May 2001, Issue 12

Newsletter

European Desalination Society
htttp://www.edsoc.com

WELCOME TO CYPRUS

European Conference on

DESALINATION AND THE ENVIRONMENT: WATER SHORTAGE

May 28-31, 2001, Lemesos (Limassol), Cyprus

On behalf of the European Desalination Society and our co-organisers, the International Water Association, the Water Development Department of Cyprus and Water Board of Lemesos, may I welcome you to Cyprus and to the third in our series of conferences on Desalination and the Environment. Thank you for coming.

The theme of this year's event is Water Shortage, particularly appropriate as we come to the eastern Mediterranean. Water shortage is an increasing problem globally but particularly so in this part of the world. Not only does it limit development and the quality of life, but in many cases it leads to political tensions over the sharing of diminishing water resources. Desalination technology and the membrane technologies that have spun off from it, have a significant contribution to make and role to play in the conservation, augmentation and efficient use of natural water supplies. We hope that this conference will contribute to the appreciation, the understanding, the co-operation and the networking necessary to tackle water problems in this region and worldwide.

Our thanks go to our hosts here in Cyprus for their wonderful co-operation in planning and preparing for the conference, particularly Nicos Tsourtis and Bambos Charalambous. I would also like to thank all those who have worked hard to organise this conference.

The scientific committee, under Jan Schippers, has produced a packed programme for you, our thanks to them.

Particular thanks go to the European Union who are providing very generous financial sponsorship for the conference.

Particular thanks also to Miriam Balaban and her team from the Science and Technology Park of Abruzzo who have undertaken the bulk of the production, scientific editorial and administrative work for the conference. Our thanks to Ursula Annunziata for organising the exhibition and to the exhibitors for their participation. Lastly, but not least, thank you to all the authors who have submitted and prepared papers for presentation. Your work after all is the substance and meat of the conference.

I hope that you will enjoy and be stimulated by the papers you attend and by the contacts you renew or make during the meeting. May I wish you a pleasant stay here. Do participate in the plant visits and do see something of this lovely island while you are here!

Bill Hanbury

European conference on

DESALINATION AND THE ENVIRONMENT

Malta, 18–22 May 2003

DESALINATION PROCESSES ENHANCED BY MULTIPLE MEMBRANE SYSTEMS

Randy Truby, Koch Membrane Systems, San Diego, CA

INTRODUCTION

Desalination using RO has been an established process for many brackish and seawater applications for over three decades and is found in many market sectors.

RO plant operators sometimes have difficulty keeping the membrane surface clean, particularly when treating seawater, surface waters, or waste streams. Fouled membranes lose flow, and require higher operating pressures to maintain design flow rates. This results in higher operating costs due to cleaning chemicals, down time, and labour to clean the membranes. Manufacturers would often evaluate a potential feed water, and if the SDI or NTU indicated a high fouling probability, the RO system design would take this into account via membrane selection or by decreasing the membrane flux. While technically effective, this approach tended to increase the capital cost of the RO system.

UF and MF have emerged in the last decade as an efficient way to remove suspended solids, some organics, and microbiological contaminates including waterborne pathogens from potable water. These membranes are very forgiving when operating on highly turbid waters, and can function continuously on waters that would rapidly foul a reverse osmosis membrane, even if conventional clarification/filtration pre-treatment were employed.

A new approach to water treatment has recently emerged and is becoming the solution of choice. This technique involves combining membrane processes in one plant taking advantage of synergies that result in a more efficient and reliable system. MF followed by RO, and perhaps more interestingly UF followed by RO is being utilised in many locations around the world with excellent results.

MF-RO

For many years RO has been utilised to reclaim municipal secondary effluent. The WF21 system has been reported on at length, as well as the biofilm fouling which is a part of the plant operating experience. Design engineers, facing a municipal wastewater effluent, have coped with biofilm by either specifying cellulosic membrane that did not foul as rapidly, and responded well to cleaning, or by using TFC membrane which was derated in flux by as much as 50%.

In the late 1990's three large systems were installed that are treating municipal secondary effluent using a combined membrane approach. These systems utilise MF to remove the major foulants from the secondary effluent, followed by RO to remove the salts, organics, and microbes. The experience to date has been very positive. The MF runs well, and the RO cleanings have been reduced from once per month in a typical plant to no cleanings in over 1.5 years. The permeate quality from the RO is excellent. At one location, the permeate is sold to a nearby refinery as boiler feed water.

UF-RO

Brackish water treatment

On the Island of Bermuda a new system is now in operation treating brackish water to produce potable water. This system utilises UF pretreatment, followed by RO to remove salts.

The UF utilises state of the art, no modifiers added, polysulfone hollow fibre membranes. The hollow fibres are asymmetric with the feed stream entering the inside of the 35 mil fibre. Under pressure of about 1 bar, permeate passes through the membrane at approximately 125 lmh flux. A non-chemical backwash is typically engaged via a PLC device on a regular schedule. This keeps the UF membrane surface clean even when turbidities spike to over 100 NTU. The polysulfone fibre is chlorine tolerant, and thus can easily be sterilised using chlorine. The UF cartridges are housed in clear vessels allowing for fibre integrity testing using a visual method, or using an automatic pressure decay test included in the logic of the PLC.

The RO membranes are Magnum (sixty inch long) elements with close-coupled design requiring less O-rings and interconnectors. This reduces possible leak sites, and helps ensure system integrity. With the UF as a pretreatment step to the RO the potential for fouling is eliminated. This allows the RO to be designed at higher flux rates, and with a longer expected lifetime due to fewer chemical cleanings.

Seawater treatment

UF makes an excellent pretreatment technology for seawater RO systems. A typical hollow fibre, UF system operating at only 1 to 2 bar driving pressure and 90% overall recovery has a very low energy requirement. In many cases it will require as little as 0.05 kWh per m^3 of UF permeate to operate the UF system.

The surface of the UF membrane remains clean and the flow is constant at 85 lmh flux as a result of an automatic backwash cycle about once per hour. The membrane chemistry is polysulfone and thus chlorine tolerant. If biological growths are evident the backwash water can include up to 100 mg/L free chlorine for quick sterilisation. This flexibility eliminates the need for continuous chlorination/dechlorination that inadvertently has resulted in biofilm build-up in some RO membranes in the past.

Data for a typical HF polysulfone UF system operating on open intake Mediterranean seawater shows the seawater SDI of 6.0 being reduced to 2.0 or less. The UF permeate has a turbidity of less than 0.2 NTU. This quality seawater provides an excellent feed water source for the RO. An RO system operating on this UF treated seawater exhibited no loss in permeate flow, and no chemical cleaning for over one year.

Pathogen removal by UF

Both MF and UF have demonstrated that they will eliminate fouling when used as pretreatment ahead of RO. Both MF and UF systems run at about the same pressures and recoveries. Some MF membranes are not tolerant to chlorine, and this can be a factor depending on the feed water, and the potential need for sterilisation.

The UF membrane has a barrier surface that is capable of removing waterborne pathogens such as Cryptosporidium, Giardia, and viruses. MF will not fully remove viruses. The success of UF and MF membranes at reducing pathogens has resulted in a large number of installations all over the world to protect public drinking water supplies.

Trials have shown the ability of even partially fouled UF membrane to remove viruses up to log 6.8 when treating Colorado River water. The same membrane can remove Cryptosporidium and Giardia up to log 6.5. This data was developed as part of a study that resulted in the State of California crediting this membrane with 4.0 log removal for Cryptosporidium, Giardia, and viruses when applied to municipal potable water systems.

DESIGN OPTIONS

When water quality and safety are a consideration the combination of UF membrane that can be sterilised using chlorine and remove viruses to 4.0 log, followed by RO that can remove over 6.0 log viruses (in some virus challenge tests RO has achieved 6.8 log virus removal) is a powerful multiple membrane plant design. The two membrane barriers in series provide excellent assurance of water purity.

CAPITAL AND OPERATING COSTS

RO systems

RO systems designed to treat UF permeate can typically be 20% more aggressive in terms of flux compared to operating with conventional pretreatment. This allows the RO system to have less membrane surface area, less vessels, less manifolds, and a smaller footprint. This translates into a capital cost saving. A typical brackish water RO system has a capital cost of about \$130 per m^3 of capacity. With UF as pretreatment this capital cost should be reduced to about \$90 to \$105 per m^3.

Seawater RO systems have a capital cost of from \$530 to \$1060 per m^3 depending on the location and design. Using UF as pretreatment should reduce this capital cost to \$460 to \$860 per m^3 for the same reasons as cited above.

Operating costs for the RO system are also lower when following UF membrane. This has been demonstrated at sites where cleaning of the RO membranes has been eliminated, or reduced to yearly. The calculation of operating cost savings is not just the savings in chemicals, and labour, which can be substantial. Operating cost savings should also take into account greater plant availability as downtime for cleaning is reduced, in addition to energy savings as the need to increase pressure in response to fouling between cleanings is eliminated.

Typical operating costs for a brackish water RO system range from \$0.08 per m^3 of permeate to \$0.13 depending on power cost, recovery rate, and the feed water source. Seawater RO system operating costs range from \$0.40 to \$0.66 per m^3 of permeate. Energy recovery devices and improved membranes have made this process more efficient over the last decade.

UF Systems

UF and MF systems have been sold in increasing numbers over the last decade. A clearer picture of the anticipated capital costs is just now emerging for a range of capacities. There are about seven different MF/UF manufacturers from the USA, Japan, France, the Netherlands and Canada. It appears that MF and UF systems in the 10,000 to 15,000 m^3/day capacity range are priced at about \$120 per m^3 of capacity. MF/UF systems capable of 100,000 to 150,000 m^3/day are priced at about \$65 per m^3 of capacity. It is anticipated that MF/UF systems sized around 400,000 m^3/day will have a capital cost of less than \$50 per m^3 of capacity.

UF systems to treat seawater may require a slight premium due to the corrosive nature of the higher chloride levels. However, this may be less than a 10% increase as the operating pressures and recovery should be the same as for brackish water.

The operating costs for MF/UF systems are generally \$0.08 to \$0.11 per m^3 of permeate. This number is heavily influenced by membrane lifetime and replacement membrane cost. It can be anticipated that as experience is gained these costs will be reduced.

CONCLUSION

Manufacturers from many countries are installing multiple membrane systems all over the world. The variety of applications is growing rapidly with excellent results. The reliability of the RO is greatly increased as a result of consistent "clean" feed water provided by the UF or MF membrane. Cleanings and downtime are reduced. Capital costs of the RO can be reduced significantly when UF or MF is used as pre-treatment. Capital and operating costs have been reduced in recent years, and there is reason to anticipate lower MF/UF membrane costs as experience is gained.

ENERGY SAVINGS IN SEAWATER DESALINATION IN MALTA

Antoine Riolo, Chief Executive Officer
Water Services Corporation
Qormi Road, Luqa LQA 05 Malta

Existing situation and background to the projects

Fresh water supplies in Malta are much less than the demand. Water scarcity could adversely affect tourism, the major industry of the country, and so cause severe damage to the economy of the country. Even with demand management through a two-part tariff and an intensive leakage control programme, half the national demand has to be produced by desalination.

Since 1982 Malta has relied on seawater desalination through the RO process to augment natural water supplies. By 1994 a total of 110,000 m^3/day plant capacity was installed on a number of sites.

Desalination of seawater is energy intensive. This makes desalinated water relatively expensive, and the operation environmentally harsh. Investment to obtain lower specific energy consumption is only one of a number of initiatives being taken or advocated by the Water Services Corporation to reduce the cost of desalination. Another initiative relevant to energy savings is to take advantage of the fact that water is storable and run RO plant at night.

The pumping and energy-recovery equipment used in the desalination programme of Malta was of two types:

a) ***Combined pump/turbine in one casing.***
The high-pressure pump and turbine impellers are on the same shaft and in one casing as the pump. The power recovered reduces the demand of the electric motor. The unit runs at a speed exceeding 5000 RPM through a gear increaser.

b) ***Separate high pressure and reverse running pumps***
The reverse running pump has exactly the same function as the turbine in the integrated turbo pump.

Combined pump/turbines were used in the first plant in 1982, and in three more phases up to 1990. It was found to be an extremely reliable system. The manufacturers developed it in stages such that a typical unit bought in 1992 was capable of producing over twice the capacity of that bought in 1982.

Separate high pressure and reverse running pumps were used for Phase 4 of the Pembroke plant in 1994. It was cheaper in capital cost, hydraulically more efficient and had a lower specific energy consumption. It was less noisy, since it ran at lower speed than the integrated turbo-pump and did not use any gearbox.

The specific energy consumption of a given RO process plant depends on various factors – the level of the pressure at which the process is run, the condition of the membranes, the water recovery, the level of engineering maintenance and operations, and most important the efficiency of the components.

Comparisons of alternative energy recovery systems were made under standard conditions of:
- Top pressure of 1000 psig
- Membranes in 'as new' condition
- Recovery of 45%
- Pump and energy recovery equipment generally in 'as new' condition

The specific energy consumptions obtained by the arrangements described earlier were

Pump/turbine type	Integrated	Separate
Component efficiencies		
H.P. pump	80%	82%
Energy recovery turbine	74%	81%
Power consumption kWh/m^3	4.35	4.1

Alternatives considered;Selection procedures

The specific energy consumption indicated above meant that at full production some 230 MW h/year were used for water production. This was some 17% of the energy produced by the power station in 1994.

The Water Services Corporation – owner and operator of these plants – was always keen to achieve lower specific energy consumption levels to reap economic and environmental benefits. New technology was constantly being evaluated for this purpose.

In the competitive tender for purchase of plant in 1993, it was evident that the Pelton wheel offered an advantage on paper of lower specific energy consumption. Enquiries on this turbine's track record elsewhere did not yield 100% encouraging results, because it appeared that some manufacturers had casting problems. We were worried that the unit was not robust enough to guarantee reliability and sustainability of its performance over a period of time.

Matters appeared to have changed for the better by the late 1990's. Newer technologies in energy recovery had by then appeared on the market. It was therefore decided to survey the market fully, to get to know what is realistically available and advantageous to the Corporation.

Accordingly, a request for information – RFI – was published in the international press in March 2000 explaining the application, the existing plant in Malta, the objectives and the desired results. The RFI asked original equipment manufacturers to submit proposals for equipment to be retrofitted in existing plant and that would yield better operating results. A significant decrease in electricity consumption was required such that the project as a whole – capital costs balanced against savings – would be value for money.

The response was encouraging.

Four different technologies were on offer
a) Pelton wheel
b) Pressure exchangers Type 1
 (rotating cylinder)
c) Pressure exchangers Type 2
 (moving piston)
d) Turbo chargers

The turbo charger offered only minor improvement from the existing level of consumption and was not cost-effective. It was not considered further.

Options (b) and (c) operate generally on the same principle. Option (b) however was considered much more advanced and state-of-the-art for the size of plant being considered, and held promise for the future. Option (c) incorporates an elaborate hydraulic control system, which was considered to be superceded by the advanced rotating cylinder technology. It was also more difficult and wasteful of space to install and operate.

Both these devices if incorporated in properly designed flowsheets, offered specific energy consumption of the order of 2.8 kWh/m^3. Option (b) in particular was very attractive and was marked for adoption. Option (a) – the Pelton Wheel – was by now developed and was operating reliably elsewhere.

It was therefore evident that consideration should be limited to the Pelton Wheel and to the rotating cylinder pressure exchanger. As well as being the best performers in terms of energy recovery efficiency, each was more suited to one of the existing plant arrangements.

With a combined pump/turbine unit, to change either the HP pump or the existing energy recovery turbine the whole pump/turbo group would need to be replaced. It would mean installing a new HP pump and re-engineering practically the whole train.

Complete re-engineering would be needed, in any case to install the pressure exchanger bank. The flowsheet also required a HP pump of lesser capacity than the original design for a given output. This was thus an ideal situation for application of the new pressure exchanger.

The Pelton wheel could simply replace the reverse running pump in a separate arrangement with minimum re-engineering and alterations to the existing set-up.

The decision to incorporate the Pelton wheel was thus more straightforward.

Two modules were converted to Pelton machines initially, with four more following. The projected energy recovery efficiency of 86% has been achieved. This means the target specific energy consumption of 3.2 kWh/m^3 under the standard operating and process parameters has been reached. The capital invested, including the in-house installation and engineering work will be recovered in 1.1 years from the savings in electric energy so obtained at the cost of electricity in Malta (2.8 US cents per kWh).

The installation of the pressure exchanger was not such plain sailing. Existing water production modules in Maltese plants are rated 2000 and 4600 m^3/day. Their electricity supply infrastructure was sized to produce that amount at 4.3 kWh/m^3. If this specific consumption is now to be reduced to 2.8 kWh/m^3 then each module, while retaining its existing electricity infrastructure, will be capable of producing 90% more, i.e. 3840 and 8740 m^3/day.

In order to disturb the membrane banks as little as possible to avoid costs and downtime, and also to retain optimum module size in relation to demand it was decided to standardize on train sizes of 3840 m^3/day. Two membrane banks of 2000 m^3/day nominal capacity would be combined and the new unit driven by one existing motor.

One motor in every two would be redundant and useable elsewhere. Where before we had RO modules producing 4000 m^3/day at the high specific energy consumption, the membrane bank would be retained and the motors replaced by the smaller ones removed from the older 2000 m^3/day modules, as described above. The reverse running pumps that were replaced by Pelton Wheels in the other flowsheet arrangement were of the right size such that after refurbishment, they provided the HP pumps required in the new pressure-exchanger based process plant.

It is estimated that the outlay will be recovered in 1 to 1.2 years, including the in-house engineering costs. A tentative time-frame for completion is fifteen months.

Overall results

The environmental benefits of this project are obviously very favorable. The retrofitting of the new technology energy recovery devices will, once completed and at full stream, reduce the total energy used for desalination by some 23.2% (excluding product transfer).

Financing for these projects, estimated to require 1,600,000 US $ will be financed through bank loans. The annual overall recurrent budget for desalination in the Maltese Islands is of the order of 10 million US $ per annum, with production standing at 16,700,000 m^3/annum on average. It is estimated some 20,945,452 kWh per year valued at 1,172,086 US $ per year will be saved at today's level of production.

Annex
Pressure Exchanger by Energy Recovery Inc (USA)

The Energy Recovery Device in the form of a Pressure Exchanger utilizes the principle of direct positive displacement to allow low pressure raw seawater to be pressurized by direct contact with the concentrate flow. A cylindrical rotor with longitudinal ducts parallel to its rotational axis is used to transfer the pressure energy from the brine stream to the feed stream. The rotor spins inside a sleeve between two end covers with port openings for low and high pressure.

By rotation, the ducts filled with low-pressure feed water are exposed to the high-pressure brine, which displaces the now pressurized feed water through the opposite outlet port. As the rotor continues rotation, the same ducts filled with concentrate are now exposed to low pressure feed water, which displaces the depressurized concentrate water through the opposite port at a slight backpressure.

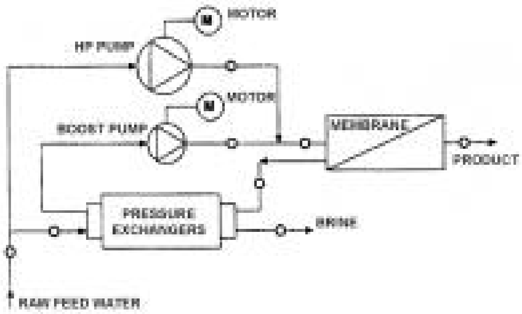
The primary high-pressure pump will only be required to pump the equivalent of the product flow at the "normal" operating pressure. The secondary booster pump is required to boost the pressure of the remaining feed coming from the pressure exchanger up to the MIP.

The guaranteed performance of the CPE-1HP unit is as follows:

– 90% min. net energy transfer efficiency at 1000 psi.

– 0.3 m^3/hr internal leakage per unit.

The process flow sheet to incorporate the pressure exchanger is shown below



ADST

First Announcement

EDS

EUROMED 2002: TECHNOLOGIES AND STRATEGIES

Desalination Strategies in South Mediterranean Countries
April, 2002, Sharm-El-Sheikh, Egypt

www.desline.com, www.edsoc.com, www.adst.sci.eg/EuroMed.htm

MISSION AND OBJECTIVES

Many of the arid and semi-arid regions, located in North Africa and in the Middle East benefit significantly from the desalination technologies. Therefore, there is an ever-increasing incentive to develop and implement such technologies because of the continued population growth in those areas, which is consuming and contaminating natural water resources. Long and short-term strategic plans on issues related to the need, design, operation, maintenance and economics of desalination technologies have to be developed.

The conference is targeted at enhancing the cooperation between European countries and countries of the southern rim of the Mediterranean within the frame of the following objectives:
- To assess the water requirements in countries in the southern rim of the Mediterranean.
- To present the state of the art and latest developments in desalination technologies
- To highlight the major future trends in desalination operations
- To discuss the relationship between the economic aspects, policies and decisions
- To materialize strategies for determining the required desalination technologies in countries in the southern rim of the Mediterranean.

TOPICS

- Challenges and potentialities of desalination
- New trends in desalination technologies
- Desalination in remote areas
- Brackish and ground water desalination
- Thermodynamics of desalination plants
- Environmental impact of desalination plants
- Process management of desalination operations
- Economics of desalination plants

FOR ADDITIONAL INFORMATION PLEASE CONTACT

Prof. Dr. R.R. Zahran
Department of Chemical Engineering
Faculty of Engineering
Alexandria University, Alexandria-21544, Egypt
Tel. (+203) 591-1152 (+203) 591-0096
Fax. (+203) 591-4340 (+203) 591-0720
e-mail: adst@frcu.eun.eg, zahranrr@intouch.com

or

Prof. Miriam Balaban
Secretary, European Desalination Society
Via Antica Arischa, 1, 67100 L'Aquila, Italy
Tel. (++39) 0862 3475 308 / 355 / 214
Fax. (++39) 0862 3475213
e-mail: miriam.balaban@aquila.infn.it

REGISTRATION FORM

Name_______________________________

Organization_________________________

Address:____________________________

____

____

Country ____________________________

Telephone __________________________

Fax Number _________________________

E-mail Address ______________________

☐ I wish to attend the Conference

☐ I wish to present a paper

Deadline for Abstracts 30/09/2001

COMMENTARY ON DISTILLATION

Dr. Corrado Sommariva
Head of Desalination Department
Mott MacDonald UK

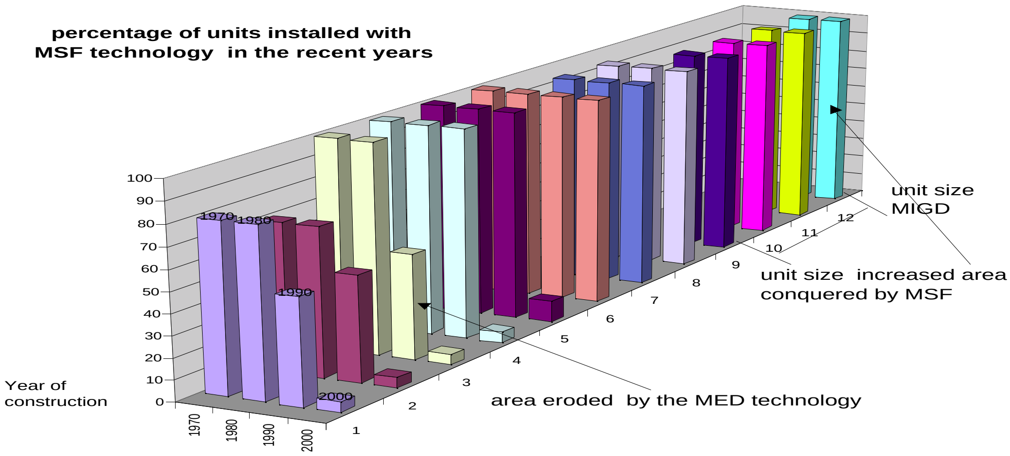
Continuous efforts have been made by the desalination industry towards the targets of making water from desalination plants a mass consumer good. Particularly in the last three years several innovative ideas have been implemented in desalination projects and sensible price reductions have been obtained in the selling price of water.

Strong market competition and the enormous potable water demand have opened new frontiers to desalination technology. In response the desalination industry has promoted research into innovative technical solution, in both MSF and MED technologies.

The figure indicates the percentage of distillation units installed with MSF technology in the two last decades against the unit size. As can be seen from the picture either MED or MSF processes have grown moving towards unit sizes which were considered impossible until a few years ago.

MSF has consolidated its domination in the range of 7.5 MIGD unit size and above, and it is challenging the 15 MIGD unit size. MED has become the most competitive technology for unit size up to 3.5 MIGD and is now challenging the 5 MIGD unit size.

The articles presented in the last newsletter described the enhancement achieved in these processes and the state of the art seen from both the MED or the MSF plant design perspectives.



LOOKING AHEAD

EuroMed Conferences
2002 Egypt
2004 Morocco
2006 Algeria

Desalination and the Environment
2001 Cyprus
2003 Malta
2005 Italy

Membranes in Drinking and Industrial Water Production
Autumn 2002 Muhlheim, Germany
September 2004 United Kingdom
September 2006 L'Aquila, Italy

Membrane Technology for Wastewater Reclamation and Reuse
9-13 September 2001 Tel Aviv, Israel

Neil Wade, *Editor*

European Desalination Society
Science and Technology Park of Abruzzo, Via Antica Arischia 1, 67100 L'Aquila, Italy
Tel. +39 0862 3475 308 Fax +39 0862 3475 213 Email: miriam.balaban@aquila.infn.it
http://www.edsoc.com http://www.desline.com