 2.5-fold leap in the last 40 years. In 2025, a total of 3 billion people in 52 countries of arid areas such as the Middle East are expected to be suffering from water shortages *(Chart)*.

Human society needs energy, food and water for sustainable development. Water in particular is considered to be the most important material as one of essential elements to maintain life. Membrane separation technology changes undrinkable water such as seawater and urban wastewater into safe water with great efficiency, providing a necessary amount of water when needed. The technology has made it possible to supply high-quality water at affordable prices.

CHART
World map of water shortages



Source: U.N. Millennium Report

3. Water-Environment Business: Demineralization, Purification, Wastewater Treatment & Reuse

The Association of Membrane Separation Technology of Japan (AMST) classifies membranes used in the separation technology into the following categories: the seawater reverse osmosis (SWRO) membrane, the brackish water reverse osmosis (BWRO) membrane, the nanofiltration (NF) membrane for the separation of solute in clean water, the ultrafiltration (UF) and microfiltration (MF) membranes for the elimination of viruses and particles, and the large-pore membrane for cryptosporidium removal.

* SWRO Membrane

Currently, large-scale desalination plants based on the SWRO membrane technology, each with a capacity of more than 100,000 tons per day, have been built and in operation all over the world. *Table 1* shows major SWRO desalination plants in operation. Their key device, the reverse osmosis (RO) membrane element, is almost exclusively supplied by Japanese manufacturers. According to a survey conducted by the AMST, approximately 70% of all RO membranes are made in Japan, underlining the country's contribution to mitigating the worldwide shortage of water.

* MF/UF Membranes for MBR

In newly emerging countries with rapidly growing populations, urban sewerage and household wastewater are often discharged into rivers after perfunctory treatment. It is safe to say their major challenge is to take measures to reduce the environmental load, including the practical processing of wastewater sludge, from the viewpoint of water-linked environmental preservation.

The membrane bio-reactor (MBR), Japan's state-of-the-art water treatment technology, is

TABLE 1

Major desalination plants in operation

No.	Plant/City	Country	Capacity(m^3/day)	Since
1	Ashkelon	Israel	330,000	2005
2	Rabigh	Saudi Arabia	218,000	2008
3	Hamma	Algeria	200,000	2008
4	Fujairah	United Arab Emirates	170,000	2003
5	Perth	Australia	136,000	2006
6	Point Lisas	Trinidad & Tobago	136,000	2002
7	Tuas	Singapore	136,000	2005
8	Medina Yanbu 2	Saudi Arabia	128,000	1998
9	Carboneras	Spain	120,000	2002
10	Jeddah 1	Saudi Arabia	113,600	1989/94

Note: Colored frames show plants using Japanese-made membranes.
Source: Association of Membrane Separation Technology of Japan

a hybrid system combining biological processing that uses highly concentrated activated sludge and solid-liquid separation processing that uses membrane separation technology. As compared with the widely used standard activated sludge method, the hybrid system has a significantly reduced plant footprint, is easy to maintain, and is a sophisticated and stable wastewater-processing method. The MBR employs a new biological response system enabling efficient, high-level denitrification and dephosphorization.

As mentioned above, the MBR is capable of handling the operational process with high speed under a heavy load and is thus attracting attention as a means of solving water-related environmental problems in urban areas.

* MF/UF Membranes for Clarification & Pre-treatment in Wastewater Reclamation, with BWRO Membrane for Reuse of High-Quality Water

Secondary treated sewerage effluent can be processed with MF or UF membranes followed by the BWRO membrane to produce high-quality reclaimed water (newly named as NEWater in Singapore, "a non-direct portable water source," drinkable only after waterworks purification), finding a wide range of urban, industrial and agricultural applications and allowing the efficient use of water resources.

Made-in-Japan membranes have a number of successfully installed cases, including a high-performance sewerage-processing plant with a capacity of 300,000 cubic meters per day in Sulaibiya, Kuwait, which started the supply of irrigation water in 2005. In Orange County, California, some Japanese membranes have been used to replenish ground water with high-quality recycled wastewater to protect the groundwater basin against seawater intrusion.

In Singapore, the NEWater Project started in 2006 at the Ulu Pandan sewerage treatment plant using Japanese membranes. In each of three other locations, a water-processing plant with a capacity of 300,000 cubic meters per day has been operated since 2001, turning urban wastewater into a source of indirectly drinkable water.

The method combining the MF/UF and BWRO membranes consumes about one-50th of energy required at vaporization-based desalination plants in the Middle East. It is expected to result in the widespread use of water recycled from urban sewerage treated by membrane-based processing systems in regions short of water throughout the world. Wastewater thus processed can be used for urban and agricultural irrigation purposes, contributing greatly to the effective use of water resources. *Table 2* shows major membrane separation-based plants for wastewater treatment.

TABLE 2

Major membrane separation plants for wastewater disposal/recycling

No.	Country	Place	Capacity (m^3/day)	Year	Type	Purpose
1	Kuwait	Sulaibiya	375,600	2004	MF	Advanced sewerage treatment
2	Kuwait	Sulaibiya	320,000	2005	BWRO	Advanced sewerage treatment
3	United States	Orange County, CA	264,980	2006	BWRO	Advanced sewerage treatment
4	Singapore	Ulu Pandan	191,000	2007	MF	Advanced sewerage treatment
5	United States	Gwinnett County, GA	189,000	2005	MF	Advanced sewerage treatment
6	Singapore	Ulu Pandan	167,700	2006	BWRO	Advanced sewerage treatment
7	Qatar	Doha	135,000	2007	MF	Advanced sewerage treatment
8	United States	King County, Washington	117,000	2011	MF	MBR
9	China	Beijing	80,000	2006	MF	Advanced sewerage treatment
10	Oman	Muscat	76,000	2004	MF	MBR

Note: Colored frames show plants using Japanese-made membranes.
MF: microfiltration, BWRO: brackish water reverse osmosis, MBR: membrane bio-reactor
Source: Association of Membrane Separation Technology of Japan

* UF/MF/LP Membranes for Water Purification

Membrane use in potable water treatment began in the United States, Japan and some other countries in the 1990s as tap water was polluted on a large scale by cryptosporidium, a chlorine-resistant enteropathogenic protozoa. Since then membrane treatment plants have been quickly put in service primarily by the United States and Western countries. The AMST has found that more than 40% of membranes of the kind used at water purification plants in the world were made in Japan.

4. Japan's International Contribution with Membrane Technology

Membrane separation technology offers effective solution to water-environment problems arising in the near future from rapid population growth and social evolution in developing countries.

In the first place, it is useful in two ways to cope with water shortages in arid zones. One is to ensure the supply of urban water by desalinating seawater using RO membrane technology. The other is to reduce the environmental load efficiently and promote the reclamation of municipal sewerage through the membrane separation/MBR process, providing an effective means of securing an unconventional source of water supply in big cities located in arid areas.

Secondly, the membrane separation/MBR process can be applied to sewerage treatment – including human waste – as one measure to reduce the load on the urban water environment. It is expected to lead in the future to increased food production (on the assumption of greater corporate involvement in agriculture) by using water recycled from sewerage as agricultural water and at the same time using sludge compost for farm production. Membrane separation technology, one of Japan's core state-of-the-art technologies, will help solve water-related environmental problems and also contribute to developing the international community. JS