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1.1 Introduction

The quantity and availability of fresh water is one of the important issues that the world is facing today.

The overexploitation of aquifers and the subsequent lowering in their levels is a problem in many areas in the world including the ones in the Near East. The Millennium Development Goal (MDG) water indicator, which compares the total freshwater withdrawal with the total renewable freshwater resources, reflects the overall anthropogenic pressure on freshwater resources. As can be seen from Table 1 water use is, in many countries in the near East, unsustainable: withdrawal exceeds recharge rates and the water bodies are overexploited. The overexploitation leads to the intrusion of seawater and/or the upward diffusion of deeper saline water into the groundwater with the consequence of deterioration of the groundwater quality. The depletion of water resources can impact negatively on the aquatic ecosystems and, at the same time, undermine the basis for socio-economic development.[1]

Table 1: MDG* Water Indicator by country (FAO, AQUASTAT Survey 2008) [1].

Country	Freshwater withdrawal	Total actual renewable freshwater resources	MDG Water Indicator
	Total	TARWR**	Total freshwater withdrawal as percentage of TARWR
	million m^3	million m^3	%
Bahrain	239	116	206
Israel	1552	1780	87
Jordan	848	937	90
Kuwait	415	20	2075
Palestinian Territory	408	837	49
Gaza Strip	123	71	173
West Bank	157	766	21
Qatar	221	58	381
Saudi Arabia	22467	2400	936
Syrian Arab Republic	13894	16797	83
United Arab Emirates	2800	150	1867
Yemen	3384	2100	161

* MDG - Millennium Development Goals

** TARWR – Total Actual Renewable Water Resources : sum of internal renewable water resources (IRWR) and external actual renewable water resources. It corresponds to the maximum theoretical yearly amount of water actually available for a country at a given moment.

Different alternatives can be used to improve the situation of water resources in the world. This includes: rational use of water resources, optimization of water use (e.g. appropriate irrigation technologies), protection of water sources, the application of innovative technologies to treat low quality water sources such as municipal and industrial waste water and saline waters.

Desalination of seawater is the most important process used to reduce the water scarcity problems in coastal zones in the world. The application of desalination technologies (principally thermal and membrane based desalination) accounts for a worldwide production capacity of 24.5 million m^3/day[2].

Table 2 shows the countries with the highest desalination capacity in the world. Approx. 45 % of the worldwide desalination capacity can be found in the Arabian Golf. Figure 1 shows the distribution of the desalination plants in the Mediterranean countries. Spain is the number four as producer of fresh water by means of desalination and the main producer in Europe. About 70 % of the Spanish desalination plants are situated in the Mediterranean coastal areas [2] (s. Figure 1).

Table 2: Top ten desalination countries in the world (online plant and plants under construction before 2008) [3].

Country	Capacity (m^3/day)	Share of global production (%)
Saudi Arabia	10,598,000	17
United Arab Emirates	8,743,000	14
USA	8,344,000	14
Spain	5,428,000	9
China	2,553,000	4
Kuwait	2,390,000	4
Qatar	2,049,000	3
Algeria	1,826,000	3
Australia	1,508,000	2
Japan	1,153,000	2

The application of desalination has an inevitable environmental impact. Desalination may cause considerable damage to the environment in a number of ways including [4], [5]:

a) The uncontrolled discharge of concentrated brine that can contaminate water aquifers and damage aquatic ecosystems. The brine discharge may also contain apart of high salt concentration, chemicals (e.g. anti-foulants, anti-scalants), corrosion materials, etc. Total dissolved salts (TDS), temperature and density of the discharge are of critical importance as they result in damage to the aquatic environment.

b) Desalination plants work with thermal and electrical energy from an attached power plant. The energy used in the process amounts to a certain carbon dioxide emission, which results in environmental pollution.

c) Desalination plant may cause noise pollution, gaseous emissions and chemical spills.

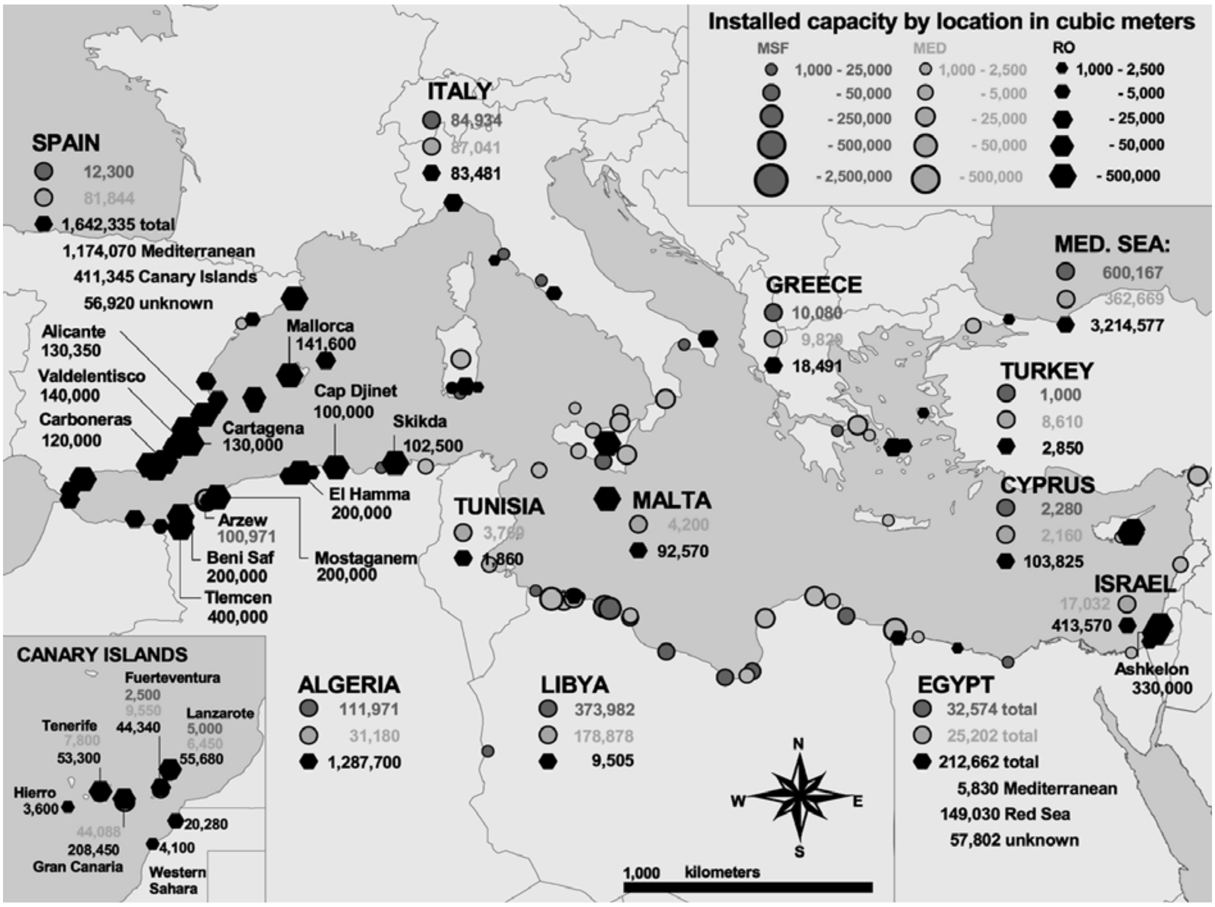

Figure 1: Seawater desalination capacity in the Mediterranean Sea area. The map shows all sites with capacities >1000 m3/day and specifically identifies those with capacities >100,000 m3/day, taken from [2].

1.2 Desalination technologies

There are a lot of different desalination technologies for water treatment, from very old process such as multi-effect distillation (MED) which date from middle of the 19 century [6] to the application of forward osmosis (FO) [7], [8].

In 1999, the Reverse Osmosis (RO) worldwide desalination capacity was about 10 %. The main desalination process was Multi Stage Flash distillation (MSF) with 78 % of the total desalination[3]. Nowadays membrane based desalination (RO and Electrodialysis (ED)) represent more than 56 % of the total desalination capacity while thermal desalination technologies (Multi Effect Distillation (MED), MSF) account for 33 % (Figure 2).

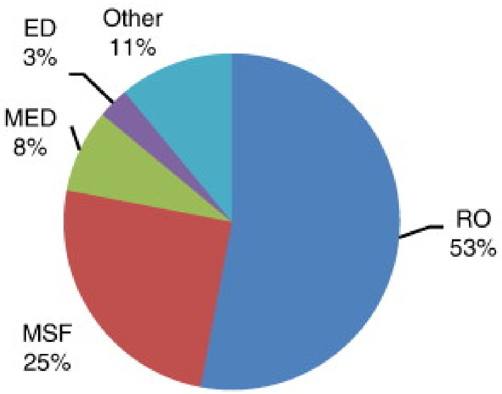

Figure 2: Global desalination capacity by process, according to [3].

In the countries of the Western Asia Region multi-stage flash distillation (MSF) is the principal desalination technology with 53 % of the total treatment capacity. RO accounts for approx. 28 % and MED for approx. 9 % [3].

Differences between desalination capacity in the world in comparison with the Western Asia Region are due to the energy sources available in this region. Countries with no or low availability of fossil energy sources use mostly membrane technologies which requires electrical power as the only source of energy. Where energy prices are low thermal technologies are used [3].

Major desalination technologies can be categorized in three groups [4], [9]:

1-Thermal technologies or phase change processes

2- Membrane based technologies

3- Hybrid processes

4- Other commercial desalination technologies

1.2.1 Thermal desalination technologies

Historically, thermal technologies have dominated the desalination market, particularly in the Middle East, where the low energy costs and large scale cogeneration plants have supported the application of this kind of desalination process [10].

Thermal desalination technologies are based on the evaporation and condensation of water. The main processes in this category include:

a- Multi stage flash distillation (MSF)

MSF is based on the principle of flash evaporation. In MSF process, steam is generated from saline water, reducing the pressure and increasing the temperature. The steam is condensed by heat exchange, where the sea water to be desalted is pre-heated. Figure 3 shows a schema of a multistage flash unit. Seawater passes after pre-treatment through the pre-heating system (heat recovery stage). The raw water is further heated by externally supplied steam before flowing into the evaporator flash chambers. The evaporator contains between 19-28 stages in modern desalination plants. Top brine temperatures are between 90-115 °C. Higher temperatures improve the risk of scaling formation [11], [12].

The main advantages of the MSF are the simplicity and reliability of the process. Heat exchange with the saline raw water doesn't occur through heat exchanger surfaces and therefore the presence of scaling does not reduce the heat transfer [13]. Nevertheless, scaling formation can be considered as a serious problem by MSF. Precipitation of salts and corrosion problems are expected mainly in the last chambers, where the brine becomes more concentrated as a result of the successive evaporation in the multistage [14]. Addition of acids or antiscalants help to minimize this problem.

By the MSF process the quality of the product water is not influenced by the initial concentration of salts and suspended particles. The product water contains about 50 ppm salts [13].

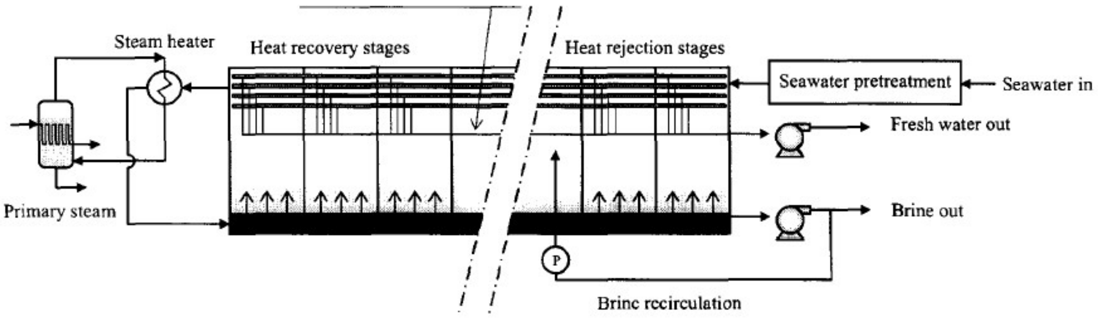

Figure 3 : Schema of a MSF system, taken from [13].

The main disadvantage of the MSF process is the high energy consumption as a consequence of the low performance ratio of this technology. MSF systems consume energy in the range of 5–6 times compared to that of the modern seawater reverse osmosis (SWRO) desalting system [15]. The performance ratio often applied to thermal desalination processes is the gained output ratio, defined as the mass of water produced per mass of heating steam [16]. Typical performance ratios for MSF units are between 8-11 [13], [17].

b- Multi-effect distillation (MED)

MED is based on heat transport from condensing steam to seawater or brine in a series of stages (evaporators) also called effects [13]. MED plants utilize horizontal tube, falling-film evaporative condensers in a serial arrangement, to produce through repetitive steps of evaporation and condensation, each at a lower temperature and pressure, a multiple quantity of distillate from a given quantity of low grade input steam [18]. MED units are powered by heat available from very low pressure steam (0.2–0.4 bar) or hot water sources above 55°C [18].

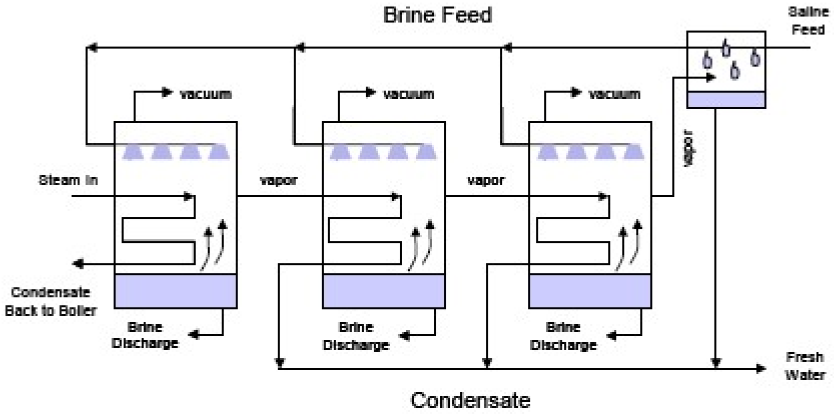

Figure 4: Schema of a MED process (horizontal tube - parallel feed configuration ,[16]).

First MED systems presented major scaling problems on the heat transfer tubes. In the 1960s, MSF was introduced into the desalination market and MED lost favor and was replaced with MSF, which presented less scaling problems and was easyer to operate [6]. MED technology presents a better thermal performance compared to MSF and newer plants are nowadays designed to reduce scaling formation [16].

Advantages of MED include: operation at low temperature (< 90 °C for low temperature ME plants) and thus less scaling and corrosion problems [6], [18], simple water pre-treatment [18], possibility of using different and alternative energy (heat) sources [19], [20], production of high purity destillate (usually less than 20 ppm), low energy consumption (1.2 kWh/m^3- to 2.5 kWh/m^3) [18], [21].

Disadvantages of MED are the large heating areas required, high quality materials due to corrosion problem and scale formation [6], [22].

c- Thermal and mechanical vapor compression (TVC/MVC)

Vapor compression distillation (VCD) can be considered as a variation of MED. VCD is based on compression of the vapor generated by evaporating water instead of condensation, so that the latent heat of the vapor can be efficiently reused in the evaporation process [23]. Vapor compression can be carried out using a mechanical compressor (MVC) or an steam jet (thermal vapor compression (TVC)).

MVC systems are driven by electric power and require no external heating source. As a result, they can be used in remote areas with access to power lines. Another advantage of the MVC process is the absence of a down condenser and its associated cooling water requirements. Instead, the compressor operates on the vapor formed within the system. MVC does have a number of operational drawbacks, including the need for electric power, limitations imposed by the capacity of the compressor, and maintenance and spare parts requirements for the compressor [24].

Since the development of MVC in the late 1960s, energy requirements of MVC plants have been reduced (from 20 kWh/m^3) and currently range from 8 to 12 kWh/m^3, with the potential for further reductions [25]. Figure 5 shows a scheme of the MVC desalination process.

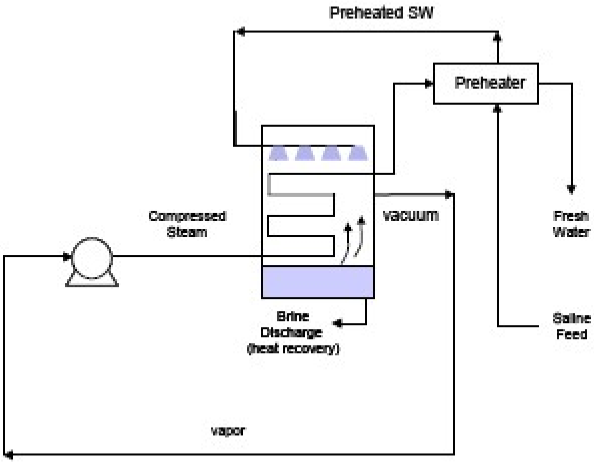

Figure 5: Scheme of a single stage mechanical vapor compression desalination system, taken from [16].

In a thermally driven vapor compressor relatively high-pressure steam is expanded in a nozzle to high velocity and low pressure; the expanded steam at high velocity entrains the vapour generated in the evaporator. Both streams flow towards the lowest pressure spot and mix together in a violent and rapid manner. The mixture flows through the diffuser section and slows down, and the pressure rises [25].

The advantages of the TVC over the MVC process include the following [24]:

(a) TVC units have no moving parts, as the mechanical vapor compressor does, so maintenance and spare parts requirements and costs are lower;

(b) TVC uses relatively high-pressure steam, which is cheaper than electric power, resulting in lower energy costs;

(c) TVC can be integrated directly into the power plant cycle.

Low temperature VCD is a simple, reliable process and produces high quality product water (5 to 25 mg/L TDS). The VC distillation process is generally used in small- and medium-scale seawater desalting units, due to scale limitations for large size vapor compressors [22]. VC units are usually built for capacities ranging from 20 to 2,000 m^3/d [22], [25], [26].

Improvements in the designs of mechanical and thermal vapor compression systems are required before they can compete with other desalination processes. The efficiency of the mechanical compressor must be enhanced and its design improved to simplify maintenance and reduce spare parts requirements. It is also necessary to reduce the pressure and flow rate of the fluid streams [25].

1.2.2 Membrane based technologies

a- Reverse Osmosis (RO)

RO separation is based on countering the natural osmotic process by artificially applying pressure on the side of the more concentrated salt solution (e.g. brackish water, seawater) to drive the process in a direction opposite to that dictated by the natural osmotic phenomenon [25]. In order to allow water to pass through the membrane, the applied pressure must be higher than the osmotic pressure. The membrane is permeable to the solvent (water) but not to the solute (salt). Figure 6 shows a block diagram of a membrane set-up.

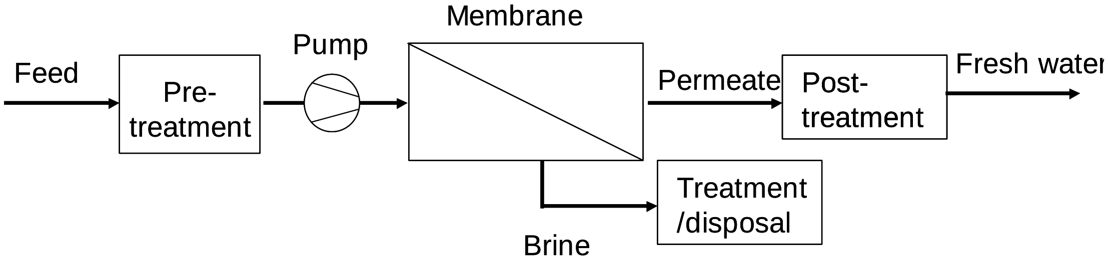

Figure 6: Block diagram of a RO desalination system.

Pressures needed for the separation were as high as 120 bar in the early days of RO, but today, the pressure is usually in the range of 50 bar for seawater, and 20 bar for brackish water [13].

Permeate flux and salt rejection are the key performance parameters of a reverse osmosis process. Under specific reference conditions, flux and rejection are intrinsic properties of membrane performance. The flux and rejection of a membrane system are mainly influenced by variable parameters including: pressure, temperature, recovery and salt concentration in the feed water [27].

Currently spiral wound modules are used for desalination. An alternative to spiral wound modules presents hollow fiber modules, where fine fibers (about 0.5 mm) are used [13]. Hollow fiber modules have a high packing density. However, the low flow of the feed solution in the fibers meant that a extremely good feed pretreatment is required to prevent membrane fouling.

Advantages of RO desalination includes:

- Lower energy consumption, due to the application of energy recovery devices (ERD) such as Pelton wheel, Francis turbine (reverse running pump) and Hydraulic Turbo Charger [28]. ERD can reduce the energy consumption of RO systems to 2.2 kWh/m^3 product for sea water treatment. For brackish water treatment the energy consumption can be reduced to 1 kWh/m^3 product or less, depending to the salt concentration in feed and ERD [29];
- Less vulnerable to corrosion and scaling due to ambient temperature operation [22];
- Modular design, simplifying module replacement and cleaning [22];
- High space and production capacity [22].

The principal disadvantages of RO systems are:

- Cost for chemical used for feed treatment and cleaning procedures;
- Membrane replacement;
- Vulnerable to feed water quality changes [22];
- Expensive pre-treatment depending on saline water quality [10], [16].

Table 3 shows a comparison of MED, MSF and RO desalination processes.

Despite the enormous success of reverse osmosis for desalination, improvements are still required in terms of the desalted water costs, water productivity (that means higher water recovery factors), better water quality and enhanced eco-sustainability of the desalination process (solving brine disposal problem).

Table 3: Comparison between MED, MSF and RO.

		MED (Multi Effect Destillation)	MSF (Multi Stage Flash Destillation)	RO (Reverse Osmosis)	ED (Electrodialysis)
Electric energy consumption	kWh/m³	1.5 – 2.9 [16], [10]	3.25 – 5.0 [16], [10]	4.5 – 8.5 (sea water) [16], [10] 0,5 – 2,5 (brackish water) [3]	17 (sea water)[25] 3-7 (brackish water) [25]
Thermal energy consumption	kWh/m³	4.5 – 6.5 [16], [10]	6.75 – 9.75 [16], [10]	-	-
Total energy consumption	kWh/m³	7.4 – 9 [16], [15]	10.5 – 13 [16], [15]	4.5 – 8.5 (sea water)[16],[10] 0.5 – 2.5 (brackish water) [3]	17 (sea water) [25] 3-7 (brackish water) [25]
Recovery [30]	%	0 – 65	25 – 50	30 - 60 (single pass, Sea water) 75 - 90 (brackish water)	85 - 94
Cost of the product water	$/m³	1 [10]	0.9 – 1.5 [10]	0.53 – 1.94 [10], [31], [32] [33](sea water) 0.2 – 0.7 (brackish water)	1.2[30], 0.6 [16]
Raw water pre-treatment		antiscalants [18]	antiscalants	intensive pre-treatment including: desinfection, flocculation, pH-adjustment, filtration: granular media, MF or UF-membrane antiscalants [34],[35],[36],[37]	addition of antiscalants allows the system to operate with concentrated salt scale factors well beyond saturation [38]; filtration (UF/MF) improves RED performance [39]
Salt concentration in the product water [22]		< 10 mg/L TDS	< 50 mg/L TDS	< 500 mg/L TDS (sea water) < 200 mg/L (Brackish water)	140 – 600 mg/L TDS
Salt concentration in brine (Max. TDS in mg/L) [40]		50.000	50.000	65000 – 85000	
Concentrate blending [5]		typical, with cooling water	typical, with cooling water	possible , not typical	possible , not typical
Brine discharge temperature in comparison to raw water (sea water) [40], [2], [41]	°C	+ 12 - 15	+ 12 - 15	+ 1	ambient temperature

[2] Lattemann and Höpner, 2008; [3] ESCWA, 2009; [5] Younos, 2005; [10] Mezher et al. 2011; [15] Darwish et al. 2010; [16] Miller, 2003; [18] Ophir and Lockiec, 2005; [22] Eltawil et al., 2009; [25] ESCWA, 2001; [30] ASIRC, 2005; [31] Sauvet-Goichon, 2007; [32] Greenlee et al. 2009; [33] Malaeb and Ayoub 2011; [34] Bonnelye et al. 2004; [35] Bonnélye et al. 2008, [36] Prihasto et al. 2009, [37] Sutzkover-Guttman and Hasson, 2010; [38] Reahl, 2011; [39] Xu and Huang, 2008; [40] Roberts et al. 2010; [41] Sommariva et al. 2004

b- Electrodialysis/Electrodialysis reversal

Desalination by means of electrodialysis (ED), electric current is used as driving force to draw salts through a selective membrane (cation exchange membrane/anion exchange membrane), producing a freshwater effluent.

In Electrodialysis reversal (EDR), the electric current field in the membrane stack is periodically switched resulting in the reversal of the polarity of the electrodes and leading to a break up and flush out of scales and fouling agents deposited on the membranes before they can build up. This reversal minimizes the need to add anti-scaling chemicals into the desalination process, thereby reducing costs [30].

Electrodialysis/EDR are mainly applied to water of low salinity (e.g. brackish water) or in special application such as ultrapure water production, pharmaceutical production, boiler feed water or nitrate removal, while RO can be used for a much wider spectrum of feed water sources, including seawater [30]. At higher salt concentrations (> 12,000 mg/L TDS), the cost of the ED process becomes uneconomical as it is proportional to the salt concentration in the feed water [[38]].

Main advantages of EDR/ER desalination systems include [22], [38]:

- ability to perform at very high water recovery,
- less affected by many feed constituents (e.g. silica, TOC) compared to RO,
- operation at low to moderate pressures.

Disadvantages of EDR/ED desalination processes include [42]:

- the high cost of electrodes and ion exchange membranes (especially bipolar membranes),
- relatively short life time of membranes when working in high-density electrical field,
- only suitable for feed water up to 12,000 mg/L TDS.

1.2.3 Hybrid processes

A good option for optimized performance of a desalination system is the application of a hybrid systems. Hybrid systems refer to the combination of two or more desalination processes.

Main advantages of hybrid processes involving the integration of RO with MSF include lower capital costs and energy requirements compared to that of a MSF plant with the same capacity, smaller feed water requirements and less concentrate disposal problems since the concentrate of the RO is used as feed to the MSF unit, and utilization of electrical power generation from MSF in the RO plant. Moreover, the hybridization of NF as softening membrane for treatment of feed water to MSF and MED could lead to significant improvement in productivity of thermal desalination plants [43].

An additional hybrid process consists in the combination of Microfiltration/Ultrafiltration (MF/UC) as pre-treatment step for RO. Although UF/MF pre-treatment remains more costly than a single filtration on mono or multimedia filter, the benefit of the coagulation/membrane filtration on the design (filtration flux) and operation (frequency of cleaning, membrane life duration) can significantly improve the economical balance of the process. It also allows a definitive advantage concerning RO membrane fouling and its related impact on cleaning frequency, RO membrane replacement and plant availability [35].

1.2.4 Other desalination technologies

Membrane distillation

Membrane distillation (MD) is a thermally driven membrane process. The function of the membrane is to separate the “cold” (liquid) water stream from the “hot” (steam) water stream. The liquid feed to be treated by MD is in direct contact with one side of the membrane and does not penetrate inside the dry pores of the membranes. The hydrophobic nature of the membrane prevents liquid solutions rom entering its pores due to the surface tension forces. As a result, liquid/vapor interfaces are formed at the entrances of the membrane pores. The MD driving force is the transmembrane vapor pressure difference [44].

MD process was first patented early in the 1960s by Bodell [45], [46]. In 1967 Findley published different studies about the mass transfer phenomena in the MD [47]. At that time, interest on this process declines due partly to the observed lower MD production compared to the reverse osmosis technique [44], [48]. MD process has recovered interest within the academic communities in the early of 1980s when novel membranes and modules with better characteristics became available [49 to 51].

The benefits of MD compared to other separation processes are derived from its characteristics, which included [44], [48]:

- It can be operated at low temperature, meaning that low-grade heat (such as solar energy, waste heat and geothermal) can be used. However, it should be noted that this does not mean the required heat energy for MD is low.
- Modular design and it needs smaller space than conventional distillation.

- High solute rejection can be achieved.
- It can work with high solute concentration of feed or with near saturated solution.
- Lower hydrostatic pressure than pressure driven membrane processes is needed.
- Less pretreatment compared to pressure-based membrane processes is needed.
- Less sensitive to feed variations (e.g., pH, TDS, etc.)

Most important drawbacks for the commercial application of MD include[44], [48]:

- Relatively low permeate flux compared to other separation techniques such as reverse osmosis.
- Permeate flux decay due to concentration and temperature polarization effects, membrane fouling and total or partial pore wetting.
- Membrane and module design for MD.
- High Thermal energy consumption: uncertain energy and economic costs for each MD configuration and application.

Solar distillation

Solar distillation devices reproduce the hydrological cycle on a much smaller scale. The basic design of a solar still can be compared with a greenhouse. Solar energy enters the device through a sloping clear glass or plastic panel and heats a basin of salt water. The basin is generally black to absorb energy more efficiently. The heated water evaporates and then condenses on the cooler glass panels. The condensed droplets run down the panels and are collected for use [16], [22].

Solar efficiency are typically between 30 and 45 %, e.g. they utilize less than 45 % of the incident radiation. This low efficiency mainly is due to the complete loss of latent heat of condensation of water vapor on the solar still glass cover [52]. The production capacity of a simple type still, even under optimized operating conditions, range between 2 and 5 L/m^2/day [53]. This makes solar distillation uneconomical.

Therefore is important to use very inexpensive materials of construction to minimize capital costs. Even so, the installation costs of solar stills tend to be considerably higher than other methods [16]. In addition the stills are vulnerable to weather damage. Modifications to the stills to increase efficiency, such as trackers to follow the sun, have generally proven to be too expensive to be practical. However, stationary stills tilted towards the sun do experience an incident energy increase of about 16 % [16].

1.3 Conclusions

The usage of brackish water resources through desalination is growing rapidly all over the world, especially in areas with water scarcity, such as the Lower Jordan Rift Valley (LJRV). This area hosts a relatively high quantity and variety of brackish water resources, ranging from weak seepages to substantial groundwater bodies. The brackish water bodies represent the natural outflows of the extended aquifers underlying Jordan. Desalination of these resources could contribute to increase the quantity and improve the quality of the regular water supply for the local population (both domestic and agricultural). The salinity of these sources varies from a few hundreds up to over one hundred thousand mg/L of salt.

Difficulties that accompany the establishment of desalination plants are many and vary with time. One of the most significant is the brine disposal and/or treatment. In most of countries there are no regulations or environmental constrains for brine disposal. Desalination plants located in coastal areas, discharge brine without treatment directly into the sea with the risk of damage or impact on the marine environment. Desalination plants of inland brackish water are obligated to find low cost alternatives for the disposal of brine. There are three different environmental-friendly and relatively low-cost options for the LJRV region that can be considered:

- Disposal of brine into the Dead Sea: one of the problems of brine discharge is the high concentration of salts, the Dead Sea is an adequate alternative with a low risk of environmental impact.
- Use of evaporation ponds: a brine treatment method which is limited to small desalination plants could be effective only in regions with dry climate and high evaporation rates. The high quantities of the disposal solid waste is easier to handle and can be always re-used for commercial applications.
- Disposal of brine into fish ponds: Once brackish water desalination technologies will be active in a large scale, agricultural options such as fish and sea food industry can be implemented to the area.

Additional important issues of desalination technologies are high energy consumption especially now with increasing energy prices. Optional alternatives for desalination facilities in isolated areas could be renewable or "green" energy (e.g. wind, solar and/or biomass). The use of photovoltaic systems to generate energy for the membrane is a very promising alternative for the LJRV.

Thus, the scarcity of fresh water, the availability of high quantities of unused brackish water resources, the disposition of renewable energy sources and the geographical location makes the LJRV a high potential region for rational membrane based desalination technologies.

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2 Desalination of sea water in Israel

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2.1 Introduction

What is desalination?

Desalination is a term that describes the process of separation of substances dissolved in water. The purpose of desalination is to reduce the amount of salt in sea/ brackish water. The technology removes salts of two types of solutions: brackish water in which salt concentration does not exceed 10,000 mg of salt per liter of water and seawater in which salt concentration reaches 40,000 mg of salt per liter. The desalination technology produces drinking water quality of from water that previously would not be for drinking (about 20 mg Cl/L compared to Israeli regulation that allows up to 600 mg Cl/L).

What are the methods of desalination?

There are two main methods of water desalination;

1. Evaporation processes (the oldest technology) - the water evaporates slowly while moving between several cells, in which temperature and pressure levels are dropping down gradualy. Each of the cells evaporates certain amount of water, while the salts remain in the water that does not evaporates. The water with the salts (about half of the raw water) is removed back into the sea as brine. Water vapor are condensed in a process through which the water drops are collected and finally obtained as desalinated water.
2. Membrane processes (more innovative technology) – The known and widespread process is reverse osmosis (OR). In this process, the salty water is compressed through membranes that allow passage of water and prevent passage of salts. Water passes through the membranes are desalinated water, while water that remains in solution is the disposal to be poured back into the sea.

Due to the high energy of the evaporation process, it is more suitable only for countries with very low electricity price, while reverse osmosis is much more energy efficient and for this reason its use is growing.

It is worth noting here the Israeli point - the first inventor and developer of desalination membrane is the deceased Prof. Sidney Laub age who immigrated to Israel in the late 60s and worked as a professor at Ben Gurion University.

Why desalinate?

There are three main reasons for desalination:

1. Solution to water shortages – maintain the possibility to fill up the existing and expected future shortage of fresh water, by producing affordable high quality water from the inexhaustible sea water reservoir.
2. Water quality - the desalination process brings the most significant improvement in water quality by reducing significantly the level of calcareous residual, highly improving the effluent used for agriculture irrigation as well as considerable improvement of the groundwater table.
3. Economic advantage - thanks to technological improvements and competitive market, desalination costs are declining and production is improving efficiency. Although desalinated water are more expensive then natural fresh water, the extra cost is nothing compared to the economic damage of drying agricultural areas and public green areas, parks and gardens. The cost of desalination of one cubic meter of water is about 2.6 to 3.1 NIS per cubic meter, while the damages caused by water shortages are estimated at approximately 8 NIS per cubic meter which is not supplied for agriculture. The damage is far greater when it comes to urban use.

What percentage of the water problem desalination solve?

The National water system provides approximately 1150 Mm3/y fresh water.

The desalination production stands now on a total of about 300 Mm3/y desalinated water per year, which is about 24% of the fresh water consumption per year.

According to the Water Authority future master plans the desalinated water production will stand on 505 Mm3/y scope by 2013. This amount constitutes about 44% of the yearly fresh water consumption.

This scope of desalination will begin to restore aquifers and maintain The Sea of Galilee full.

2.2 Planning and executing

With the outbreak of the severe water crisis in Israel, The Ministry of Infrastructure initiated an emergency master plan. The framework of the master plan is to increase the amount of desalinated water to about 750 million cubic meters gradually, thus improving significantly the water situation in Israel. Seawater desalination is actually the only option for producing drinking water regardless of sediments existing reservoirs.

After a succession of several years of drought in the late Nineties, the Israeli government decided to enter the era of large desalination of seawater volume. A government decision to begin building a desalination plant which will produce 50 Mm^3/y (million cubic meter per year) has been approved during the year 1999 and during early 2002 the Israeli government approved construction of seawater desalination facilities with overall output of 400 Mm^3/y. During 2002 agreements were signed with desalination groups who won public tenders for the construction of the first desalination plant in Ashkelon (Fig. 1).

From 2003 until 2006 the a few number of government decisions reduced the capacity of desalination up to 230 Mm^3/y.

The desalination unit within the Water Authorities was established in 2005. Its central role was decided as follows:

In managing and supervising the construction of seawater desalination facilities from the tender to select the operator, throughout the years of activity; Assists in policy development and water resources information and preparing plans to integrate desalination products to the national water supply systems.

The objectives facing the water authority in developing desalination plants are:

- Achieve reliable and regular supply of water processes sustainable.
- Improve water quality
- Fill the water shortage in natural reservoirs during the dry years and coastal Aquifer restoration

Unfortunately after a succession of several more dry years as well as increase in water consumption as a result of natural growth and raise in standard of leaving following the establishment of the Water Authority, government decision to increase the amount of desalination to- 505 Mm^3/y not later than 2013 was approved (on 01.07.2007).

After a particularly dry winter during 2007/8, Israeli government decided (on 01.06.2008) to increase the scope of desalination to 750 Mm^3/y and target submission was determined by the year 2020. However, a remark was added that 600 Mm^3/y should be provided as soon as possible.

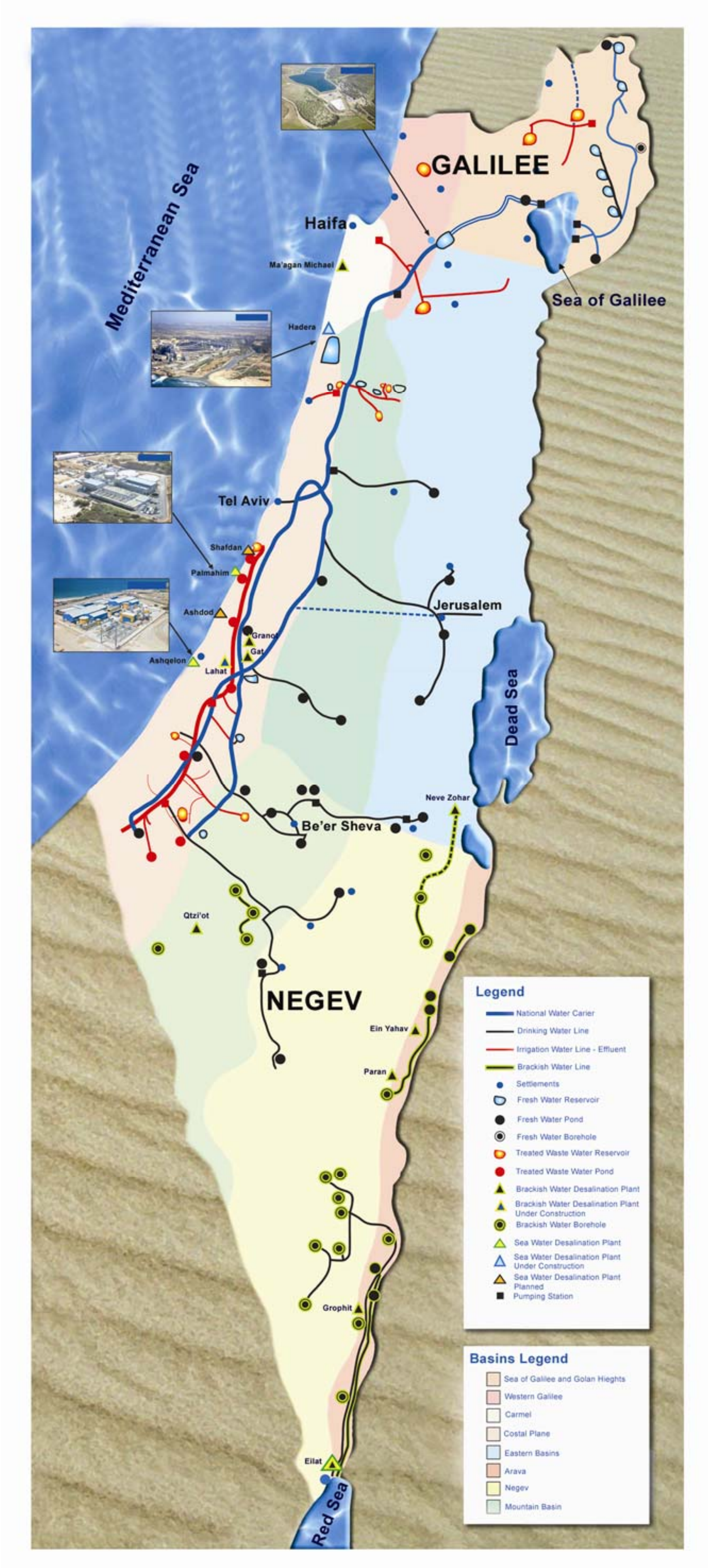


Figure 1: Location plan of all water facilities in Israel.

The government's decision last dated 06.01.2008 (Decision Number 3533) states that the Israeli government decided to increase the amount of desalination of sea water from 505 Mm3/y (million cubic meters per year) until 2013 to 750 Mm3/y until 2020 and to promote the first 95 Mm3/y as soon as possible.

Fig. 2 shows the government decisions graph regarding the scope of desalination over the years.

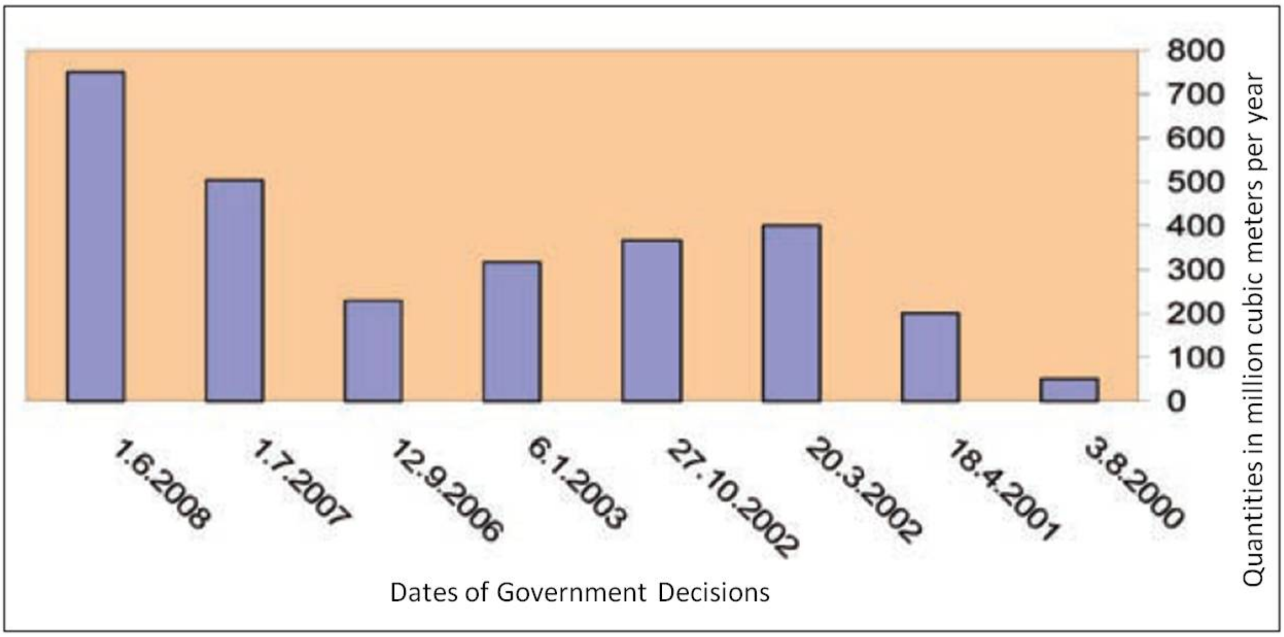


Figure 2: Government decision for desalination scale and volume during the years.

All these projects should be constructed by private entrepreneurs in a BOT format using public tenders.

The selected desalination technology was reverse osmosis (RO) which performed the separation of water and salts through special membranes developed for this purpose. This technology is well known and has a tremendous savings in the energy component (which is the largest production cost in desalination facility) relative to older evaporation technologies.

In order to accomplish the distinguish government decisions, a rapid establishment of desalination plants was started (as described below) initiating tenders processes for future installations.

The following are the construction of desalination plants program:

Ashkelon desalination plant (Fig 1)

This facility is the world's largest reverse osmosis technology. Established and operated by VID group. The facility is located south of the city of Ashkelon (Fig. 1) near the Electric Company power plant in Ashkelon. The project is in a BOT format, the production is 100 Mm^3/y and it is planed to operate for the next 25 years. .

Construction began in 2003. Water supply began in August 2005 and reached full production in December 2005.

In 2007, the facility provided 105 Mm^3/y, in 2008 111 Mm^3/y in 2009 114 Mm^3/y. After its expansion (see below) the facility provides approximately 120 Mm^3/y since 2010.

Palmahim desalination plant (Fig 1)

The facility is located north of Kibbutz Palmahim (Fig. 1). The facility was built and operated by the Via Maris group (Sea Way Desalination Ltd).

The project is using the BOO method and will operate for about 25 years. The output of the facility is planned for 30 Mm^3/y. Construction began in May 2005 and water supply began by the end of May 2007.

The facility was under expansion (see below) and since May 2010 it provides 45 Mm^3/y.

Palmahim desalination plant

Ashkelon desalination plant

Hadera desalination plant (Fig. 1)

The facility is located south of Hadera power station (between the power plant and the Hadera Wadi). The facility is located and operated by the H2ID group.

The project construction began in June 2007 using the BOT method and will be operating for about 25 years. The facility Production is 100 Mm^3/y.

Hadera desalination plant

The facility began to provide water in December 23, 2009 and now reaches full production due to expansion processes of a total of 127 Mm^3/y since March 2010.

Desalination plant in Ashdod (Fig.1)

The facility is now in an advanced process of construction by Mekorot, The National Water Company Ltd. which received a special concession from the government. It is located in the northern industrial area of the Ashdod city, and planned to produce 100 Mm^3/y.

The construction began towards the end of 2010 and supplying desalinated water will begin at the end of 2012.

Desalination Plant Sorek (Fig.1)

The facility is now under construction, located south of Nahal Sorek and north of the Shafdan Facility (of waste water purification).

Preliminary Tender determined the groups that can access the commercial tender have been completed in January 2009 and during January 2010 the commercial tender was published and the agreement with the concession was signed. The planned production is 150 Mm^3/y.

Establishment of the facility was scheduled to start at mid 2010 and desalinated water supply to the national system is expected by second half of 2013.

This facility is planed to be the largest of its kind.

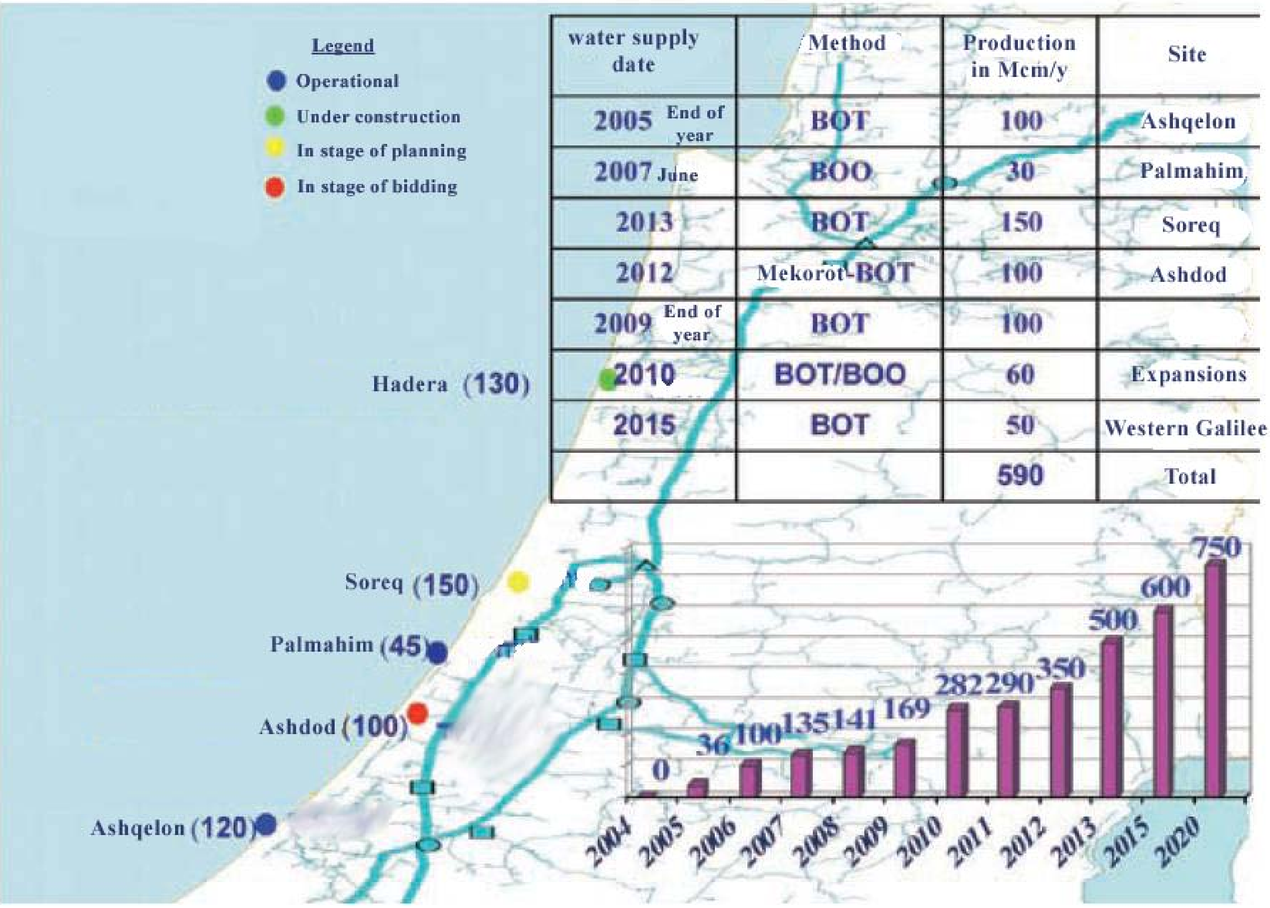
Expanding the existing desalination plants

In early 2009 tender process ended for the expansion of existing facilities (Ashkelon, Palmahim, Hadera) for additional 57 Mm^3/y, some immediately and some during 2010.

Layout desalination by 2020

Outline of seawater desalination have been and should continue as needed to allow the closing of gaps between supply and demand for years to come. During 2010 the total supply of the sea water desalination facilities was close to 300 Mm^3/y. By the end of 2013 the total supply will reach 450-500 Mm^3/y. The future increased production depends on the desalination scale of the Ashdod plant. It is expected that the total production will increase to 550 Mm^3/y by 2014 Mm^3/y and by 2016, with the establishment of additional desalination facility in the Western Galilee, to 600 Mm^3/y. This amount is considering only sea water desalination.

Summary of seawater desalination program to the extent of 600 Mm^3/y is presented in Fig. 3.



water supply date	Method	Production in Mcm/y	Site
2005 End of year	BOT	100	Ashqelon
2007 June	BOO	30	Palmahim
2013	BOT	150	Soreq
2012	Mekorot-BOT	100	Ashdod
2009 End of year	BOT	100	
2010	BOT/BOO	60	Expansions
2015	BOT	50	Western Galilee
		590	Total

Figure 3: Summery of desalination sea water plan up to 600 Mm^3/y scale.

Over the last year perennial master plan was completed with long annual planning horizon towards 2040. In parallel the expansion process of the national master plan for seawater desalination sites TAMA 34/B/2/2 is carried out. The expansion master plan aims to find areas for the establishment of desalination plants with a total production of approximately 1.75 billion cubic meters of desalinated water per year until the year 2040. This program is an extension of the existing master plan TAMA 34/B/2 that defined areas to the extent of 750 Mm^3/y by the year 2020.

Over the last year in the framework of the master plan, an examination of the national water system was carried out to evaluate the absorption of the scope of the planned desalination capacity and upgrades the national system's transmission range of these water quantities in all required directions.

Upgrade of the national system includes a series of projects to be completed over the next decade and will cost aproximately10 billion NIS.

Desalination of brackish

In Israel there are a number of desalination plants where the raw material used is brackish water wells of brackish groundwater sources. Such facilities exist in Eilat, Arava, The Southern Coastal Plain, Plain Region and Caramel Coast Region. The scale of the brackish water desalination is now about 35 Mm^3/y, and will increase to the end of guidance to output up to 80 Mm^3/y. .2020 At this point, with increasing volumes of brackish water desalination, in 2013 we will produce 50-60 Mm^3/y In addition to seawater desalination. Brackish water curved graph appears in Fig. 4.

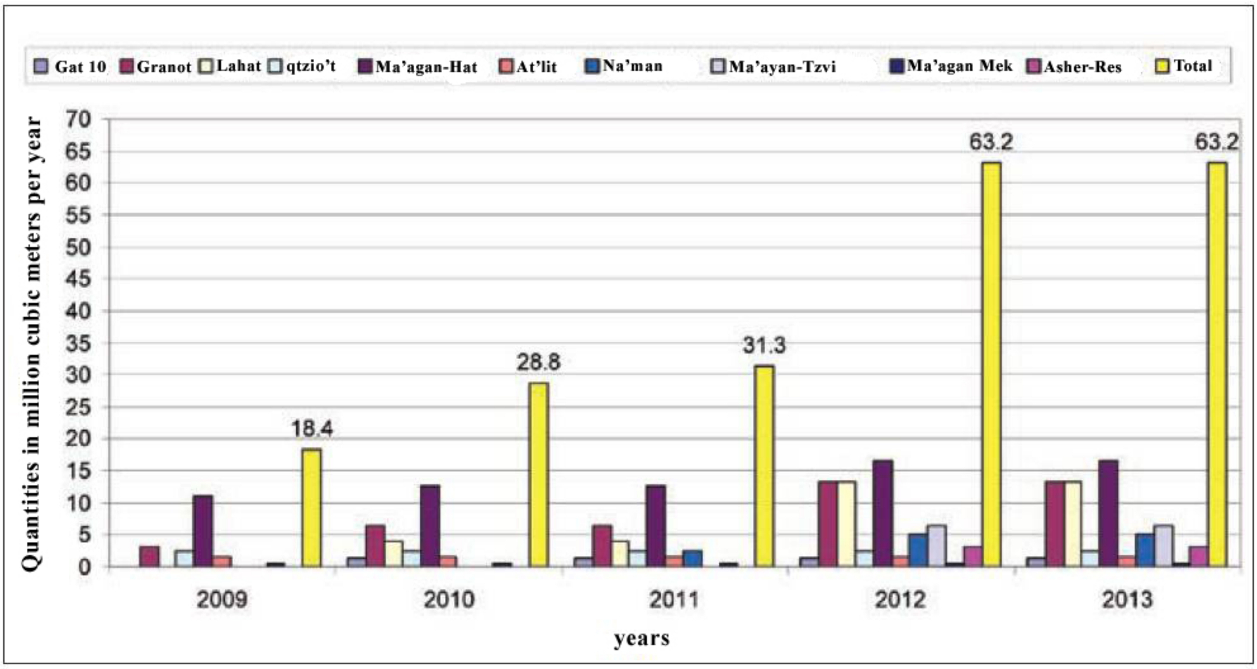


Figure 4: The scale of brackish water desalination over the years.

2.3 Coping with difficulties economic aspects and long-term risks

Difficulties that accompany the establishment of desalination plants are many and vary with time. In the past, the biggest difficulty was the financial difficulty and the opposition of the agricultural lobby. Now a day there are new variety of difficulties:

1. Dealing with the price of desalination water as reflected by the consumer's rate and the need to convince consumers that it is appropriate and efficient way to turn the water sector to water management sector and not a sector of water crises and change the water product from shortage to available products in sufficient quantities for the development and needs of the Israeli customers. This topic is very significant for future development of the water sector and in fact creates the budgetary source for planning and implementation of future water sector, with the ability to examine long-term planning horizon of decades ahead .
2. Totally another issue is dealing with "green" bodies of all kinds that still think the water shortage is temporary and the future will bring all the necessary quantities of natural fresh water without the need for desalination. There priority is the importance of nature protection which is much greater then the need to increase the amount of water required for the population. This balance between development needs and the desire to protect open spaces makes the struggle even more difficult and inhibits significantly the time required for any statutory permits for future construction of desalination plants.
3. Coping with the Environment Ministry on several issues, such as origin locations of disposal materials to the sea, setting parameters for quality of the disposal materials, defining quality parameters and settings for brackish desalination disposal and well improvement to the sea and streams as well as various research requirements of desalination facilities, and finally and especially the time required to summarize all these issues which reflects also on the extended duration for receiving statutory permits .
4. Dealing with the lack of areas close to the beach due to real estate development programs as well as Defense Ministry camps located in many coastal areas of potential locations for the establishment of desalination plants. Formulation of agreements with the Defense Ministry is an ongoing factor which also expressed in the long term on required statutory permissions.
5. Coping with the demands of the Ministry of Health, mainly over the issue of "Shield Radius" blocks faster development of brackish water desalination facilities mostly

on land. It is also expected to deal with drinking water quality regulations that are in the process of changes and updates.

6. A necessary agreement with landowners, primarily to deliver ground piping, is the most inhibiting factor in establishing the plumbing system that links between desalination plants and the national system. This issue causes a great delay in the construction schedule of these systems.
7. The authorities long timescales of planning and building which are also contributing their share to the delay of about 5-7 years from the governmental decision on the establishment of a desalination plant, through the tender and statutory processes, until the desalination plant begins to provide water to the national system.

All that is written above requires daily coping with difficulties, some objectives, of the various systems involved in decision making processes of implementation of the desalination program which will follow the continued growth and prosperity of the Israel. Dealing with these barriers and difficulties, which tackle our ability to succeed, are the key to autonomy and non-dependence of the natural water sector only and allow the ability to provide the gap between water supply and water demand that accompanies the water sector since before the establishment of Israel until today.

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2.4 Summary and discussion

Following the water crisis affecting the State of Israel, The Ministry of National Infrastructures initiated emergency plans to deal with the crisis in the water sector.

Part of the program objectives (backed by the Cabinet), is to increased amount of desalinated sea water in Israel to at least 750 Mm^3/y, when 500 Mm^3/y of which will be completed by the end of 2013, another 50 Mm^3/y in 2016 and the rest by the year 2020. The desalinated water production now is close to 300 Mm^3/y in Ashkelon, Hadera and Palmahim sites.

This initiative significantly improve the water situation in Israel, to such an extent that even in severe drought as we experience these days, the water sector will continue to be repaired. Because the sea water reservoir is endless, you can draw out as much as we wish, and provide desalinated water regularly.

Israel is among the leading country in the field of desalination. The water desalination facility in Ashkelon based on reverse osmosis is the largest and most advanced of its kind.

By means of desalination technology drinking water are produced with much better parameters compared to present drinking water regulations (e.g. desalinated water is about 20 mg/L of chlorides compared to about 250 mg/L tap water today) from water that previously would not be drinking.

Israel is considered a pioneer in water desalination, the Hadera plant is considered the world's largest and most advanced of its kind in the process of reverse osmosis (membrane processes). Desalination solve the water shortage, improving the quality, as well as an economic alternative, since in recent years desalination costs decreased significantly, and prevents economic damage to the drying agricultural areas and gardens.

Disadvantages and regulations

Although desalination plants are an excellent solution to the problem of water crisis in Israel, they have also conspicuous disadvantage. Desalination facility space requirements range from 55 to 70 acres. Israel is a very small country in territory with highly expensive land costs. Weighting should be made between the prices for the land and the strategic need for disperse desalination plants across the country.

The National desalination Master Plan defines sites for desalination facilities. The location of the Desalination Facility is decided upon considering the followings:

- Statutory
- Land use
- Distance from the sea
- Disposal extraction landlocked
- Protection of groundwater recharge areas
- Aquifer contamination
- Objection of the "Greens" associations
- Connection to the national system
- Achievable location of intermediate reservoir

- Energy source
- Population needs
- Coast/value
- And more…

The large facilities of sea water desalination are always located as close as possible to the sea. The brackish desalination facilities location is recommended up to 2-2.5 Km from the sea. The needs of such facilities include sea water pipe line from the sea to the plant and brine disposal pipe line from the plant to the sea.

Furthermore, it should be noticed that such pipe lines are situated above the coastal aquifer which could be contaminated by leaking.

The Kziot facility in the NEGEV (see location in Fig. 1) is an example for 2 mistaken decision which raise the water coast tremendously.

1. The facility is based on the ancient evaporation method.
2. The brine disposal is transferred by pipe line to the distant Dead Sea (in other inland facilities the brine disposal is transferred by short pipe lines to fish ponds).

The above mentioned raises the water coast up to 2$ per cubic meter compared to 52 cents in preferable locations.

The most important issue in the framework of SMARTII is the fact that there are no desalination facilities at all in the Palestine, only a few very small ones in the Gaza Strip.

Additional data of the Ashkelon desalination plant:

The facility, which is considered the leading facility of its kind in the world, is operating from 2005 and provides more then 120 Mm3/y of water to Israel, constituting about 15% of domestic water consumption in the country. The facility, which operates in a reverse osmosis technology, including a variety of technological innovations which was developed by the IDE Israeli Technologies and the French company VIOLA, provides water which is considered the highest quality.

This facility was built by VID in the framework of BOT agreement whereby the developers finance and build the desalination plants on state land available to them, operate and maintain the facilities, and sell the water output to the Israeli government in nominal prices for a period of 25 years (including construction period). At the end of the agreement, the plant will be transferred to state ownership.

In December 2006 the Company announced that the desalination plant in Ashkelon, won a special prize for "outstanding achievements" at the annual meeting of the Israeli Association for desalination. This award joins the award "The desalination plant of 2006", which the facility won in the prestigious ceremony of "Global Water". Ashkelon desalination plant, long known to the international water industry as the largest and most advanced factory of its kind in the world, received the award as a sign of great contribution to technological and economic advancement in the global water desalination industry. These winnings established the status of the Ashkelon desalination plant as a leader in desalination in the world.

TABLES:

Sea water desalination facilities:

Facility location	Concessionaire	Implementation Phase	Annual water quantity Mm^3/y	Expected start of water supply
Ashkelon	VID	Water provider	120 after expansion	August 2005
Palmahim	Via Maris	Water provider	45 after expansion	June 2007
Hdera	H2ID	Water provider	127 after expansion	December 2009
Ashdod	Mekorot (Initiation)	Delayed due to price differentials between the state and company sources. It is unclear at this stage when and if it will be implemented in the coming years.	110	Unknown yet
Sorek	Not yet selected	For Tender	150	2013
Additional expanding of the existing facilities	Ashkelon. Palmahim, Hadera	Expected to sign agreements in early 2011 and suppose to supply at 2012-2013	75	2013
Western Galilee	Not yet selected	Conceptual planning and Statutory review	50	2016
Total			677	

Brackish desalination facilities implemented by Mekorot:

Project	Main structures	Implementation Phase (status)	Annual water quantity (Mm^3/y)
Safaria	A desalination plant, raw and concentrate disposal lines and drilling	Land (real estate) problems along the disposal line, replacement sites are examined	1.6
Granot	A desalination plant, raw material disposal lines and drilling	Activated. Expended is planned expansion	2.5
Gat	Desalination facility and row material disposal line	Activated	1.4
Lahat	A desalination plant, raw material disposal lines, heat station and connector line to Yarkon line	Tender	8.4
Shizaphon	A desalination plant, station and lines	Test-run	1.1
Kziot	A desalination plant, raw water, brine and product water lines, boosters and evaporation ponds	Disabled due technology process issues. Restarted in 2006.	2.8
Arava desalination facilities	Neot Hakikar, Idan, Hazeva, Ein Yahav, Sapphire, Zofar, Zukim, Faran, Be'er Ora, Yahel, Lotan, Ketorah, Grofit, Yotveta	Be'er Ora is activate. Temporary desalinator in Zukim. Desalinators were tested and approved in Central Arava. Other in general planning	3.0
Total			20.8

Brackish water desalination facilities of private entrepreneurship:

Facility location	Concessionaire	Implementation Phase (Status)	Annual water quantity Mm^3/y	Additional Potential	Expected start of water supply
Ma'agan Michael	Ma'agan Desalination	Activated from 2004. Expansion to 13 Mm^3/y at 2009.	8.5	5	2009
Neve Yam	Tambur Ecology	Postponed at this stage	2		Unknown
Atlit + Na'ayan Zvi	Caramel coast Water Association	Activated. Maayan Zvi facility is in construction and statutory certificates.	4	2	2004
Heletz	Lapidot+T.M.B	Conceptual planning		2.5	Unknown
Na'aman-Curdani	A partnership of communities in the region (Afek, Kfar Masaryk and Ein Hamifratz)	Activated		6	2009
Mate Asher	ELA Region Cooperation and the region settlements	Conceptual planning		3.5	Unknown
Harod Valley	Harod Water Association	General planning		7	Unknown
Rotem plain	Not agreed yet	In discussions, general planning and preparation of the tender documents.		10	Unknown
Hamey Yoav	Sde Yoav collective charge	Discussions and general planning		2	Unknown
Total			14.5	38	

3 Review on the Desalination and Brackish water in Gaza strip and in Jericho

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3.1 Introduction

In Palestine the water crisis is exacerbating day after day; due to the recurrence of droughts and entrapment of rain which led to the decline of available water resources, not to mention the tightening of the occupation by control over all ground water resources, which reflected it in a negative effects on various sectors, especially the agricultural sector.

So the search for additional sources of water to agricultural use (rain water harvesting, treated water) has become a necessity and is currently considering moving to how access to modern technology at competitive prices. In the light of the expected shortfall in natural water sources, the desalination of water is the best way to secure water supply in required quantity and quality.

While this technology is commonly used in Gaza strip, it hasn't been used in West bank in spite of its importance. In west bank, there is a good quality of brackish water especially in Jericho that around 28 mcm of brackish water allocated in it. So it's vital to build desalination plants and establish projects that support it. This literature subdivided into two parts:

- Desalinized water in Gaza – in terms of a quantity and quality point of views
- Potentiality for using the brackish water in Jericho.

3.2 Desalinized water in Gaza – in terms of a quantity and quality point of views

A study titled DRINKING WATER SUPPLY THROUGH RO DESALINATION PLANTS IN THE GAZA STRIP, By Ahmed (2007) indicated that performance of these RO plants was satisfactory in removing high TDS, though the efficiency deteriorated with time. The average utilization of these RO plants since their installation was about 50% as compared to the design capacity, mainly due to the non continuous availability of power in some areas; time lapsed in repairs of pumps, and non-availability of spares. The average capital cost/m3 and O & M cost/m3 of product water from these plants works out to $0.29 and $0.10 respectively; when plants are utilized as per the design capacity. These costs are high and not affordable by the rural population. The RO plants were socially acceptable since the population was satisfied with the treated water quality.

A study titled Regulatory challenges of Palestinian strategies on distribution of desalinated water By El Sheikh. (2004) Concluded that Distribution of desalinated water in Gaza is taking place on commercial bases without paying attention to health and environmental standards. The regulator does not have the full picture on linking this business with the national plans. Consumers are not aware of the water quality they need to drink. The available desalinated water installations can cover requirements of drinking water if operated effectively.

A study titled POTENTIAL OF APPLICATION OF PV SYSTEM FOR BWRO DESALINATION IN GAZA By Ahmed (2006) concluded that: Several studies concerning suitable technical matches between renewable energies and desalination processes propose the combination of PV and RO technologies as very promising among the existing ones. In particular, this combination appears to be very suitable in Gaza for remote (coastal) sites lacking of electric grids where water scarcity is a big problem and, at the same time, the solar energy potential is high. In such areas where fresh water has to be transferred by long piping systems to guarantee water supply, such systems have appeared to be more economical than the alternative of transporting water. Although for small systems specific energy consumption values (i.e. kWh/m3) are rather high compared to standard medium size (RO) systems, the investment costs of such systems are reasonable in comparison to other conventional desalination techniques.

Further research activities associated with other prototype plants should focus on

optimizing such systems with the aims of reducing water production costs.

A study titled DIAGNOSIS OF LIMITATIONS IN OPERATIONAL CAPACITY OF SEA WATERDESALINATION PLANTS IN GAZA STRIP By El-Sheikh, et. all. concluded that:

Delay and obstacles facing the plant operation do not mean that Gaza people do not need this good quality water. The plant cannot be operated under the current political situation as an investment project.

A study titled SOLAR ELECTRIC POWERED REVERSE OSMOSIS WATER DESALINATION SYSTEM FOR THE RURAL VILLAGE AL MALEH: DESIGN AND SIMULATION By MAHMOUD(2003) Concluded that: The illustrated simulation results show that the desalination plant will produce 3962m3/year which corresponds to an average of 10.85m3/day. This means for Al Maleh a daily production of 1m3 fresh water would require 821.2Watt PV-peak power. The plant will operate for 5 h/day delivering 10.85/5 = 2.17m3/h which is very close to the design criteria. The simulation results show also that the water production varies linearly with the solar radiation intensity. It is obvious that this solar powered plant is matched with the seasonal daily consumption; it means that the system would produce about 3 times more fresh water in summer than in the cold winter months, where water consumption is less. This result was obtained even the replacement of the storage batteries each 5 years had been considered. This will encouraged seriously using the solar electric generators instead of diesel generators, when planning to develop the infrastructure of non-electrified rural areas.

A study titled Seawater Desalination Projects: The Challenge and the Options to Meet the Water Shortage (1999) concluded that:

The proposed Regional Seawater Desalination project will be able, over a period of 10-15 years, to provide 1 billion cubic meter of desalinated seawater, and provide a solution to the current water crises as well as to meet the future needs of Israel, Jordan and the Palestinian Authority. Implementing this project will require a cooperative effort and direct investment of the leading industrialized countries and the international community at large, with active participation of Israel and its Arab neighbors.

A study titled Evaluation of Common and Small Scale Brackish Water Desalination Plant for Drinking Purposes in Gaza Strip By Prof. Dr. Abu Mayla, et.al. (2009) Concluded that Due to the bad quality of Municipal water in Gaza strip, desalinated water use increases and the availability of renewable supplies decreases, using of desalinated water increases by the people. Small Desalination plants become more popular way to obtain potable water for cities. Growing demand for safe, clean water, combined with drought conditions and increasing populations, are driving the market for desalination plants. This market is expanding to offer fresh opportunities to new and established market participant. The number of competitors in the market is expected to increase as the number and size of desalination plants grows. This increase in competition will maximize plant efficiency, making the cost of desalinated water more attractive to consumers. These plants depend on the RO. filters as the main process of the desalination so the product water contains very low concentrations of water parameters. The study deals with the Small desalination plants in Gaza Strip (managements and operation) to evaluate these plants mainly water quality, and to provide real knowledge about these plants for the consumers.

Also there was concentrated on the desalinated water consumers to evaluate customer opinion for desalinated water quality, produced and consumed in addition to the customer ability to pay and to assess knowledge of consumers about the quality of water they have to drink. The results show that there was not any management of plants establishing according to location of water sources needs desalination in Gaza Strip. In addition to do that There are wide variations of water quality in Gaza Strip, that not all the water in

Gaza Strip needs the same elements removal technology. The inlet water quality in most plants were less than WHO and Palestinian standards with high desalination efficiency led to completely removed of essential elements that important to human health The total contamination (microbiological tests) percentages in inlet water is (41%for the total coliform and 27.3% for the fecal coliforms) while the total contamination percentages in outlet water is (45.5% for the total coliforms and 31.8% for the fecal coliforms), in some plants, the contamination by total coliform and fecal coliform in inlet water is higher than that in outlet water, but in other some plants, the contamination level in outlet water is higher than that in inlet water.

The microbiological tests results of the desalinated water in tanks and tanker cars were different from the same tests results for the desalinated water in the plants. The total microbiological contamination of the desalinated water in the plants was 45.5% ,31.8% total coliform and fecal coliform ,respectively , while the total contamination in tanker cars was 14.2% ,7.7% for the same tests, and for the tanks the total contamination was 25% and 13.33% . Many of plants owners need more information about the standards, also they need to be aware about the water problem in Gaza strip and how could they share in solving it, how could they mange there investment not only to gain the money but also to e part of the water problem solution in Gaza strip. According to the consumers the small desalinated plants solve part of their drinking water quality problem.

A study titled Prospects of Water Desalination in the Gaza Strip By Ismail.(2003)

Concluded that: Gaza aquifer is the backbone of water resource for supplying water to the people in the Gaza Strip. Developing and managing the water resources is a crucial and essential target for decision makers. Gaza Strip in particular suffers from water shortage and poor water quality, so desalination as a reliable source of fresh water is essential to be adopted by the Palestinians to meet future needs in a sustainable way. Integration on local level between the three regulatory parties (Palestinian Water Authority, Ministry of Health and Environment Quality Authority) is crucial and vital in order to regulate and organize the desalination industry. cooperation, data exchange and experience are required between neighbor countries. Desalination projects need high capital investment; in this sake integrated cooperation between public and private sector is highly recommended in order to increase the efficiency of water supply operational conditions, which will reflect positively on customers. A feasibility study of GSWDP concludes that Gaza desalination facility project (GSWDP) is financially viable.

According to economic analysis results, low-income individuals can afford to pay 1.56% to 2.1% extra the current municipal tariff. In this sake a family with 7 members and average monthly income at US$340/month can afford US$0.84 /M3 of desalinated water at consumption rate 70 l/c/d. PWA as a regulator of water sector has to develop clear regulations, guidelines, and contract conditions in order to organize the water market, specially the quality of desalinated water. Proper institution with effective legislations and policies should stimulate improvements in minimizing unaccounted for water and increasing the delivery efficiency. Training and capacity building in desalination industry are essential for local staff mainly on Operation and Maintenance (O&M), and should be extendable to cope with any progress in the desalination market. To make the desalination industry more successful, PWA should be engaged in a process of institutions development in order to cope with any progress in international desalination technology, economic, and regulatory information. More attention should be given to the effect of brine that is pumped from both RO house units and the private brackish water desalination plants into the sewerage networks to avoid any prospects of Water Desalination in the Gaza Strip reaction with the concrete manholes and asbestos or steel pipes. In addition it should be noted that sewerage pipes diameters might be under design regarding uncontrolled quantities of brine discharged from the domestic or private desalination units. Since the principle of desalination process depends mainly on using some chemical materials, while problems are sometimes faced with Israel who restricts the entry of such materials to Gaza from their security viewpoint, this creates a risk on the operation of desalination plants. In this case, USAID should secure or obligate Israel to allow for the entry of chemicals required for operation of the proposed plant.

Gaza Strip with semi arid climate has a potential of solar energy (200Watt/M2) that could be utilized for small-scale water desalination as an environmental friendly source of energy. It was clearly reached that cost of cubic meter produced from GSWDP, which is a very important indicator, wasn't analyzed and presented clearly by USAID to part of water professionals and the public. The West Bank, the other part of Palestine (inland area) suffers also from water shortage, so a desalination plant could be build at Gaza Sea in order to meet future needs of people there. Some parts of the Gaza Strip have less chloride ions but suffer from high percentage of nitrates concentration (over than 100ppm), so nitrate removal technology should be adopted as a pilot scheme with more research to be practiced in future.

A study titled Existing and the future planned desalination facilities in the Gaza Strip of Palestine and their socio-economic and environmental impact By A. Assaf (2001)

Concluded that:

Among the many options for providing a long lasting solution to the water shortage problem and deteriorating water quality of water resources in the Gaza Strip is to allow natural recharge over time to restore and cleanse the aquifer from pollution and increasing salinity. This can be achieved by having to depend for at least one decade on a strategy of obtaining the urgently needed desalinated water from the sea using appropriate seawater desalination technology.

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