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International Market Survey on Membrane-Based Products for Decentralised Water Supply (POU and SSS Units)

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International Market Survey on Membrane-Based Products for Decentralised Water Supply (POU and SSS Units)

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List of Abbreviations

ED: Electro-Deionization

MF: Microfiltration

MWCO: Molecular Weight Cut-Off

NF: Nanofiltration

PA: Polyamide

PDT: Pressure Decay Test

PES: Polyethersulfone

POE: Point-of-Entry

POU: Point-of-Use

PVDF: Polyvinylidene Fluoride

RO: Reverse Osmosis

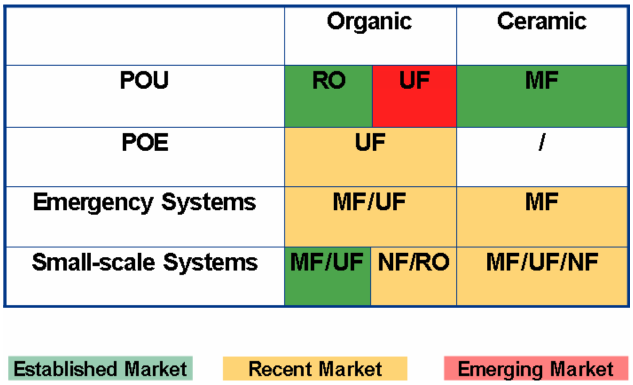
SSS: Small Scale Systems

TMP: Trans-Membrane Pressure

UF: Ultrafiltration

1 Extended abstract

Membrane processes stand as a promising technology to ensure a safe water supply at the community and the household levels. As the price of membranes has notably decreased over the last years, the market of membrane-based systems for decentralised applications has developed and diversified. In order to have a view of what the current market offers, 204 water companies were contacted and asked to characterise their Point-of-use (POU) or small-scale membrane systems, with a focus set on operation and maintenance, costs and energy requirements. Such study was not performed previously. With a 15% reply rate, the survey enables to identify the different market niches. That includes ceramic POU, organic POU, organic point-of-entries (POE), modular treatment units and emergency systems, whose technical characterization is further detailed in the Annex. Besides, the review of the marketed membrane modules reveals that ultrafiltration is the most available process. The survey also shows that the pre-treatment is a key parameter when considering options for decentralised water supply. As needs for sustainable solutions for small water supply are established, the membrane market is expected to grow and more standardised products to appear. The market evaluation can be summarized in Figure 1. Depending on the product niche, the membrane material and the filtration type, different degrees toward the market maturity are then highlighted.



	Organic		Ceramic
POU	RO	UF	MF
POE	UF		/
Emergency Systems	MF/UF		MF
Small-scale Systems	MF/UF	NF/RO	MF/UF/NF

🟩 Established Market
🟨 Recent Market
🟥 Emerging Market

Figure 1 - Market Overview for membrane-based systems regarding small water supply

Such systems would be broadly applied in developed countries, but they represent also great potential for transition and developing countries. However, few systems designed for long-term operation with low-energy and low-chemical requirements exist yet. Therefore, the R&D identified within Techneau matches a non-fulfilled yet requirement

2 Introduction

Universal access to safe water stands as one of the main priorities of the next decade. Indeed, the UN Millennium Declaration (UN 2000) set up the goal of reducing by half the 1.1 billion people without sustainable access to drinking water by 2015. In remote and/or rural areas of industrialised countries, drinking water supply is very often handled through small and decentralised schemes (Hulsmann 2005). As the construction and operation of water distribution networks are not technically or economically viable in many regions of the world, the use of decentralised small water systems has been developing. Point-of-Use (POU) technologies, which imply a drinking/cooking consumption of 20–200 L/d, have entered households and buildings (4-50 people) whereas Small-Scale Systems (for a full water use of 5-1000 m^3/d) have been installed in isolated communities (50-5000 people).

While POU technologies are widely used in developed countries as an additional treatment of tap water (EPA 2006), small membrane-based systems stand as alternative solutions for rural areas and in developing and transition countries where a centralised treatment would not be affordable. An important development of those systems is then expected as they would offer modular construction, easy use and maintenance and achieve a high degree of pathogen reduction (Verbanets and Pronk 2006).

Yet, in developing countries, membrane-based systems remain an expensive investment and they may face some specific regional problems regarding the quality of the raw water. Moreover, operation and maintenance may be inappropriate and fail to be performed by the local populations. In developing countries, these systems should be consume little energy and should do not require much chemical usage.

Thus, simple, low-cost and long-term sustainable systems are required. In order to sustain a well-targeted development of small membrane-based systems, the current commercial offer of the international market should then be investigated. This is the concrete aim of this comprehensive survey. That implies the identification of the potential products, which are likely to be (cost) effective in a long-term perspective, and the critical parameters that would be involved in given local areas. To the author's knowledge, such an international market survey on membrane-based systems for small-scale water treatment was never published.

3 Market Background

3.1 Membrane market for water supply

Although membrane technologies demonstrated research breakthrough and commercial success first in the 60's for specific industrial processes such as nuclear power, they are now commonly applied in different areas, such as haemodialysis, food and beverage processing or biopharmaceutical manufacturing. Regarding drinking water production, their uses are not new. In 1920s, early synthetic UF membranes were commercially manufactured in Germany and first related tests on bacterial contamination in drinking water were run. Later, the damages on the German water supplies after the World War II caused a critical interest in membrane technology and new opportunities for water supply were highlighted. Today, membranes systems are fully accepted in the water industry and are no longer viewed as unselective, slow and expensive technology (Hanft 2007).

In the 1990s, a significant evolution in the costs to construct and operate membrane-based water treatment facilities was observed. Indeed, within ten years, capital costs of membrane plants halved while the product life expectancies were extended. This cost reduction opened alternative sources of drinking water to communities. In the US, whereas 140 membrane plants supplied 750 000 m^3/d of drinking water in 1993, 500 plants produced more than 7.5 million m^3/d in 2006 (Hanft 2007).

Besides, the interest in the membrane technology for water supply is motivated by increasingly stringent drinking water regulations. Pathogen removal has been indeed a critical issue since the 1990s as several *Cryptosporidium* or *Giardia* outbreaks were reported, some of them with dramatic consequences, such as Milwaukee in 1993. The need to replace or upgrade obsolete treatment systems was stressed out, with the necessity to achieve secure disinfection. Membrane filtration would provide a physical barrier to prevent the microbial content from remaining in the drinking water. Furthermore, unlike conventional water treatment, the process is little dependant on the raw water source itself. Membrane manufacturers have then developed various products such as vacuum-driven systems, or submerged membranes, low-pressure systems, and fouling resistant and chlorine resistant modules, which contributed to a competitive market.

The membrane market offers a large panel of systems regarding the type of filtration (MF, UF, NF and RO), the flux capacity, the membrane area or the membrane configuration. Besides, combinations of MF/RO or UF/RO are also been developed for large-scale seawater desalination or water reuse schemes. Many polymers have been tested as membrane materials and R&D is now reinventing the use of "new"materials, such as ceramics. Thus, even if the inorganic membrane market only represented $0.6 billion out of the $8 billion market for membrane equipment in 2003, the corresponding annual growing rate is higher: 14% compared to 8% for the total market (Hofman, Ridder et al. 2007).

3.2 Decentralised water supply as a priority issue

Currently 1.1 billion people lack access to safe drinking water. That mostly explains the 4 billion cases of diarrhoea that occur every year and that cause 1.8 million deaths. Children under 5 are particularly affected by waterborne diseases which harm their nutrient uptakes and their growths (WHO 2007). WHO estimates that 94% of those cases could be prevented with appropriate interventions to provide clean water and to improve sanitation and hygiene. Figure 2 shows the percentage of population who can use improved drinking water sources.

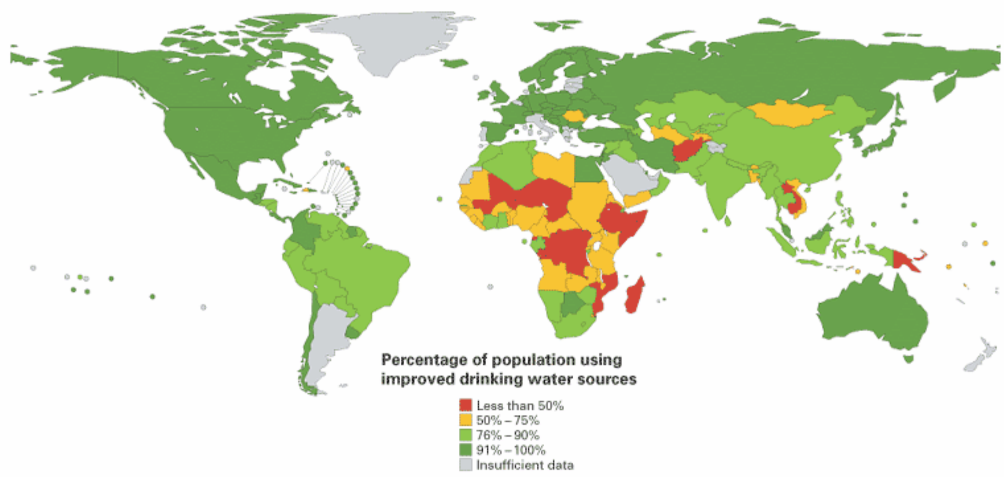


Figure 2 - Water Coverage in 2004 (WHO 2007)

Thus, when centralised water treatment systems are absent or inadequate, populations have to find their drinking water on their own. In many parts of the developing world, they depend on rivers, streams or other potentially contaminated surface sources. Moreover, the collected water is often held in unsafe storage facilities. That leads to an unsatisfying drinking water quality. Boiling the water can be used as a prevention measure but it cannot be considered as a sustainable and economical treatment method.

The lack of safe water is often part of a vicious cycle where populations suffer from poverty and live in precarious conditions. Thus, it is important to find simple and low-cost techniques to treat and store the water and by doing so, enhance health and contribute to better living conditions, development and productivity.

Working at the household and community levels enable targeted and immediate effects in order to reduce the risk of contaminated water. Self-sustaining and decentralized water schemes were clearly identified to be priority for rapid implementation. Recent investigations reveal that improved point-of-use water quality alone would halve the diarrhoeal morbidity (WHO 2007).

Working at a decentralised scale will contribute to meeting the Millennium Development Goals faster. When the UN set the target of halving the 1.1 billion people without sustainable access to safe drinking water by 2015, it was clear that progress should be made on both the quantity (access) and the quality (safety) aspects of the water supply.

At the household level, Point-of-Use (POU) technologies to be installed at the tap could provide up to 200L/d for drinking and cooking needs and Small-Scale Systems could supply isolated communities (10-5000 people) with up to 1000 m^3/d. Figure 3 shows the different types of decentralised concepts regarding consumption volumes and uses. Thus, even though it is labelled as small water supply, the panel of technological solutions may be quite diverse from 20L/d to 1000 m^3/d and the same outcome should be dealt with different means.

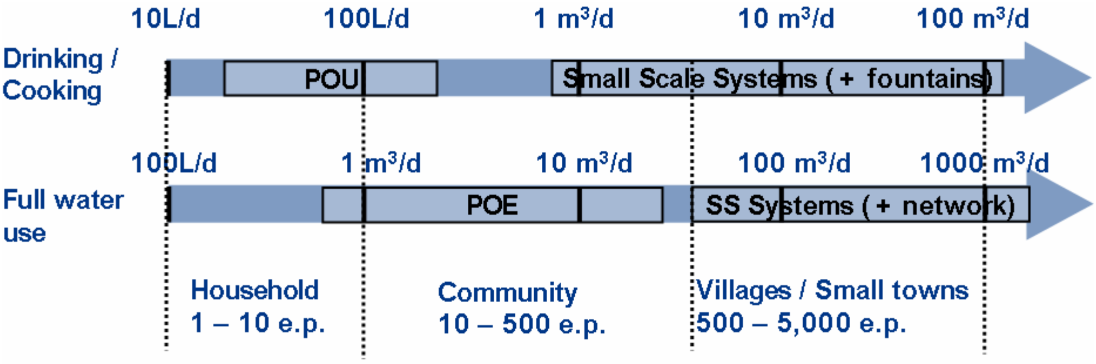


Figure 3 - Ranges of the water facilities for small supply - based on (Hulsmann 2005; WHO 2007)

3.3 Market expectations of membrane-based systems for decentralised water supply

With the cost reduction of the membrane systems, new alternative treatments can be considered for decentralised water supply. Membrane processes offer certain advantages for small water supply. Indeed, membrane systems seem promising as they efficiently remove pathogens and offer a modular design that enables flexibility in term of flow capacity.

The relevance of the use of membrane-based POU and small-scale systems is highly related to local socio-cultural, economical and political conditions. Verbanets and Pronk (2006) established a first approach related to the different market needs, as summarized below.

3.3.1 Developed Countries

In urban and peri-urban areas, membrane-based POU systems are mostly used as an additional treatment although a centralised water network could already provide good drinking water quality. That can be viewed as a preventive action as consumers would prefer extra-treatment to ensure safe drinking water (EPA 2006).

In rural areas, POU and small-scale systems may be useful as good tap water cannot be always supplied and larger treatment plants would require unavailable financial resources and technical skills. Moreover, the water sources may be quite sensitive to variations of pollutant concentrations. The decentralised water systems often need specific design and they are therefore relatively costly. The Weknow program reveals that at least 10% of the EU population depends on small water supplies, making decentralised water supply a hot topic in Europe. Uncertainty still remains as the use of private wells is spread but not monitored (Hulsmann 2005).

3.3.2 Transition Countries – Post Soviet Union Region

In urban and peri-urban areas, small membrane-based systems are being increasingly used due to the unreliable quality of the tap water, which can be explained by the old infrastructure of the waterworks and by the governmentally dependent water policies. Systems that are used in developed countries are however hardly affordable for those populations.

Regarding the rural areas, a similar situation to developed countries is observed. However, due to industrial pollution and fertilizer abuse, contamination levels may be high in the drinking water supplies, especially for nitrates, heavy metals and salinity. A need for a low-cost system that is suitable for a wide range of pollutants is here obvious.

3.3.3 Developing Countries

In urban and peri-urban areas, small membrane systems can be found in rich communities, such as touristic resorts, as well as in high-standard buildings (hospitals or hotels). They could stand as temporary solutions in case a reliable and sustainable centralized waterworks has not been successfully implemented yet. Indeed, any pressure drops, leakages or illegal connections in the waterworks may affect the quality of the distributed water.

In rural areas, water quantity and quality are deficient. Indeed, the lack of supply infrastructure forces the populations to go and fetch water in the surrounding water sources. POU and small-scale systems are therefore relevant solutions to be implemented. However, compared to transition countries, the acceptable cost level and the ability to ensure operation and maintenance of the water systems are even lower.

In rural households, consumption of energy for non-cooking purposes is indeed expected to be small. Around half of the people in developing countries are dependent for fuel on biomass (i.e. wood, dung and crop residue) and a large population live under the poverty threshold of 1 to 2$/day. Technology options for household-level electricity services in rural areas are also targeted within the Millennium Development Goals and include the use of micro-hydro, wind or diesel generator sets. An independent rural community of 250 inhabitants could be then provided with a limited rate of 2 to 3 kWh per month (Modi, McDade et al. 2005).

In order to provide a sustainable access to safe water, membrane systems should then be well-adapted to local conditions, that is to say, low-cost, easy-to-maintain, robust and as far as possible independent of chemicals and energy supply.

4 Market Survey

4.1 Survey Objectives

While decentralised water supply is acknowledged as a priority issue, membrane processes seem a promising technology for small water supply. Thus, it is interesting to have a view of what the current market is composed of and to try characterising the main trends. This inventory of available products would avoid redundant research programs on membrane systems and provide useful input for future developments.

As key criteria for membrane-based systems for decentralised application have been clearly identified as low cost, little operation and maintenance requirements (i.e. independence from chemicals) and low energy needs, technical characteristics are to be collected and compared.

Moreover, the pre/post-treatment processes should also be taken into account when regarding the system's suitability to treat a broad range of pollutants.
Moreover, future directions for the development of membrane-based systems will be discussed.

The report sets off the methodology and main outcomes of the investigation. The Annexes include the list of companies identified (Annex I) and lists of membrane systems and membrane modules (Annexes II and III).

4.2 Methology

From June to October 2007, the international market survey covered small decentralised water processes with a focus set on membrane systems. POU and SSS manufacturers and retailers were identified through Internet and specialised press. The Green Pages lists 587 membrane companies that are active in the field of water supply and purification. When searching for decentralised water supply and small systems, only 194 companies were still to be considered. Besides, additional literature studies have raised the number to 204 potential companies to be further investigated.

The next step was to collect information on the membrane-based systems that are produced by those companies. As available data types would differ from one company to another, each company was contacted and asked to fill up a standard form on required information. Contacts were established via emails or contact requests from the corresponding websites. In a first approach, it was asked to interact with an engineer, as they would probably be more knowledgeable about technical features of the membrane products. In best-case scenario, the questionnaire was then sent to this qualified person. Otherwise, when the customer service of the company was the direct contact, it was asked that the form should be sent forward to the person that would have the appropriate skills to fill it up. Moreover, in order to save some time and ease the company's task, some forms were pre-filled with data that were available in online technical documentation.

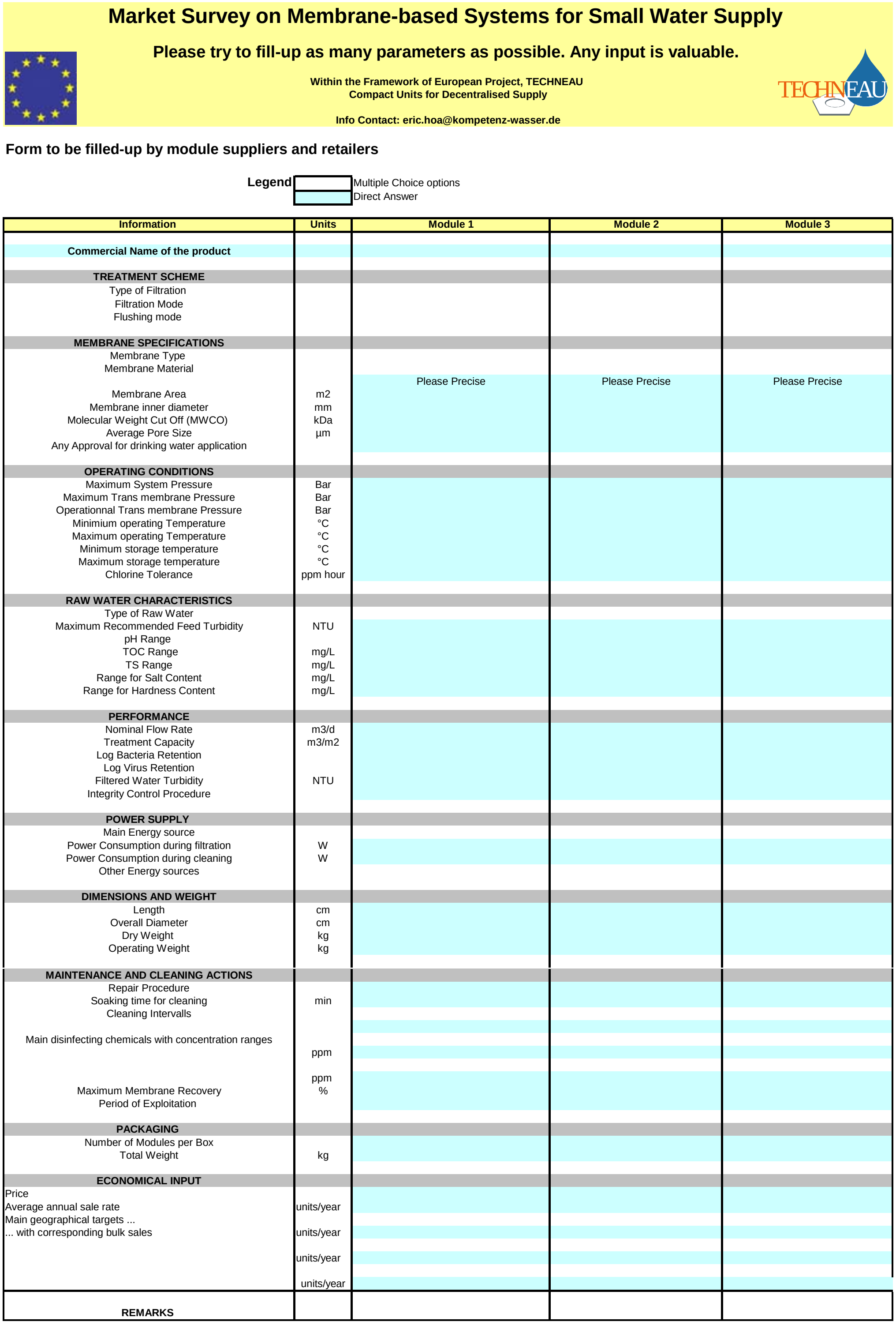
Using a standard form would make easier the comparisons between the products. Companies were asked to provide the technical characterization of their products and economical data on their market implication. Figure 4 shows the form developed to gather data concerning commercial membrane modules. A similar excel sheet was also provided for membrane-based treatment units. A database was then built with *Microsoft Access* in order to compile and exploit the data. The results on the different membrane modules and treatment units were then thoroughly analysed.

Technical data consisted essentially in:

- the treatment scheme (MF/UF/NF/RO , filtration configuration, presence of a pre-treatment or post-treatment unit)
- the membrane specifications (type - flat sheet or tubular, material - polymeric, textile or ceramic -, membrane areas, average pore size)
- the operating conditions (regarding pressure, temperature or chlorine tolerance)
- the raw water characteristics (feed turbidity, TOC, TS, Salt and Hardness contents)
- the performing treatment (flow capacity, pathogen removal, permeate turbidity)
- the operation and maintenance requirements
- the energy supply
- the packaging features

Moreover, economical figures such as prices, bulk sales and regional sales were also requested in the form. Naturally, it was not expected that company representatives could answer all criteria. Nevertheless, they were invited to complete the form as much as they could.

In the mean time, the potential users of such products were also contacted to provide information on their usage, or possibly comparative studies. Indeed, within the framework of cooperation and development missions, some NGOs work on ensuring access to drinking water in remote and/or dry regions, or could react in emergency when disasters occur and provide safe water to affected populations. Customer associations were also approached in order to collect possible qualitative/comparative tests with small membrane-based water systems.



Market Survey on Membrane-based Systems for Small Water Supply

Please try to fill-up as many parameters as possible. Any input is valuable.

Within the Framework of European Project, TECHNEAU
Compact Units for Decentralised Supply

Info Contact: eric.hoa@kompetenz-wasser.de

Form to be filled-up by module suppliers and retailers

Legend
☐ Multiple Choice options
▨ Direct Answer

Information	Units	Module 1	Module 2	Module 3
Commercial Name of the product				
TREATMENT SCHEME				
Type of Filtration				
Filtration Mode				
Flushing mode				
MEMBRANE SPECIFICATIONS				
Membrane Type				
Membrane Material				
		Please Precise	Please Precise	Please Precise
Membrane Area	m2			
Membrane inner diameter	mm			
Molecular Weight Cut Off (MWCO)	kDa			
Average Pore Size	µm			
Any Approval for drinking water application				
OPERATING CONDITIONS				
Maximum System Pressure	Bar			
Maximum Trans membrane Pressure	Bar			
Operationnal Trans membrane Pressure	Bar			
Minimium operating Temperature	°C			
Maximum operating Temperature	°C			
Minimum storage temperature	°C			
Maximum storage temperature	°C			
Chlorine Tolerance	ppm hour			
RAW WATER CHARACTERISTICS				
Type of Raw Water				
Maximum Recommended Feed Turbidity	NTU			
pH Range				
TOC Range	mg/L			
TS Range	mg/L			
Range for Salt Content	mg/L			
Range for Hardness Content	mg/L			
PERFORMANCE				
Nominal Flow Rate	m3/d			
Treatment Capacity	m3/m2			
Log Bacteria Retention				
Log Virus Retention				
Filtered Water Turbidity	NTU			
Integrity Control Procedure				
POWER SUPPLY				
Main Energy source				
Power Consumption during filtration	W			
Power Consumption during cleaning	W			
Other Energy sources				
DIMENSIONS AND WEIGHT				
Length	cm			
Overall Diameter	cm			
Dry Weight	kg			
Operating Weight	kg			
MAINTENANCE AND CLEANING ACTIONS				
Repair Procedure				
Soaking time for cleaning	min			
Cleaning Intervalls				
Main disinfecting chemicals with concentration ranges				
	ppm			
	ppm			
Maximum Membrane Recovery	%			
Period of Exploitation				
PACKAGING				
Number of Modules per Box				
Total Weight	kg			
ECONOMICAL INPUT				
Price				
Average annual sale rate	units/year			
Main geographical targets ...				
... with corresponding bulk sales	units/year			
	units/year			
	units/year			
REMARKS				

Figure 4 - Form sent to companies to characterize their membrane modules

4.3 Respondant panel

Figure 5 represents the panel of replies. 15% of contacted companies replied via online data and form completion. Most of the time (36%), direct contact with the companies failed. It can be due to problems with the email accounts (wrong address or overload message box), unread email messages (as no read receipt was delivered) or unanswered requests on the websites.
When preliminary contact with the company was established, it was still difficult to get the form completed. Thus, the contact person would either give the contact information of a more qualified employee or reply that the request was sent forward to the concerned service, which would consider it as soon as possible. In 34% cases, no outcome occurred.

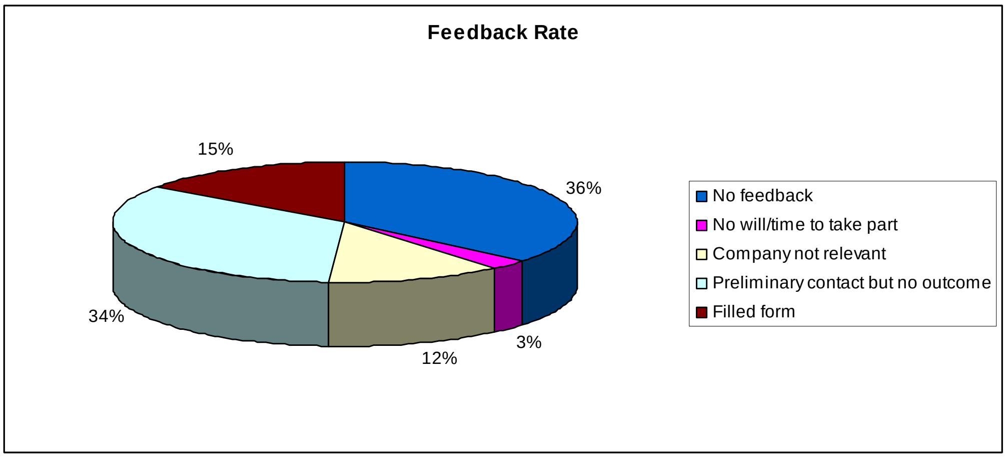


Figure 5 - Feedback rate

It can be noticed that still 12% of the contacted companies were actually not active in the small membrane technology for decentralised water supply. Due to the similarity between water and wastewater decentralised issues and the commercial attraction for membranes, some companies may seem to be able to provide solutions at first sight, although their products have not been targeted for small-decentralised water supply. This can also partly explain the rates of “no feedback” and “preliminary contact/no outcome”, as companies would have figured out that they would not fit in this survey.
As the survey took place from June to September 2007 – with an extension to October, it also suffered from the summer quietness in the companies as well as the September full-activity. During this time slot, it was indeed quite difficult to reach the appropriate company employees, as they would be on annual leaves or have little time to catch up with this survey, as new priorities would face up.

This panel of replies also gives hints on the regional interest of the market. The geographical distribution of the identified companies (Figure 6) shows that the US leads the worldwide market in the number of companies (36). Therefore, the market for membrane systems for small water supply seems mature in the US as many companies compete. In this large country, small-scale solutions have found customer recognition.

Besides, the Asian market is significant with 22 companies identified in China and 8 in India. Due to their demography and their development disparities, those countries face strong environmental issues, which include water coverage. That can explain the interest for small decentralised water systems.

Europe is also well-represented in the market for membrane-based systems for small supply. Germany and the Netherlands are particularly active in the water technology. Indeed, the populations are there known to be environmentally concerned and ensuring access to safe water stands as an essential right. Thus, the relevance of socio-economical background in relation to the local market structure is here pointed out.

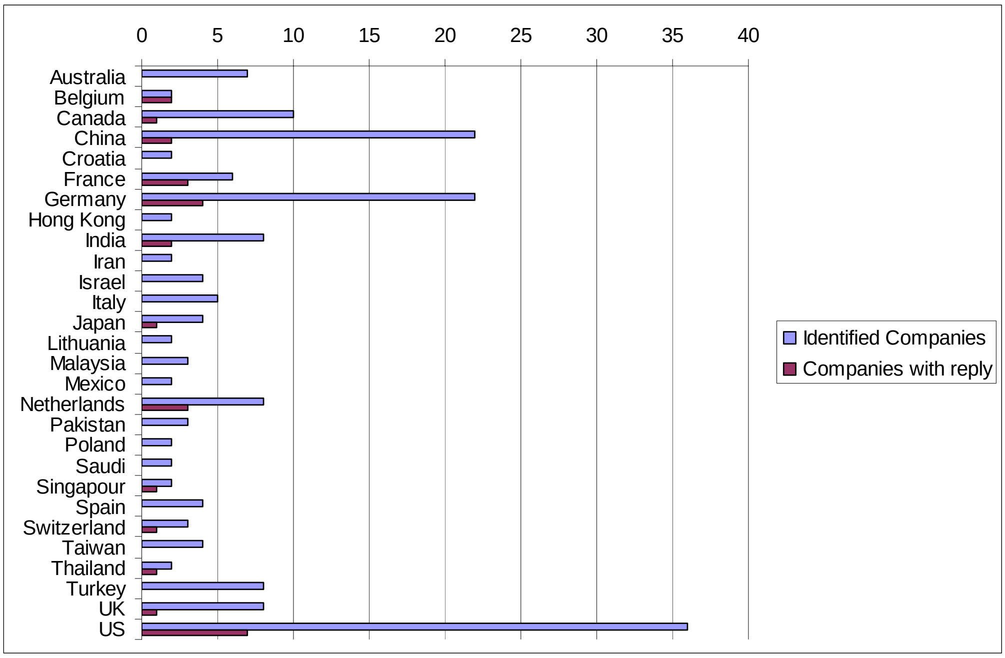


Figure 6 - Geographical Distribution of the identified companies and the companies for which data were collected

5 Identification of market niches

In this following part, modules and treatment systems are considered regarding relevant criteria: necessity of pre/post-processes, raw water quality, the treatment efficiency, maintenance requirements, energy needs and cost. This survey enables also to identify the different types of membrane-based systems.

The complimentary inventory of products is detailed in the Annexes, with three sections dedicated to:

- the list of companies
- the list of membrane systems
- the list of membrane modules

5.1 Point-Of-Use Systems

Different types of POU systems have been identified. That includes products based on ceramic filtration (MF) and polymeric filtration (UF/RO). Complimentary products are detailed in Annex II 8.2.1.

5.1.1 Ceramic POU Systems

Ceramic candle filters can be installed at the countertop or under the sink in order to treat directly tap water. Doulton is the main supplier of ceramic water filters. The MF candle (see Figure 7) is composed of diatomaceous silica and is combined with an activated carbon core, which is used to adsorb pollutants such as chlorine, pesticides, herbicides, toxic chemicals and to improve the taste and odors of the treated water. In some products (see CP200UC in Figure 8), a second candle is added with a media chosen to remove specific pollutants – such as fluoride, arsenic, MTBE or nitrate.

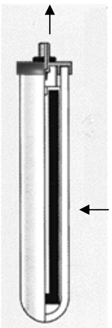


Figure 7 - MF ceramic candle by Doulton

In order to prevent a bacterial proliferation on the candle surface, the Doulton products are manufactured with a small amount (about 0.07%) of pure silver throughout the porous ceramic shell. As silver is a bactericide substance, the impregnated ceramic candle has a self-sterilizing effect, which is known as the bacteriostatic effect.

Mechanical regeneration of the ceramic filter is rather simple as the fouling layer can be manually removed with a brush. This procedure can be repeated several times before the filter has to be changed. The lifespan of the ceramic candle is indeed determined by the volume of water that can be treated – 2400L, 3800 or 4000L – or by a 6 month-operation.

Figure 8 - Doulton products: Stainless CP100UC, CP200UC, Doulton portable system

The characteristics of the main Doulton products are presented in Table 1:

Table 1 - Ceramic POU systems by Doulton

Model	Price ($)	Lifespan (L)	Flow Rate (L/min)	Operating Pressure (bars)	Diameter (cm)	Height (cm)	Certifications
CP100SC	179	4000	2	3	12.7	28	WRc; ISO-9002
CP100UC	179	2400	2	3	12.7	28	WRc; ISO-9002
CP100IUC-CL	199	3800	4	3	15.2	28	NSF 42 and 53; WRc; ISO-9002
Stainless - CP100UC	279	2400	2	3	7	29.2	NSF 42 and 53; WRc; ISO-9002
Stainless - CP100SC	279	4000	2	3	7	29.2	NSF 42 and 53; WRc
CP200UC	279	2400	2	3	10.2*	33	WRc
CP200SC	279	4000	2	3	10.2*	33	WRc
Doulton Portable Trail Companion	275	2400	2	manual pumping	n.a	n.a	NSF 42 and 53; WRc

* for each candle

Initial costs for those products vary from 179$ to 279$. One should also consider that candles for replacement cost around 50-60$. That would represent an average cost of 125$/year, if the installation is considered to be amortized in 10 years. Currently, there is a higher demand for stainless products as they are more compact and better-looking filters.

British Berkefeld – which now belongs to Doulton – also uses those ceramic candles for its line of gravity flow water filters. The latter are composed of 2 stainless steel chambers. The upper chamber houses the ceramic candles through which water percolates into the lower chamber from where the treated water is drawn via a tap (see the Big Berkey filter on Figure 9).

The system presents a relatively slow rate of filtration, which can be improved with the use of additional ceramic candles (from 4 to 8). Because of the fine pore size (0.9 µm) of the ceramic filter, more than 99.99% of the principal bacteria and cysts remain on the surface of the filter. The systems have quality approvals from the US National Science Foundation and from the UK Water Research Commission. Prices for the British Berkefeld water filters vary from 135$ to 435$, depending on the number of candles.

Figure 9 - Big Berkey by British Berkefeld

Table 2 presents the characteristics of the British Berkefeld products

Table 2 - British Berkefeld products

Model	Number of candles	Price ($)	Lifespan (L)	Flow Rate (L/d)	Diameter (cm)	Height (cm)	Certifications
SS-4	4	209	23000	90	21.6	49.5	NSF 42 and 53; WRc; ISO-9002
Big Berkey	4	235	23000	110	21.6	49.5	NSF 42 and 53; WRc; ISO-9002
Imperial Berkey	6	335	55000	450	25.4	63.5	NSF 42 and 53; WRc; ISO-9002
Crown Berkey	8	435	55000	600	28	76.2	NSF 42 and 53; WRc; ISO-9002
Arctic Travel Pure	1 - 2 - 3	135	23000	18 - 36 - 54	17.8	34.3	NSF 42 and 53; WRc; ISO-9002

As they are independent from any tap entry, those systems are particularly relevant for remote households. In 2005, the Aquapol research project monitored the implementation of such filters in African households (Aquapol, 2005). The filters are often found prominently displayed in the home and seem to be highly valued due to their efficiency and their stainless steel design. Still they are too costly for developing populations.

Similarly, clay pots have been used in developing countries.
Since 1998, Potters for Peace has been active in the production of a low-tech, low-cost, colloidal silver-enhanced ceramic water purifier (see Figure 10).

Field experience and clinical test results have shown that this filter can effectively eliminate approximately 99.88% of most water born disease agents.

The manufacturing process is provided to local communities, which are trained to produce and use the system. Given the appropriate material means, the population is then in charge of making the pots. Thus, this system contributes to self-sufficient communities. However, a lack of quality control on the fabrication could lead to poor treatment efficiency or short lifespan of the product. Thus, it is rather inappropriate to literally use the term "membrane" as it is not produced under controlled conditions and with exactly specified properties. Currently, it is recommended to change the pot annually. Although they are based in a similar process as the gravity driven systems developed by British Berkefeld, they remain a cheap solution – 10$/pot but offer a slow flow rate of 1-2 L/hour. However, developing populations would tend to trust more easily the British Berkefeld systems due to their aesthetic attract.

Figure 10 - Clay pots by Potters for Peace

5.1.2 POU - Reverse Osmosis Systems

When looking at countertop or undersink systems, RO systems play a major role in the water market. This is particularly relevant in US where point-of-use technologies, which also include activated carbon units and water softeners, are largely retailed through the country.

Companies share the market, such as Ametek, American Plumber (Figure 11), Apec, Aqua Flo, Aqua Pure, AquaSafe, Culligan, DESAL, Filmtec, Honeywell, Hydranautics, Kenmore, Kinetico, KISS, Matrikx, MCS, Omnifilter, Omnipure, Pentair, Plymouth Products, Premier, Pura, PureGen, Puritron, Purtrex, Rainsoft or Waterworld USA. The RO systems are standardized so that cartridges for replacement are compatible to systems from different brands.

Figure 11 - WRO 3000 by American Plumber

Under-the-sink POU-RO units represent an average cost of 116 $/year. This amount includes the replacement of cartridges plus the amortized costs of the system installation, which are based on a lifespan of 10 years. (Raucher, Hagenstad et al. 2004)

5.1.3 POU – Ultrafiltration Systems

Few simple POU-UF systems were also identified.

Hyflux claims to offer the only ultrafiltration POU countertop device with its Gurgle F38 product (see Figure 12). This system (pore size 0.015 µm) operates with three different modes according to the use of the treated water. Hence, the user chooses the functionality amongst the washing, rinsing and drinking and cooking modes, as the degree of treatment is not the same. Thus, asking for a higher quality of treated water would cause a lower outflow. The system costs around 150$ and the filter cartridge (~50$) needs to be replaced after 1000 treated litres or 3 months of operation. Under a working pressure of 1bar, the filtration flow rate is to reach 0.8 L/min.

Figure 12 - Gurgle F38 by Hyflux

Yet, similar products have entered this market niche. Indeed, Norit H_2OK line of products includes some POU cartridges using capillary membrane filtration. When the Norit WaterFilter is based on a MF process and can produce 10L/min, the Norit WaterPurifier is based on a UF step and can provide up to 4L/min. These cartridges can treat 5000L during a 6 month-lifespan.

In the end of 2007, Kärcher announced that they would introduce a new POU-UF product using the Multibore technology from Inge. Memfil is also identified as an emerging membrane company with a large panel of systems that are available on the market, including POU-UF systems. Even though detailed technical data were difficult to collect, Memfil is representative of the Asian market, which wants to diversify its commercial offers and to cover all market niches for water production. Thus, they use strong commercial strategy to make their brand and their products known to the public although detailed information are more difficult when the scientific community is interested.

Figure 13 - Lifesaver Bottle

It can also be noted that Lifesaver Systems developed a water bottle, which contains an UF system (0.015 µm) to remove pathogens (see Figure 13). Equipped with a Norit/Filtrix membrane, the system it is not exclusively intended for tap water, as it can be used in a natural environment with surface waters. Due to its pneumatic action, Lifesaver bottle can produce a pressurised jet of sanitized water, which can be used to clean directly onto a wound. One innovation lies in the Failsafe technology that shuts the system and protects the user from contamination once the cartridge lifespan has expired. The bottle can contain up to 750 mL and it can treat 4000L or 6000L with a respective cost of 280€ and 320€ (195£ and 230£ + tax).

5.2 Point-Of-Entry Systems

As water contamination during transportation and through pipe leakage can be a common issue, households may choose to treat the water at the point-of-entry. Details are available in the Annex 8.2.1

The Homespring Purifier by Zenon (see Figure 14) is the most acknowledged POE membrane system. That water filtration system treats all water that enters the house in two treatment steps: adsorption through granulated activated carbon (GAC) and ultrafiltration through hollow fiber PVDF membrane (0.02µm) (Gray, Feidler et al. 2007). Three sizes of filters have been designed - the larger system enables a peak flow of 42 L/min or a continuous flow of 25m^3/d - and they received certifications from the NSF (norms 42 and 53). The system uses the existing home water pressure. Thus, electricity is only required to activate the controller in order to start the daily backwash cycle. Maintenance requirements imply the annual inspection of the membrane integrity and the change of the activated carbon filter by a certified technician. The membrane module itself should last from 5 to 10 years depending on the raw water quality. Gray et al. performed a demonstration assessment of such systems and suggested that POE may be cheaper than building centralised treatment plants with widespread distribution systems for towns with less than 150 households (Gray, Feidler et al. 2007).

Figure 14 - Zenon Homespring unit

5.3 Small-scale Systems

5.3.1 Modular Systems

In order to provide safe drinking water at a local scale and ensure the self-sufficiency of remote communities, many membrane companies have developed their own decentralized treatment unit. Based on the flexibility that the modular configuration enables, a large range of flow capacity exists. Thus, the Aquamem series of Polymem goes from the single UF100L module, which can supply 10m^3/d to a 16- UF80 module-unit providing more than 1000m^3/d. In France, Aquasource is the market leader with its Ultrasource units (see Figure 15). It is based on a dead-end filtration with a special backwash mode to avoid the use of a backwash tank.
Other identified products (detailed in the Annex 8.2.2) include Virex 900 by Seccu, JurbyFlow by Jurby, Microclear by Weise Water Systems, Zenon Z-boxes, Pall Aria AP-Series, Lineguard Norit/Filtrix, Uflex by Krüger or UltraFlow MU systems. Uflex has a prefilter in order to protect the ultrafiltration step and the backwash is fully automatic. All operating parameters are recorded and stored, and are available for operational control and maintenance.

Those small-scale systems include up to 60 modules and require power supply (going from 0.4 kWh to 24 kWh for respectively 96 and 864 m^3/d) and regular chemical maintenance (using mainly NaOCl and NaOH) in order to prevent the membranes from fouling or clogging.

Treatment units using ceramic membranes are less numerous (Aquastel, HITK and Elga Berkefeld). Indeed, the TWA UF 15 from Elga Berkefeld contains 3 UF modules with ceramic membranes (NGK) with a flow capacity of 5m^3/h for each module. The system also includes flocculation and adsorption processes as pre-treatment and chemical disinfection as post-treatment. For the moment, it has only been used for emergency circumstances (see Annex 8.2.3).

Figure 15 - Ultrasource by Aquasource

The various panel of available skid units is illustrated in Figure 16, regarding the nominal flow rates and the membrane area.

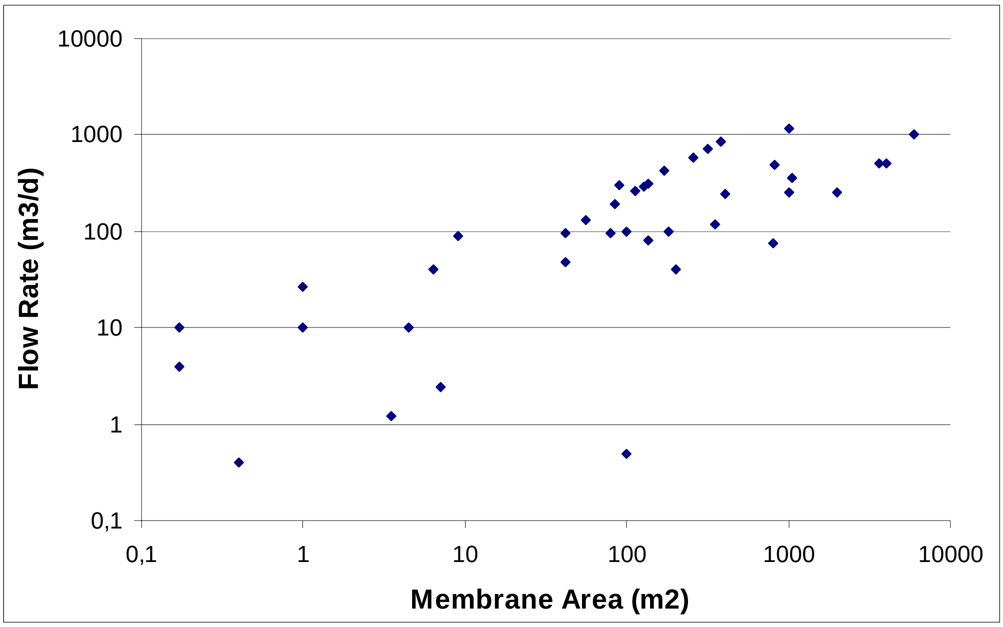


Figure 16 - Panel of Skid Units

Moreover, the membrane filtration step is to be complemented by pre/post treatment facilities. In order to reduce the fouling and optimize the lifespan of the membrane, Pretreatment is identified as a key element. Indeed, the feed turbidity has direct consequences on the operation and maintenance requirements. When different clean-out-of place (COP) systems (Legio (Aquapurus), Seccua (Virex 900), Filtrix (Lineguard), Pall (Aria LT1)) were tested in German rural areas in order to have long chemical-free operational systems (from 3 weeks to 6 months), it was indeed recommended to maintain a low feed turbidity (around 1 NTU) or to use an additional air backwash to the treatment scheme in order to sustain the treatment flow capacity (Müller, Witte et al. 2007). For other manufacturers such as Inge, a reduction of the outflow will be preferred if the turbidity is high so that the module could operate longer (Inge, 2005).

Pretreatment options include softening processes, and coagulation or adsorption on activated carbon. It can also be noted that in South Africa, the University of Stellenbosh and the Durban University of Technology are developing a UF prototype but in this case, the pretreatment would consist in a filtration through woven-fibers in order to lower the feed turbidity below 5 NTU. Aquasource applies in-line coagulation before the UF process and membrane fouling is reduced.Regarding the post-treatment, chemical or UV disinfection and pH correction can be implemented, as well as ion exchange resins or activated carbon for the removal of targeted pollutants.

From a general perspective, membrane companies are willing to integrate their membrane modules into a compact treatment unit. However, due to the variety of polluted raw waters to be treated, and the hard task of designing a universal treatment system, water companies tend to specifically design their membrane-based units according to the case requirements. Thus, it was difficult to collect technical parameters on small-scale systems that are not packaged as a standard product.

5.3.2 *Emergency Systems*

Regarding emergency systems, this survey showed the gap between the commercial membrane-based units and the actual water systems that NGOs use on the field. Indeed, even though NGOs are keen to know about new water supply technologies, they often keep their traditional treatment systems that have shown efficient results through the past missions.

Indeed, as difficult transportation and fast intervention characterise some water missions, NGOs search for a compact, light, and simple system, which enables to supply drinking water at any remote place of the world. In any disaster context, the priority is to set up short-termed solutions and improve the raw water quality as much as possible. Many NGOs design their own systems in order to save money. Simple treating process mainly consists in sand filtration, disinfection/chlorination and adsorption on activated carbon. GSCF – "Groupe de Secours Catastrophe Français » - uses prefiltration on polypropylene cartridges (25 µm) (see Figure 17)

Figure 17 - Own treatment system designed by GSCF

5.3.2.1 Commercial Products

Commercial products for emergency purposes are detailed in the Annex 8.2.3.

PWN and Norit designed the Perfector-E (Figure 19) as a quick response to the Asian Tsunami in December 2004. Using a small generator (<0.05 kW hr/m3 is required), this UF system is user-friendly (no use of chemicals, maintenance every 3 months) and it provides safe drinking water. The system implies forward and backward flushing. Besides, the process is combined with a UV post-treatment unit, which contributes to the overall price of the system (20 000€ per unit).

Figure 18 - Perfector-E by Norit/PWN

Similarly, the Skyjuice Foundation designed the Skyhydrant (see Figure 19) as a disaster relief system for production of drinking water. Using a PVDF Siemens/Memcor membrane (0.1µm), it operates under a 300 mm gravity head without extra electrical power supply and it can produce 10m^3/d. However, a washing sequence is recommended every 1-2 hours for 90 seconds. Additional chemical cleaning should also be performed in order to remove residual fouling with a frequency that varies from daily to weekly. 300 systems have already been implemented in 16 different countries. The annual average cost has been assessed to 0.2 € per person.

Figure 19 - Skyhydrant by the Skyjuice Foundation

5.3.2.2 Non-Commercial Products

The university of Kassel designed an emergency system (Figure 20) that is based on a simple process: dead-end MF filtration driven by gravity. The product has been tested with hollow fibers (Zenon ZW 10 - pore size 0.4 µm) but also flat sheet membranes. Moreover, it is robust, chemical-free and easy to transport (<25kg) and to set up. It can provide water for small communities of 200-500 people for more than 3 days. No drinking water certification is recognized but the system replies to emergency circumstances.

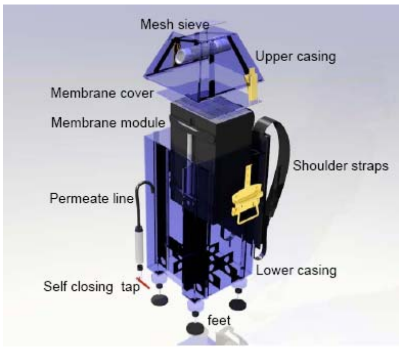


Figure 20 - Prototype of a MF gravity-driven system by the University of Kassel

It can be noted that no small scale system was identified to warranty long term operation under low maintenance and low energy and chemical requirement over a broad range of feed water quality (ideal specifications of membrane system for small supply).

5.4 Membrane Modules

5.4.1 Polymeric Membrane

Regarding polymeric membranes, many options exist and different ranges are illustrated in Table 1. More details are listed in Annex III. From the survey, Ultrafiltration is clearly identified as the most available process with 70% of the products, with are supplied by Aquasource, Legio, Membratek, Memfil, Polymem, Toray, XFlow, Zenon or Ultra-Flo. MF (Prime Water, Toray), NF (DOW) and RO (DOW, Innosep, Membratek) membranes were less numerous.

Table 3 - General characteristics of the polymer modules

Treatment Scheme	MF : 3%, UF : 70%, NF : 13%, RO: 14%
Membrane Area (m2)	0.25 – 0.5 – 0.75 – 2.2 – 4.5 – 9 –12 – 20 - 29 - 40 -70 - 114
Membrane material	Polyethersulfone, PVDF, Polyamide, Polyethylene, Polyacrylonitrile
Average pore Size (MF/UF, µm)	0.01 – 0.02 – 0.05 – 0.08 – 0.15 -0.2
Approval / Certification	NL - D - UK - Fr - USA - Japan - NSF – KTW

Figure 21 represents the range of the polymeric modules regarding the nominal flow rates and the membrane areas. It can be seen that hollow fibers offer a larger range of possibilities with membrane areas from 0.25 to 114 m2 which enable flow rates from 0.6 to 300 m3/d.

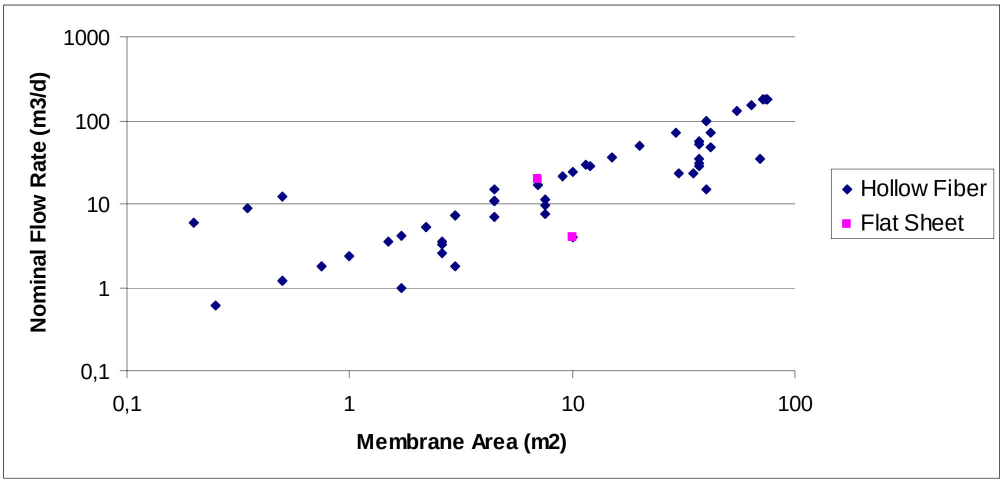


Figure 21 - Range of polymeric membrane modules

The distribution of the polymeric modules regarding average pore sizes is represented in Figure 22 and it shows that UF is the main process.

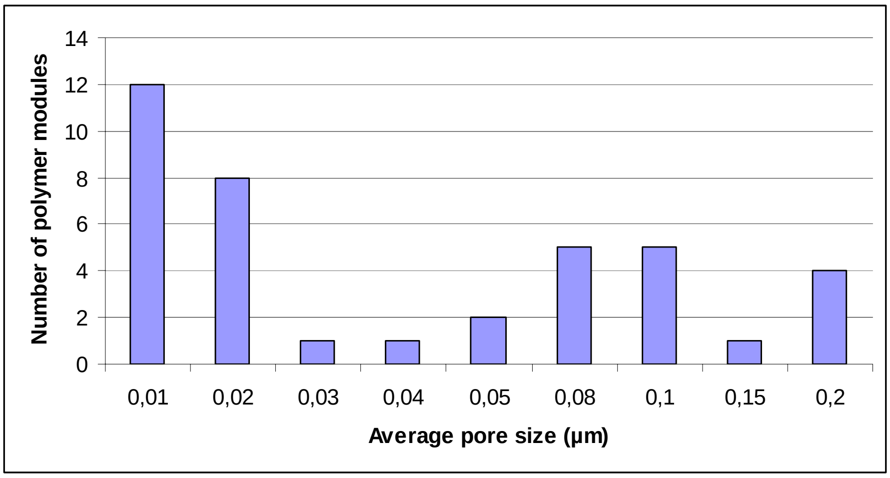


Figure 22 - Distribution of MF/UF polymeric modules in function of the average pore size

5.4.2 *Ceramic Membrane*

Many polymers have been tested as membrane materials and R&D is now reinventing the use of materials, such as ceramics. Indeed, although such materials are still more expensive than polymers, they enable higher fluxes and aggressive chemical cleaning against fouling. Thus, even if the inorganic membrane market only represented \$0.6 billion out of the \$8 billion market for membrane equipment in 2003, the corresponding annual growing rate is higher: 14% compared to 8% for the total market (Hofman, Ridder et al. 2007). From the survey, only MF ceramic modules (see Table 2) have been identified (from Aquastel and TAMI). However, it has also been seen – through Elga Berkefeld – that NGK ceramic membranes could be used in small water supply applications. It is expected that UF ceramic modules may soon enter the market of small-scale membrane systems (if not already).

Table 4 - General characteristics for ceramic membranes

Membrane Area (m2)	0.20 – 0.35 – 0.5
Average pore Size (MF, µm)	0.14 -0.2 -0.45 – 0.8 - 1.4
Flow rate (m3/d)	0.6 – 2.4 – 3.5 - 5 - 10 - 20

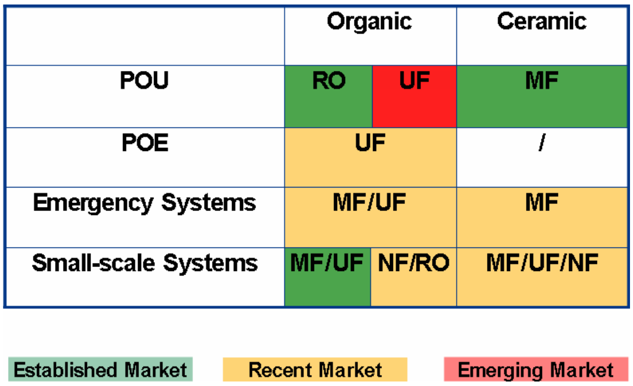
6 Conclusion and Future Perspectives

This report presented a first view of the market of membrane-based products for decentralised water supply. The identification of the market niches was performed thanks to Internet research and form requests during a 4 month-period. It is presumed that a part of the market was not consulted because the companies do not advertise on Internet on the English language. Therefore, it cannot be regarded as an exhaustive survey but a good basis for development considerations. However, at this stage, it was difficult to integrate consistent considerations on costs and energy requirements, although they are relevant parameters.

The membrane process is an attractive technology as it provides an absolute barrier that enables the removal of pathogens. However, the integrity of the support is a critical point as any leakage could have serious consequences on the drinking water quality. Thus, although the membrane itself gets cheaper, the integrity test remains a difficult technical issue for small systems. In these regards, a double-barrier approach may be recommended, such as UV post-treatment (see PerfectorE by Norit/PWN). In developing and transition countries, chemical disinfection such as chlorination or chloramination could be a cost effective option, although it cannot guarantee the same treatment performance than UV. In any case, the performance of small membrane-based systems will rely upon appropriate and regular maintenance.

Decentralised water supply was stated as a priority issue and important technological breakthroughs are expected in the forthcoming years, especially in regards to the use of renewable energy. As membrane systems have become more and more affordable, new applications should be suitable to provide drinking water in areas where a centralised water distribution is technologically or economically impossible. The membrane market for water supply and sanitation is large and many products are commercially available. Yet, when looking more specifically at small units for drinking water uses, the market is still at a growing phase, and most of developments occurred in the past 3-5 years. Thus, many companies would claim that their membrane modules are effective for treating the water a small scale although the equipment was not directly designed or tested for that purpose. Companies adopt fast development strategies to fill empty market niches in regions where a socio-economical boom is expected. The market will be mature once few products make their proofs on the field site and start being standardised and produced in large quantities. Given the observed speed of development, this may turn soon into reality, and membrane technologies may become in the coming years one cost-effective option to address the issue of decentralised water supply in developed countries, but also in transition and developing countries.

The membrane market evolution for small systems can be summarized in Figure 23. Depending on the product niche, the membrane material and the filtration type, different degrees toward the market maturity were identified.



	Organic		Ceramic
POU	RO	UF	MF
POE	UF		/
Emergency Systems	MF/UF		MF
Small-scale Systems	MF/UF	NF/RO	MF/UF/NF

Established Market | Recent Market | Emerging Market

Figure 23 - Market Overview for membrane-based systems regarding small water supply

As only few simple UF POU and low-energy small-scale systems were identified, current development activities in TECHNEAU WP2.5 are considered relevant. Indeed, the EU research project TECHNEAU (www.techneau.eu) aims to contribute to the market breakthrough with the development and the demonstration of new UF POU and small-scale systems. Equipped with a biosand pre-filter, the gravity-driven prototypes are designed to be robust and run with limited energy supply (only to bring the water up to a 2m height) and restricted chemical intervention (only chlorine for final disinfection and residual).

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8 Annexes

Annex I: List of companies

Annex II: List of membrane systems
  - POU/POE and single-moduled systems
  - Modular systems
  - Emergency systems

Annex III: List of membrane modules
  - Polymeric systems
  - Ceramic systems

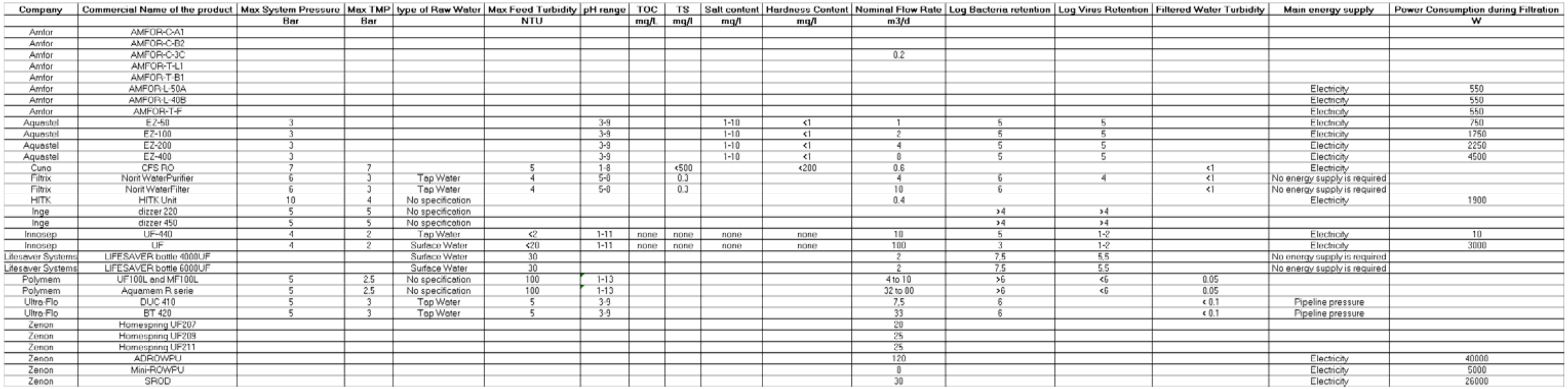
8.1 Annex I: List of companies

Companies	Countries	Website
Ande Membrane Separation Technology & Eng. / AMFOR	China	www.amforinc.com
Aqua-Plus Water Purifier Pvt Ltd	India	www.aquaplusltd.com
Aquasource	France	www.aquasource-membrane.com
Aquastel Water Systems	Netherlands	www.aquastelinc.com / www.aquastel.nl
British Berkefeld	US	www.britishberkefeld.com
Colloide Engineering Systems	UK	www.colloide.com
Cuno	US	www.cuno.com
DoultonUSA	US	www.doultonusa.com
DOW	US	www.dow.com
ELGA Berkefeld GmbH	Germany	www.elga-berkefeld.de
Filtrix	Netherlands	www.filtrix.com
HITK	Germany	www.hitk.de
Hydranautics	US	www.membranes.com
Inge	Germany	www.inge.ag
Innosep Co Ltd	Thailand	www.innosep.co.th
Jurby Water Tech International (JWT)	UK	www.jurby.com
Legio	Germany	www.legio.de
Lifesaver Systems	UK	www.lifesaversystems.com
Litree Purifying Technology Co Ltd	China	www.litree.com
Membratek	South Africa	www.vwsenvig.co.za
Memfil	Malaysia	www.memfil.com
Mitsubishi	Japan	www.mrc.co.jp/mre/english/index.html
Norit Membrane Technology BV	Netherlands	www.norit.com
PALL	US	www.pall.com
Polymem SA	France	www.polymem.fr
Prime Water International NV	Belgium	www.primewater.com
Seccua	Germany	www.seccua.de
Skyjuice	Australia	www.skyjuice.com.au
TAMI Industries	France	www.tami-industries.com
Toray Membrane Europe AG	Switzerland	www.toray-membrane.com
Trisep	US	www.trisep.com
Ultra-Flo	Singapour	www.ultra-flo.com.sg
Wat Membratec GmbH & Co KG	Germany	www.wat-membratec.com
Weise Water Systems GmbH & Co KG (WWS)	Germany	www.weise-water-systems.com
X-flow	Netherlands	www.xflow.nl
Zenon Environmental Inc.	Canada	www.zenon.com

8.2 Annex II: List of membrane systems

8.2.1 POU/POE and single-moduled systems

Company	Commercial Name of the product	Type of Filtration	Filtration Mode	Flushing Mode	Pre-treatment	Post-treatment	Module Reference	Membrane Type	Membrane material	Membrane Area	Membrane inner diameter	MWCO	Average Pore Size
										m2	mm	kDa	µm
Amfor	AMFOR-C-A1	RO											
Amfor	AMFOR-C-B2	RO											
Amfor	AMFOR-C-3C	RO				in-line post carbon							
Amfor	AMFOR-T-L1	RO											
Amfor	AMFOR-T-B1	RO											
Amfor	AMFOR-L-50A	RO											
Amfor	AMFOR-L-40B	RO											
Amfor	AMFOR-T-F	RO											
Aquastel	EZ-50	ED	Cross Flow	No Flushing	Filtration + softening		C-50	Ceramic					
Aquastel	EZ-100	ED	Cross Flow	No Flushing	Filtration + softening		C-100	Ceramic					
Aquastel	EZ-200	ED	Cross Flow	No Flushing	Filtration + softening		C-200	Ceramic					
Aquastel	EZ-400	ED	Cross Flow	No Flushing	Filtration + softening		C-200	Ceramic					
Cuno	CFS RO	RO	Cross Flow	No Flushing	softening, sediment reduction	if required		Polymer		<1	15		
Filtrix	Norit WaterPurifier	UF	Dead End	No Flushing	No	No	Norit X-Flow UFC M5	Polymer	PES	0,17	0,8	200	0,025
Filtrix	Norit WaterFilter	MF	Dead End	No Flushing	No	No	Norit X-Flow MF02	Polymer	PES	0,17	0,8		0,015
HITK	HITK Unit	NF						Ceramic		0,4	15		
Inge	dizzer 220	UF	In to out	Forward and Backward Flushing				Polymer	PES	2,2	0,9		0,02
Inge	dizzer 450	UF	In to out	Forward and Backward Flushing				Polymer	PES	4,5	0,9		0,02
Innosep	UF-440	UF	Dead End	Forward and Backward Flushing	Filtration 100 µm	No	UFL	Polymer	PES	4,5	0,8	100	0,01
Innosep	UF	UF	Cross Flow	Forward and Backward Flushing	Filtration 100 µm	No	UF-5	Polymer	PES	50	0,8	100	0,01
Lifesaver Systems	LIFESAVER bottle 4000UF	UF						Polymer				200	0,015
Lifesaver Systems	LIFESAVER bottle 6000UF	UF						Polymer				200	0,015
Polymem	UF100L and MF100L	UF	Dead End	Forward and Backward Flushing	No	No	UF100L	Polymer	Hydrophilized polysulfone	4,5	0,72 (outer diameter)	10 - 300	0,08 to 0,2
Polymem	Aquamem R serie	UF	Out to in	Water + Air Forward and Backward Flushing	No	No	UF100L	Polymer	Hydrophilized polysulfone	4,5 to 36	0,72 (outer diameter)	10 - 300	0,08 to 0,2
Ultra-Flo	DUC 410	UF	Dead End	Manual Wash	No	No	U410	Polymer	Modified Polyacrylonitrile	0,9	1	150	0,1
Ultra-Flo	BT 420	UF	Dead End	Manual Wash	No	No	U420	Polymer	Modified Polyacrylonitrile	5	1	150	0,1
Zenon	Homespring UF207	UF			Activated Carbon								
Zenon	Homespring UF209	UF			Activated Carbon								
Zenon	Homespring UF211	UF			Activated Carbon								
Zenon	ADROWPU	RO											
Zenon	Mini-ROWPU	RO											
Zenon	SROD	RO											



Company	Commercial Name of the product	Max System Pressure	Max TMP	type of Raw Water	Max Feed Turbidity	pH range	TOC	TS	Salt content	Hardness Content	Nominal Flow Rate	Log Bacteria retention	Log Virus Retention	Filtered Water Turbidity	Main energy supply	Power Consumption during Filtration
		Bar	Bar		NTU		mg/L	mg/l	mg/l	mg/l	m3/d					W
Amfor	AMFOR-C-A1															
Amfor	AMFOR-C-B2															
Amfor	AMFOR-C-3C										0.2					
Amfor	AMFOR-T-L1															
Amfor	AMFOR-T-B1															
Amfor	AMFOR-L-50A														Electricity	550
Amfor	AMFOR-L-40B														Electricity	550
Amfor	AMFOR-T-F														Electricity	550
Aquastel	EZ-50	3				3-9			1-10	<1	1	5	5		Electricity	750
Aquastel	EZ-100	3				3-9			1-10	<1	2	5	5		Electricity	1750
Aquastel	EZ-200	3				3-9			1-10	<1	4	5	5		Electricity	2250
Aquastel	EZ-400	3				3-9			1-10	<1	8	5	5		Electricity	4500
Cuno	CFS RO	7	7		5	1-8		<500		<200	0.6			<1	Electricity	
Filtrix	Norit WaterPurifier	6	3	Tap Water	4	5-8		0.3			4	6	4	<1	No energy supply is required	
Filtrix	Norit WaterFilter	6	3	Tap Water	4	5-8		0.3			10	6		<1	No energy supply is required	
HITK	HITK Unit	10	4	No specification							0.4				Electricity	1900
Inge	dizzer 220	5	5	No specification								>4	>4			
Inge	dizzer 450	5	5	No specification								>4	>4			
Innosep	UF-440	4	2	Tap Water	<2	1-11	none	none	none	none	10	5	1-2		Electricity	10
Innosep	UF	4	2	Surface Water	<20	1-11	none	none	none	none	100	3	1-2		Electricity	3000
Lifesaver Systems	LIFESAVER bottle 4000UF			Surface Water	30						2	7.5	5.5		No energy supply is required	
Lifesaver Systems	LIFESAVER bottle 6000UF			Surface Water	30						2	7.5	5.5		No energy supply is required	
Polymem	UF100L and MF100L	5	2.5	No specification	100	1-13					4 to 10	>6	<6	0.05		
Polymem	Aquamem R serie	5	2.5	No specification	100	1-13					32 to 80	>6	<6	0.05		
Ultra-Flo	DUC 410	5	3	Tap Water	5	3-9					7,5	6		< 0.1	Pipeline pressure	
Ultra-Flo	BT 420	5	3	Tap Water	5	3-9					33	6		< 0.1	Pipeline pressure	
Zenon	Homespring UF207										20					
Zenon	Homespring UF209										25					
Zenon	Homespring UF211										25					
Zenon	ADROWPU										120				Electricity	40000
Zenon	Mini-ROWPU										8				Electricity	5000
Zenon	SROD										30				Electricity	26000

8.2.2 *Modular Small-scale systems*

Company	Commercial Name of the product	Type of Filtration	Filtration Mode	Flushing Mode	Pre-treatment	Post-treatment	Module Reference	Number of modules per treatment unit	Membrane Type	Membrane material
Aquasource	Ultrasource	UF					A1A35	6		
Aquasource	Ultrasource	UF					A1A35	8		
Aquasource	Ultrasource	UF					A1A35	12		
Aquasource	Ultrasource	UF					A1A35	16		
Aquasource	Ultrasource	UF					A1A35	18		
Aquasource	Skid	UF					L1B35-64	2		
Aquasource	Skid	UF					L1B35-64	3		
Aquasource	Skid	UF					L1B35-64	4		
Aquasource	Skid	UF					L1B35-64	5		
Aquasource	Skid	UF					L1B35-64	6		
Aquasource	EcoSkid	UF					L1D35	6		
Colloide	Sub snake	UF		Water + Air Forward and Backward Flushing	No		Sub snake	Various	Polymer	
Filtrix	Norit LineGuard	UF	Dead End	Forward Flushing	No	No	Norit X-Flow UFC M5	1 or 2	Polymer	PES
Innosep	NF	NF	Cross flow	Forward Flushing	No		RO 5	6	Polymer	Composite polyamide
Jurby	JurbyFlow RO	RO	Cross Flow	Forward Flushing	Filtration, sorbtion, antiscalant dosing	Desinfection, pH correction	Filmtec/Hydranautics/Osmonics	1-45	Polymer	
Jurby	JurbyFlow UF	UF	Dead End	Forward and Backward Flushing	Coagulation, filtration	RO, desinfection, pH correction	Hydranautics/Inge/Norit	2-16	Polymer	
Mitsubichi	LFB13623							1	Polymer	Polyethylene
Mitsubichi	LFB40823							3	Polymer	Polyethylene
Mitsubichi	LFB81623							6	Polymer	Polyethylene
Pall	AP-1	UF		Water + Air Forward and Backward Flushing			Pall Microza	2	Polymer	PVDF
Pall	AP-2	UF		Water + Air Forward and Backward Flushing			Pall Microza	8	Polymer	PVDF
Pall	AP-3	UF		Water + Air Forward and Backward Flushing			Pall Microza	10	Polymer	PVDF
Pall	AP-3x	UF		Water + Air Forward and Backward Flushing			Pall Microza	20	Polymer	PVDF
Pall	AP-4	UF		Water + Air Forward and Backward Flushing			Pall Microza	36	Polymer	PVDF
Pall	AP-6	UF		Water + Air Forward and Backward Flushing			Pall Microza	60	Polymer	PVDF
Polymem	Aquamem serie	UF	Out to in	Water + Air Forward and Backward Flushing	No	No	Polymem UF100L and UF80	1 to 16	Polymer	
Polymem	Skid serie	UF	Out to in	Water + Air Forward and Backward Flushing		No	Polymem UF80 and UF120	1 to 24	Polymer	
Seccua	Virex 900	UF		Forward and Backward Flushing			SeccuMem Membrane Filter	2	Polymer	
Ultra Flo	MU01-8	UF	Dead End	Water + Air Forward and Backward Flushing	No	No	U860	1	Polymer	Modified Polyacrylonitrile
Ultra Flo	MU24-8	UF	Dead End	Water + Air Forward and Backward Flushing	No	No	U860	24	Polymer	Modified Polyacrylonitrile
WAT Membratec	New product	UF	Dead End	Forward and Backward Flushing	if required: activated carbon	if required degassing, stabilisation	MEMBRANA LuiqiCel W	1 (up to 4)	Polymer	
Weise	Aquacell PE 4	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MC03	1	Polymer	PES
Weise	Aquacell Series Up To PE 40	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	1 to 6	Polymer	PES
Weise	MA03-2	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MC03	2	Polymer	PES
Weise	MA03-8	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	4	Polymer	PES
Weise	MA03-16	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	8	Polymer	PES
Weise	MA03-20	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	10	Polymer	PES
Weise	MA03-40	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	20	Polymer	PES
Weise	MA03-80	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	40	Polymer	PES
Weise	MA03-100	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	50	Polymer	PES
Weise	MA04-12	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	6	Polymer	PES
Weise	MA04-18	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	9	Polymer	PES
Weise	MA04-24	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	12	Polymer	PES
Weise	MA04-30	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	15	Polymer	PES
Weise	MA04-60	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	30	Polymer	PES
Weise	MA04-90	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	45	Polymer	PES
Weise	MA04-150	UF	Out to In	Water+Air Forward and Backward Flushing	Screening 2 mm	No	MCXL	75	Polymer	PES
Zenon	Z-box S6	UF	Out to In				ZeeWeed 1000	6	Polymer	PVDF
Zenon	Z-box S12	UF	Out to In				ZeeWeed 1000	12	Polymer	PVDF
Zenon	Z-box S18	UF	Out to In				ZeeWeed 1000	18	Polymer	PVDF
Zenon	Z-box M12	UF	Out to In				ZeeWeed 500	12	Polymer	PVDF
Zenon	Z-box M26	UF	Out to In				ZeeWeed 500	26	Polymer	PVDF

Company	Commercial Name of the product	Membrane Area	Membrane inner diameter	Molecular Weight cut off (MWCO)	Average Pore Size	type of Raw Water	Nominal Flow Rate	Log Bacteria	Log Virus	Filtered Water Turbidity	Main energy supply	Power Consumption during Filtration
		m2	**mm**	**kDa**	**µm**		**m3/d**					**W**
Aquasource	Ultrasource	96					96					400
Aquasource	Ultrasource	132					132					550
Aquasource	Ultrasource	192					192					800
Aquasource	Ultrasource	264					264					1100
Aquasource	Ultrasource	312					312					1800
Aquasource	Skid	288					288					8000
Aquasource	Skid	432					432					12000
Aquasource	Skid	576					576					16000
Aquasource	Skid	720					720					20000
Aquasource	Skid	864					864					24000
Aquasource	EcoSkid	864					864					7500
Colloide	Sub snake	10/module	10	150	0,05							
Filtrix	Norit LineGuard	6,4/module	0,8	200	0,025	No specification	40	6	4	<1	Electricity	10
Innosep	NF	180	0,84	0,2		GroundWater	100	6	3	<1	Electricity	8000
Jurby	JurbyFlow RO		65/100/200			No specification	0,5-500				Electricity	
Jurby	JurbyFlow UF	50/module			0,02	No specification	0,5-500				Electricity	
Mitsubichi	LFB13623	136			0.1		81,6					
Mitsubichi	LFB40823	408			0.1		244,8					
Mitsubichi	LFB81623	816			0.1		489,6					
Pall	AP-1	200			0,1		40	6		<0,1		
Pall	AP-2	800			0,1		75	6		<0,1		
Pall	AP-3	1000			0,1		250	6		<0,1		
Pall	AP-3x	2000			0,1		250	6		<0,1		
Pall	AP-4	3600			0,1		500	6		<0,1		
Pall	AP-6	6000			0,1		1000	6		<0,1		
Polymem	Aquamem serie											
Polymem	Skid serie											
Seccua	Virex 900	9			0,015		90			<0,1	Electricity	5
Ultra Flo	Ultra-Flo MU01-8	42	1	150	0,1		48	3		0,1		250W/m3
Ultra Flo	Ultra Flo MU24-8	1008	1	150	0,1		48	3		0,1		250W/m3
WAT Membratec	New product	61/module	0,8	80	0,01	No specification		6	6	<0,05	Electricity	
Weise	Aquacell PE 4	3,5		150	0,05	All types	1,05	6	6	<1	Electricity	
Weise	Aquacell Series Up To PE 40	7 to 42		150	0,05	All types	2,1 to 12,6	6	6	<1	Electricity	
Weise	MA03-2	7		150	0,05	All types	2,1	6	6	<1	Electricity	
Weise	MA03-8	28		150	0,05	All types	8,4	6	6	<1	Electricity	
Weise	MA03-16	56		150	0,05	All types	16,8	6	6	<1	Electricity	
Weise	MA03-20	70		150	0,05	All types	21	6	6	<1	Electricity	
Weise	MA03-40	140		150	0,05	All types	42	6	6	<1	Electricity	
Weise	MA03-80	280		150	0,05	All types	84	6	6	<1	Electricity	
Weise	MA03-100	350		150	0,05	All types	105	6	6	<1	Electricity	
Weise	MA04-12	42		150	0,05	All types	12,6	6	6	<1	Electricity	
Weise	MA04-18	63		150	0,05	All types	18,9	6	6	<1	Electricity	
Weise	MA04-24	84		150	0,05	All types	25,2	6	6	<1	Electricity	
Weise	MA04-30	105		150	0,05	All types	31,5	6	6	<1	Electricity	
Weise	MA04-60	210		150	0,05	All types	63	6	6	<1	Electricity	
Weise	MA04-90	315		150	0,05	All types	94,5	6	6	<1	Electricity	
Weise	MA04-150	525		150	0,05	All types	157,5	6	6	<1	Electricity	
Zenon	Z-box S6					Surface Water	378				Electricity	
Zenon	Z-box S12					Surface Water	772				Electricity	
Zenon	Z-box S18					Surface Water	990				Electricity	
Zenon	Z-box M12						329				Electricity	
Zenon	Z-box M26						662				Electricity	

8.2.3 *Emergency systems*

Company	Product	Type of Filtration	Filtration Mode	Flushing Mode	Precised Pre-treatment	Precised Post-treatment	Module Reference	Number of modules	Membrane Type	Membrane material
Elga Berkefeld	TWA 15 UF	MF	Dead End	Water + Air Forward and Backward Flushing	floculation and adsorbtion	UV, storage chlorination	NGK, 180 O.D. x 1000L Sub-module	6	Ceramic	
Skyjuice	SkyHydrant SMF-1	MF		No Flushing			Memcor	1	Polymer	
Xflow /Norit	Perfector-E	UF	In to out	Forward and Backward Flushing		UV	Aquaflex SXL225 UFC M5 0.8	2	Polymer	PES
Ultra-Flo	HP-BT420	UF	Dead End	Manual	No	No	420	1	Polymer	Modified Polyacrylonitrile

Company	Product	Membrane Area	Membrane inner diameter	MWCO	Average Pore Size	Max System Pressure	Max TMP	Operationnal TMP	type of Raw Water	Max recommended Feed Turbidity
		m2	mm	kDa	µm	Bar	Bar	Bar		NTU
Elga Berkefeld	TWA 15 UF	15	2,5		0,1	4	1,7	0,1 - 0,2	No specification	
Skyjuice	SkyHydrant SMF-1				0,1		4		No specification	500
Xflow /Norit	Perfector-E	40	0,8	150	0,02	6	3	1	No specification	100
Ultra-Flo	HP-BT420			150	0,1	4	3	0,5	Surface	50

Company	Product	Nominal Flow Rate	Treatment Capacity	Log Bacteria	Log Virus	Filtered Water Turbidity	Main energy supply	Power Consumption during Filtration	Power Consumption during Cleaning	Other Energy sources
		m3/d	m3/m2					W	W	
Elga Berkefeld	TWA 15 UF	300	0,170	4		0,05	Electricity	3000	1000	Electricity
Skyjuice	SkyHydrant SMF-1	10				<0.1	No energy supply is required			Solar energy
Xflow /Norit	Perfector-E	48	0,6	6	4	<0,1	Electricity	<50 W hr/m3		
Ultra-Flo	HP-BT420	12		3		0,1	Manual Pumping			

Company	Product	Width	Depth	Height	Dry Weight	Operating Weight	Repair Procedure	Soaking Time for cleaning	Cleaning Intervalls	Disincfecting Agent
		cm	cm	cm	kg	kg		min		
Elga Berkefeld	TWA 15 UF	120	80	160	322,5	350			3-4/year	
Skyjuice	SkyHydrant SMF-1	30	30	170	13	30	Manual wash	1.5	every 1-2 hours	NaOCl
Xflow /Norit	Perfector-E	114	114	225	450	1000	Pinning	0	No chemical cleaning required	
Ultra-Flo	HP-BT420	43	61	94	20	23	Replace Module	20		H_2O_2 , NaOCl

8.3 Annex III: List of membrane modules

8.3.1 *Polymer Modules*

8.3.1.1 Characteristics of the modules

Company	**Commercial Name of the product**	**Type of Filtration**	**Filtration Mode**	**Flushing Mode**	**Membrane Type**	**Membrane material**	**Membrane Area**	**Membrane inner diameter**	**MWCO**	**Average Pore Size**
							m2	**mm**	**kDa**	**µm**
Aquaplus Water Purifiers	ULcap 2012	UF	Out to in	Forward Flushing	Hollow Fiber			0,6	70	0,01
Aquaplus Water Purifiers	Ulcap 2021	UF	In to out	Water + Air For-and-Backward Flushing	Hollow Fiber			0,9	70	0,01
Aquaplus Water Purifiers	Ulcap 3540	UF	In to out	Water + Air For-and-Backward Flushing	Hollow Fiber			0,9	70	0,01
Aquaplus Water Purifiers	ULcap 5044	UF	In to out	Water + Air For-and-Backward Flushing	Hollow Fiber			0,9	70	0,01
Aquaplus Water Purifiers	ULCap 8040	UF	In to out	Water + Air For-and-Backward Flushing	Hollow Fiber			0,9	70	0,01
Aquasource	SM1A35	UF			Hollow Fiber		1			
Aquasource	SM1F35	UF			Hollow Fiber		1,5			
Aquasource	A1A35	UF			Hollow Fiber		7			
Aquasource	A1F35	UF			Hollow Fiber		10			
Aquasource	L1B35	UF			Hollow Fiber		55			
Aquasource	L1B35-64	UF			Hollow Fiber		64			
Aquasource	L1D35	UF			Hollow Fiber		74			
Aquasource	B1H35 / AC1125	UF			Hollow Fiber		125			
Colloide		UF		Water + Air For-and-Backward Flushing	Flat Sheet		10	10	150	0,05
DOW	TW30-1812-24	RO				PA		44,5		
DOW	TW30-1812-36	RO				PA		44,5		
DOW	TW30-1812-50	RO				PA		44,5		
DOW	TW30-1812-75	RO				PA		44,5		
DOW	TW30-1812-100	RO				PA		44,5		
DOW	SW30XLE-400i	RO				PA	37			
DOW	SW30HR LE-400	RO				PA	37			
DOW	SW30HR-380	RO				PA	35			
DOW	SW30HR-320	RO				PA	30			
DOW	NF90-400	NF				PA	37			
DOW	NF200-400	NF				PA	37			
DOW	NF270-400	NF				PA	37			
DOW	NF-2540	NF				PA	2,6			
DOW	NF-4040	NF				PA	7,6			
DOW	NF-400	NF				PA	37,2			
DOW	NF90-2540	NF				PA	2,6			
DOW	NF90-4040	NF				PA	7,6			
DOW	NF270-400	NF				PA	37			
DOW	NF270-2540	NF				PA	2,6			
DOW	NF270-4040	NF				PA	7,6			
Innosep	AFT-UF	UF	Dead End	Forward and Backward Flushing	Hollow Fiber		4,5	0,8	100	0,01
Innosep	RO/NF	RO	Cross Flow	Forward Flushing	Flat Sheet		7			
Inge	Dizzer 3000	UF	Dead End	Forward and Backward Flushing			30			
Inge	Dizzer 5000	UF	Dead End	Forward and Backward Flushing			50			
Legio	typ 050-7-0025-100-40-10	UF	Dead End		Hollow Fiber	PES	0,25	0,8	100	
Legio	A typ 050-7-0050-150-40-10	UF	Dead End		Hollow Fiber	PES	0,5	0,8	100	
Legio	B typ 050-7-0075-150-40-10	UF	Dead End		Hollow Fiber	PES	0,75	0,8	150	
Legio	A typ 050-7-0050-150-80-10	UF	Dead End		Hollow Fiber	PES	0,5	0,8	100	
Legio	B typ 050-7-0075-150-80-10	UF	Dead End		Hollow Fiber	PES	0,75	0,8	150	

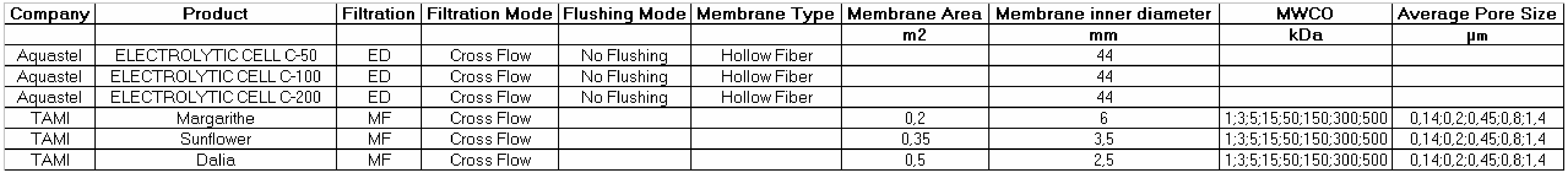
Company	Commercial Name of the product	Type of Filtration	Filtration Mode	Flushing Mode	Membrane Type	Membrane material	Membrane Area	Membrane inner diameter	MWCO	Average Pore Size
							m2	mm	kDa	µm
Legio	A typ 110-7-0220-150-40-10-20	UF	Dead End		Hollow Fiber	PES	2,2	0,8	100	
Legio	B typ 110-7-0450-150-40-10-20	UF	Dead End		Hollow Fiber	PES	4,5	0,8	150	
Legio	A typ 110-7-0220-150-40-10-32	UF	Dead End		Hollow Fiber	PES	2,2	0,8	100	
Legio	B typ 110-7-0450-150-40-10-32	UF	Dead End		Hollow Fiber	PES	4,5	0,8	150	
Legio	A typ 110-7-0220-150-80-10-20	UF	Dead End		Hollow Fiber	PES	2,2	0,8	100	
Legio	B typ 110-7-0450-150-80-10-20	UF	Dead End		Hollow Fiber	PES	4,5	0,8	150	
Legio	A typ 110-7-0220-150-80-10-32	UF	Dead End		Hollow Fiber	PES	2,2	0,8	100	
Legio	B typ 110-7-0450-150-80-10-32	UF	Dead End		Hollow Fiber	PES	4,5	0,8	150	
Legio	typ 200-1-0900-30-40-10	UF	Dead End		Hollow Fiber	PES	9	1,2	30	
Legio	typ 200-1-1200-100-40-10	UF	Dead End		Hollow Fiber	PES	12	0,85	100	
Litree	LH3-0650-V	UF	Cross Flow	Forward and Backward Flushing	Hollow Fiber		10	0,85	80	0,01
Litree	LH3-1060-V	UF	Cross Flow	Forward and Backward Flushing	Hollow Fiber		40	0,85	80	0,01
Membratek	STRO 2.5/1.7AL(S)398	RO			Hollow Fiber	Cellulose Acetate	1,7	12,7		
Membratek	STRO 4.3/3.0AL(S)398	RO			Hollow Fiber	Cellulose Acetate	3	12,7		
Membratek	STRO 2.5/1.7AL(S)719	UF			Hollow Fiber	PES	1,7	12,7	40	
Membratek	STRO 4.3/3.0AL(S)719	UF			Hollow Fiber	PES	3	12,7	40	
Membratek	MEMTUF 3.2/3.0(4-10)719	UF			Hollow Fiber	PES	3	8,9	40	
Memfil	Ultra Filter DSS-540S	UF	In to Out		Hollow Fiber				80	0,01
Memfil	Ultra Filter DSS-440S	UF	In to Out		Hollow Fiber				80	0,01
Memfil	Ultra Filter DSS-420S	UF	In to Out		Hollow Fiber				80	0,01
Memfil	Ultra Filter DRS-440S	UF	In to Out		Hollow Fiber				80	0,01
Mitsubichi	UMF-824WI	UF			Hollow Fiber	Polyethylene	8	11		0,1
Mitsubichi	UMF-2024WFA	UF			Hollow Fiber	Polyethylene	20	17		0,1
Mitsubichi	UMF-2012WFA	UF			Hollow Fiber	Polyethylene	20	17		0,03
Polymem	UF50M2	UF	Cross Flow	Forward and Backward Flushing	Hollow Fiber	Hydrophilized polysulfone	15	0,8	10 - 300	0,08 to 0,2
Polymem	UF80 and MF80	UF	Dead End	Water + Air For-and-Backward Flushing	Hollow Fiber		42	0,72 (outer diameter)	10 - 300	0,08 to 0,2
Polymem	UF120 and MF120	UF	Dead End	Water + Air For-and-Backward Flushing	Hollow Fiber		114	0,72 (outer diameter)	10 - 300	0,08 to 0,2
Polymem	Immem WW120	UF	Dead End	Water + Air For-and-Backward Flushing	Hollow Fiber		70	1,4		0,08
Polymem	MF products									
PrimeWater	dual stage MF10-C	MF	Dead End	No Flushing	Hollow Fiber		0,1	0,6		0,15
Toray	HFU-2020	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	72	0,9	150	
Toray	HFU-2008	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	11,5	0,9	150	
Toray	HFU-1020	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	29	0,9	150	
Toray	HFU-1010	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	7	0,9	150	
Toray	HFS-2020	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	72	0,9		0,02
Toray	HFS-2008	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	11,5	0,9		0,02
Toray	HFS-1020	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	29	0,9		0,02
Toray	HFS-1010	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	7	0,9		0,02
Toray	HFM-2020	MF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	72	0,9		0,1
Toray	HFM-2008	MF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	11,5	0,9		0,1
Toray	HFM-1020	MF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	29	0,9		0,1
Toray	HFM-1010	MF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	7	0,9		0,1
Toray	HFM-1015S	UF	Out to in	Water + Air For-and-Backward Flushing	Hollow Fiber	PVDF	25	0,6	150	0,1
Trisep	SpiraSep 900	UF	Cross Flow	Water + Air For-and-Backward Flushing	Flat Sheet		178	N/A	500	0,05
Ultra-Flo	Ultra-Flo U860	UF	Dead End	Water + Air For-and-Backward Flushing		Polyacrylonitrile (Modified)	42	0,8	150	0,1
Weise	MicroClear MC02	UF	Out to In	Water + Air For-and-Backward Flushing	Flat sheet	PES	5,5		150	0,05
Weise	MicroClear MC03	UF	Out to In	Water + Air For-and-Backward Flushing	Flat sheet	PES	3,5		150	0,05
Weise	MicroClear MCXL	UF	Out to In	Water + Air For-and-Backward Flushing	Flat sheet	PES	7		150	0,05
Xflow	XIGA SXL225 UFC M5 0.8	UF	In to out	No Flushing	Hollow Fiber	PES	40	0,8	150	0,02
Xflow	Aquaflex SXL225 UFC M5 0.8	UF	In to out	Forward and Backward Flushing	Hollow Fiber	PES	40	0,8	150	0,02
Xflow	Aquaflex S225 UFC M5 1.5	UF	In to out	Water + Air For-and-Backward Flushing	Hollow Fiber	PES	20	1,5	150	0,02
Zenon	ZeeWeed 500	UF	Out to in		Hollow Fiber	PVDF				0,04
Zenon	ZeeWeed 1000	UF	Out to in		Hollow Fiber	PVDF				0,02

8.3.1.2 Performance of the membrane modules

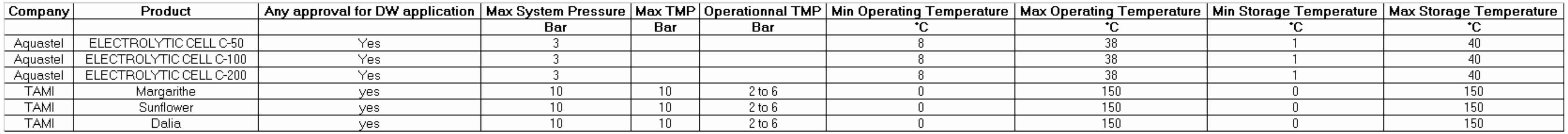
Company	Commercial Name of the product	Approval for DW	Max System Pressure	Max Feed Turbidity	Salt content	Hardness Contant	Nominal Flow Rate	Log Bacteria	Log Virus	Filtered Water Turbidity	Integrity control	Main energy supply
			Bar	NTU	mg/L	mg/L	m3/d			NTU		
Aquaplus Water Purifiers	ULcap 2012	India	2	10					6	0.1		
Aquaplus Water Purifiers	Ulcap 2021		5									
Aquaplus Water Purifiers	Ulcap 3540		5									
Aquaplus Water Purifiers	ULcap 5044		5									
Aquaplus Water Purifiers	ULCap 8040		5									
Aquasource	SM1A35						2,4					
Aquasource	SM1F35						3,6					
Aquasource	A1A35						16,8					
Aquasource	A1F35						24					
Aquasource	L1B35						132					
Aquasource	L1B35-64						154					
Aquasource	L1D35						178					
Aquasource	B1H35 / AC1125						300					
Colloide							4	5	5	<1		
DOW	TW30-1812-24		21	1			3,8					
DOW	TW30-1812-36		21	1			5,7					
DOW	TW30-1812-50		21	1			7,9					
DOW	TW30-1812-75		21	1			12					
DOW	TW30-1812-100		21	1			16					
DOW	SW30XLE-400i		83				34					
DOW	SW30HR LE-400		83				28					
DOW	SW30HR-380		55				23					
DOW	SW30HR-320		83				23					
DOW	NF90-400		41				28,4					
DOW	NF200-400		41				30,3					
DOW	NF270-400		41				55,6					
DOW	NF-2540		41				3,5					
DOW	NF-4040		41				11,5					
DOW	NF-400		41				51,9					
DOW	NF90-2540		41				2,6					
DOW	NF90-4040		41				7,6					
DOW	NF270-400		41				55,6					
DOW	NF270-2540		41				3,2					
DOW	NF270-4040		41				9,5					
Innosep	AFT-UF	NSF, USDA, KIWA	4	<5	no limit	<250	10-20	6	3	<0.05	bubble test	Electricity
Innosep	RO/NF	NSF, KIWA	14	<2	<5000	<600	10-30				checking conductivity	Electricity
Inge	Dizzer 3000		5				6					
Inge	Dizzer 5000		5				10					
Legio	typ 050-7-0025-100-40-10		10				0,6					
Legio	A typ 050-7-0050-150-40-10		10				1,2					
Legio	B typ 050-7-0075-150-40-10		10				1,8					
Legio	A typ 050-7-0050-150-80-10		10				1,2					
Legio	B typ 050-7-0075-150-80-10		10				1,8					

Company	Commercial Name of the product	Approval for DW	Max System Pressure	Max Feed Turbidity	Salt content	Hardness Contant	Nominal Flow Rate	Log Bacteria	Log Virus	Filtered Water Turbidity	Integrity control	Main energy supply
			Bar	NTU	mg/L	mg/L	m3/d			NTU		
Legio	A typ 110-7-0220-150-40-10-20		10				5,28					
Legio	B typ 110-7-0450-150-40-10-20		10				10,8					
Legio	A typ 110-7-0220-150-40-10-32		10				5,28					
Legio	B typ 110-7-0450-150-40-10-32		10				10,8					
Legio	A typ 110-7-0220-150-80-10-20		10				5,28					
Legio	B typ 110-7-0450-150-80-10-20		10				10,8					
Legio	A typ 110-7-0220-150-80-10-32		10				5,28					
Legio	B typ 110-7-0450-150-80-10-32		10				10,8					
Legio	typ 200-1-0900-30-40-10		10				21,6					
Legio	typ 200-1-1200-100-40-10		10				28,8					
Litree	LH3-0650-V	China	3	50			4			<0.1 NTU		Tap pressure
Litree	LH3-1060-V	China	3	50			15			<0.1 NTU		Tap pressure
Membratek	STRO 2.5/1.7AL(S)398		45				1					
Membratek	STRO 4.3/3.0AL(S)398		45				1,8					
Membratek	STRO 2.5/1.7AL(S)719		10				4,1					
Membratek	STRO 4.3/3.0AL(S)719		10				7,2					
Membratek	MEMTUF 3.2/3.0(4-10)719		5				7,2					
Memfil	Ultra Filter DSS-540S		3,5	20			75	2		<0.1		
Memfil	Ultra Filter DSS-440S		3,5	20			60	2		<0.1		
Memfil	Ultra Filter DSS-420S		3,5	20			25	2		<0.1		
Memfil	Ultra Filter DRS-440S		3,5	20			35	2		<0.1		
Mitsubichi	UMF-824WI											
Mitsubichi	UMF-2024WFA											
Mitsubichi	UMF-2012WFA											
Polymem	UF50M2	NSF61	5	50			18 to 54	6		<0.05	several	
Polymem	UF80 and MF80	NSF61	5	300			40 to 100	6		<0.05		
Polymem	UF120 and MF120	NSF61	5	300			110 to 280	6		<0.05		
Polymem	Immem WW120	NSF61	3				17 to 50	6		<0.05		
Polymem	MF products	NSF61	5									
PrimeWater	dual stage MF10-C	NSF	8					8			bubble point	None
Toray	HFU-2020	Japan	3	200			72-216			0,1	PDT	Electricity
Toray	HFU-2008	Japan	3	200			11.5-34.5			0,1	PDT	Electricity
Toray	HFU-1020	Japan	3	200			29-87			0,1	PDT	Electricity
Toray	HFU-1010	Japan	3	200			7-21			0,1	PDT	Electricity
Toray	HFS-2020	NSF 61, Japan	3	100			72-288	4	1,5	0,1	PDT	Electricity
Toray	HFS-2008	Japan	3	100			11.5-46	4	1,5	0,1	PDT	Electricity
Toray	HFS-1020	NSF 61, Japan	3	100			29-116	4	1,5	0,1	PDT	Electricity
Toray	HFS-1010	Japan	3	100			7-28	4	1,5	0,1	PDT	Electricity
Toray	HFM-2020	Japan	3	0,05			72-288	4	1,5	0,1	PDT	Electricity
Toray	HFM-2008	Japan	3	0,05			11.5-46	4	1,5	0,1	PDT	Electricity
Toray	HFM-1020	Japan	3	0,05			29-116	4	1,5	0,1	PDT	Electricity
Toray	HFM-1010	Japan	3	0,05			7-28	4	1,5	0,1	PDT	Electricity
Toray	HFM-1015S	Japan	2	200			25-50			0,1	PDT	Electricity
Trisep	SpiraSep 900	no	0,7	100			20		4	<0.1	PDT	Electricity
Ultra-Flo	Ultra-Flo U860	no	1	500	<100 000	<1 000	48	3		0,1		
Weise	MicroClear MC02		0,15				1,65	6	6	<1	bubble test	Electricity
Weise	MicroClear MC03		0,15				1,05	6	6	<1	bubble test	Electricity
Weise	MicroClear MCXL		0,15				2,1	6	6	<1	bubble test	Electricity
Xflow	XIGA SXL225 UFC M5 0.8	NL, D, UK, Fr, USA, Japan	6	30	0-45,000		100	6	4	< 0.1	Diffusive AirflowTesting	Electricity
Xflow	Aquaflex SXL225 UFC M5 0.8	NL, D, UK, Fr, USA, Japan	6	100	0-45,000		100	6	4	< 0.1	Diffusive AirflowTesting	Electricity
Xflow	Aquaflex S225 UFC M5 1.5	NL, D, UK, Fr, USA, Japan	6	300	0-45,000		50	6	4	< 0.1	Diffusive AirflowTesting	Electricity
Zenon	ZeeWeed 500	NSF						4	2,5	0,05		
Zenon	ZeeWeed 1000	NSF						4	4	0,05		

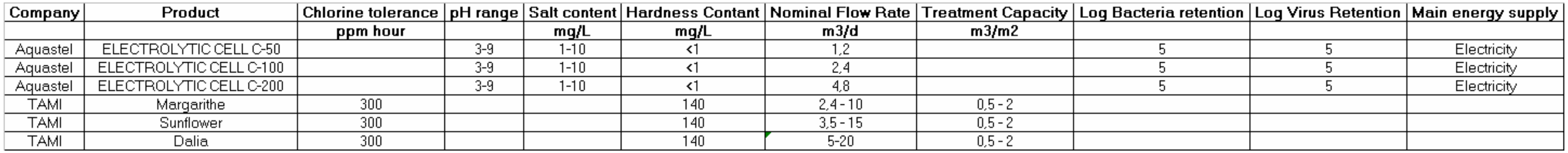
8.3.2 *Ceramic Modules*



Company	Product	Filtration	Filtration Mode	Flushing Mode	Membrane Type	Membrane Area	Membrane inner diameter	MWCO	Average Pore Size
						m2	mm	kDa	µm
Aquastel	ELECTROLYTIC CELL C-50	ED	Cross Flow	No Flushing	Hollow Fiber		44		
Aquastel	ELECTROLYTIC CELL C-100	ED	Cross Flow	No Flushing	Hollow Fiber		44		
Aquastel	ELECTROLYTIC CELL C-200	ED	Cross Flow	No Flushing	Hollow Fiber		44		
TAMI	Margarithe	MF	Cross Flow			0,2	6	1;3;5;15;50;150;300;500	0,14;0,2;0,45;0,8;1,4
TAMI	Sunflower	MF	Cross Flow			0,35	3,5	1;3;5;15;50;150;300;500	0,14;0,2;0,45;0,8;1,4
TAMI	Dalia	MF	Cross Flow			0,5	2,5	1;3;5;15;50;150;300;500	0,14;0,2;0,45;0,8;1,4



Company	Product	Any approval for DW application	Max System Pressure	Max TMP	Operationnal TMP	Min Operating Temperature	Max Operating Temperature	Min Storage Temperature	Max Storage Temperature
			Bar	Bar	Bar	°C	°C	°C	°C
Aquastel	ELECTROLYTIC CELL C-50	Yes	3			8	38	1	40
Aquastel	ELECTROLYTIC CELL C-100	Yes	3			8	38	1	40
Aquastel	ELECTROLYTIC CELL C-200	Yes	3			8	38	1	40
TAMI	Margarithe	yes	10	10	2 to 6	0	150	0	150
TAMI	Sunflower	yes	10	10	2 to 6	0	150	0	150
TAMI	Dalia	yes	10	10	2 to 6	0	150	0	150



Company	Product	Chlorine tolerance	pH range	Salt content	Hardness Contant	Nominal Flow Rate	Treatment Capacity	Log Bacteria retention	Log Virus Retention	Main energy supply
		ppm hour		mg/L	mg/L	m3/d	m3/m2			
Aquastel	ELECTROLYTIC CELL C-50		3-9	1-10	<1	1,2		5	5	Electricity
Aquastel	ELECTROLYTIC CELL C-100		3-9	1-10	<1	2,4		5	5	Electricity
Aquastel	ELECTROLYTIC CELL C-200		3-9	1-10	<1	4,8		5	5	Electricity
TAMI	Margarithe	300			140	2,4 - 10	0,5 - 2			
TAMI	Sunflower	300			140	3,5 - 15	0,5 - 2			
TAMI	Dalia	300			140	5-20	0,5 - 2			