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Mitigating the Environmental Impacts of Desalination in the Mediterranean Region
A Policy Brief Prepared by SWIM-SM

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MITIGATING THE ENVIRONMENTAL IMPACTS OF DESALINATION IN THE MEDITERRANEAN REGION
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In many Mediterranean countries, available water resources are currently scarce and often overexploited. This situation is likely to deteriorate further in view of the increasing population, economic growth, reliance on irrigated agriculture and climate change and its impacts. Recently, advances in desalination technology have made it a viable alternative source of fresh water. As a result, several Mediterranean countries have entered into ambitious desalination programmes based on mega desalination facilities(more than 50,000 m^3/day). Direct environmental pressures associated with seawater desalination in the Mediterranean Region must be assessed and mitigated.

Between 1970 and 2013, over 1,532 seawater desalination plants have been installed around the Mediterranean Sea, which represents a 560% increase[1]. As of 2013, these plants had a total cumulative installed capacity of some 12 Million m^3/day, which roughly represents 35% on average of the municipal water demand in the entire Mediterranean coastal areas[2].

The Mediterranean Sea is known for its remarkable biodiversity, but some species are reaching dangerously low abundance levels. The Mediterranean also hosts a diverse array of habitats of commercial, ecological, and cultural importance. Many are under a variety of growing pressures, UNEP-MAP (2012).

Prospects of Seawater Desalination in the Mediterranean Region:

By 2030 the Mediterranean region is projected to multiply its desalination capacity by threefold, or even fourfold, thus reaching 30 to 40 million m^3/day (Plan Bleu 2010), as compared with the current 12 millionm^3/day installed capacity. In absolute terms, desalination of seawater will continue to grow steadily. This future development will be mainly influenced by the following factors:

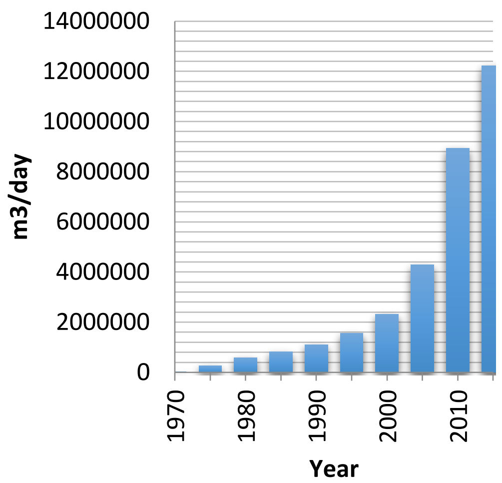

Figure 1: Cumulative installed production capacity of desalinated water in Mediterranean Countries from 1970 to 2013 from seawater. *Source of data: GWI-Desal-Data (2013).*

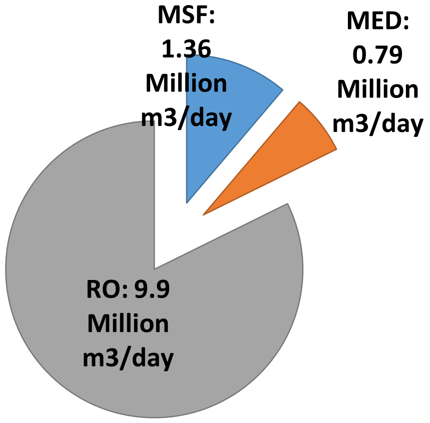

Figure 2: Cumulative installed seawater desalination capacity using different technologies in m^3/day from 1970 to 2013 for all Mediterranean countries. *Source of data: GWI-Desal-Data (2013).*

[1]GWI-Desal-data

[2]assuming 200 liter as the per capita daily consumption of some 147 million living in coastal areas of the Mediterranean sea

- RO = Reverse Osmosis
- MSF = Multiple Stage Flash Distillation
- MED = Multiple Effects Desalination

1. Mediterranean Countries that have already bridged most of their water demand-supply gaps through desalination such as Algeria, Israel and Spain are likely to slow down in their momentum and might enter into a relatively quieter phase.
2. Reverse Osmosis (RO) will most likely remain the dominating seawater desalination technology in the region.
3. Persisting regional economic and financial crisis in the Mediterranean might curb the implementation of some of the ambitious national desalination plans in the region.
4. Political instability in some Mediterranean countries might hinder and/or delay the financing and construction of their planned desalination plans.
5. Apart from financing and political instability, the main challenges that Mediterranean countries will be facing in financing and implementing their future desalination plans are i- high investment and operational costs, ii- reliance on fossil fuels and iii- producing environmentally acceptable solutions.
6. In case desalination in the Mediterranean region remains fully reliant on oil and/or gas, whose prices will continue to follow an upward trend in the long term, the energy costs and subsequently the cost of desalinated water is predicted to increase..
7. Desalination using solar energy, as an emerging technology, is already capturing the attention and imagination of water and environment officials in Mediterranean countries with very little action.
8. Despite the strong interest of water planners for Renewable Energy (RE) in desalination, it is projected that Concentrated Solar Power (CSP) desalination will take a couple of decades before replacing the currently operating fossil fuel desalination plants in the region. This lagging is attributed to the often heavy fossil fuel subsidies making the new renewable energy technologies more expensive.
9. Emerging and growing disputes on shared transboundary water resources may represent a strong driving force for more desalination to secure water supply within a national security context.

Environmental Stresses of Desalination In the Mediterranean Sea:

1. Withdrawing large masses of sea waters from the Mediterranean Sea currently estimated at 37.4 million m^3/day is posing a **serious threat to the near-shore marine environment** known for its importance as habitat for a diversity of marine aquatic lives **through impingement and entrainment at the desalination plants intakes**.

The most noteworthy adverse environmental impacts of seawater desalination plants in the Mediterranean Sea are likely to be caused by their intakes rather than their outlets.

Impingement occurs when marine organisms are trapped on intake screens due to suction from the seawater intake at high velocity.

Entrainment occurs only when smaller marine organisms such as fish eggs, larvae and plankton not excluded by screen bars at the intake get drawn into the desalination plant with the feed-water.

2. Desalination is an energy intensive process that generates significant emissions of CO_2. Energy is the largest single element in the cost of desalinated water. It ranges from 30% to over 50% the cost of finished water. When fossil fuel is

used to power the plant, and depending on the technology used, **CO2 emissions will vary substantially**: from 2kg CO2/liter for Reverse Osmosis (RO) to 10 kg CO2/liter with a thermal technology (MSF and MED). It has been estimated that the total cumulative CO_2 emissions from all operating seawater desalination plants in Mediterranean Region in 2013 is equivalent to 22.00 Million Ton of CO_2/year.

The total CO_2 emitted from desalination in the Mediterranean seawater during 2013 is equivalent to putting 4.8 Million additional cars on the roads or burning a volume of petrol slightly less than 35 Million liters/day.

3. Relatively high salt content in brine discharge would suggest that the biota living in desalination plants mixing zones is either negatively affected or living on the extreme limits of its environmental tolerance.
4. The estimated **residual chlorine** discharged from MSF and MED desalination plants into the near-shores of the Mediterranean Sea in 2013 is calculated to be 3.9 ton/day. **It is considered trivial** and of no significant impacts on the open sea, **but potentially with a real negative impact in the mixing zone**. The RO technology does not generate chlorine discharges.
5. In the Mediterranean region, the estimated levels of discharged **trace metals** (Nickel, Copper and Molybdenum and less toxic metals such as Iron and Zinc) in 2013 from seawater desalination plants **is not significant** compared to the levels discharged from industry and atmospheric fallout. Despite this fact, trace metals do not decay and might reach food chain by bioaccumulation and biomagnification. Furthermore, the discharge of chelating polymeric anti-scalants[3] in the marine environment would maintain trace metals in dissolution leading to their transport over long distances with water masses.

Attempts to dilute trace metals releases by dilution with cooling waters from desalination plants doesn't change the fact that trace metals are reaching, accumulating & permanently residing in different compartments of the marine environment.

SWIM Experts' Opinion on Desalination in the Mediterranean region:

- Many perceive desalination as the most convenient and secure means to bridge the widening water demand-supply gap. Actually, desalination is only one piece of the water resources management puzzle and a case by case assessment is required, within an IWRM context.
- Most of the desalination plants in the Mediterranean region are designed and constructed to improve reliability during droughts or as emergency supply and/or to meet anticipated demand increases.
- Proper water resource planning and efficient management need to precede any decision to invest in water desalination programmes. Increasing water supply should always become after sincere efforts to reduce demand.

[3] polymeric anti-scalants are mainly polymers of organic acids that prevent scale formation in desalination plants.

- In many Mediterranean countries, water supply service is heavily subsidized, resulting in inefficient water consumption. A more sustainable approach can be attained by revising current water tariffs to reflect the real socio-economic and environmental costs of producing and delivering desalinated water.
- Some countries of the Mediterranean region are plagued with unrealistic low water tariffs, inefficient water utilities, high Non-Revenue Water (NRW), leakages, poor water governance and inadequate sector policies. Experts project that under such conditions, unsustainable management and wasteful consumption patterns of expensive desalinated water will be common in these countries.

- Most of the research on desalination is geared towards improving the technology and reducing the production costs. Cumulative environmental effects of desalination plants around the Mediterranean Sea were never assessed, even less by factoring in the impacts of future desalination plants. Despite the efforts made by SWIM-SM project to conceptually assess the cumulative environmental impacts of desalination in the Mediterranean region, more coordinated research is still needed to analytically determine the cumulative impacts of contaminants in the brine reject. Particular attention is needed to assess the long term ecological impacts of impingement and entrainment at the mega seawater desalination plant intakes.
- Energy reuse and/or minimization will help reduce overall costs. Energy conservation through better housekeeping and energy recovery technologies need to be applied as a common practice.
- Like any infrastructure project, a desalination plant should be subject to a detailed interdisciplinary and participatory Environmental Impact Assessment (EIA). Each individual desalination project need to be evaluated taking into account the chosen site, technology used, design and ambient environmental conditions. Experts believe that, it is the responsibility of the national authorities to define the need, scope and complexity of each EIA, in line with the international best practices. An EIA should predict all potential impacts, propose means to mitigate and monitor them. The impacts should include the cumulative impacts resulting from the planned desalination plant when added to other past, present, and reasonably foreseeable future human activities affecting the same environment. Where possible, effluent flows should also be minimized in volume and concentration.
- Technological developments have dramatically reduced the production cost of desalination in the last decade. However, it still remains an expensive water-supply option with negative environmental externalities.
- Due to advancements in membrane technology, RO has emerged as a reliable maturing technology with much lower CO_2 emissions and free of thermal, trace metals or residual chlorine discharge. New seawater desalination plants should avoid by all means using an outdated, energy intensive and/or environmentally damaging technology.
- Subsurface intakes, commonly known as beach wells, use natural sand on either side of the seawater line as a filtering medium reducing or eliminating the need for pre-treatment. More important, beach wells will eliminate impingement and entrainment of marine organisms at the desalination plants intakes.
- Despite discharge of brine reject from seawater desalination has significant impacts on the near-shore marine environment, it is considered by water experts as the most common and least expensive disposal method. Deep water diffusers, whilst being more expensive, are preferable, as they have a lower environmental impact.

Suggested Policy Options and Measures for Sustainable Desalination in the Mediterranean Region:

1. In principle, **desalination should be planned and designed within an IWRM context** to sustain socio-economic development of communities. Desalination should not be considered as a mere non-conventional water resource, but as a community development project.
2. Given its high cost and its undetermined environmental impacts, **desalination needs to be considered by planners after exhausting all water conservation and demand management options**. This policy option shall not hinder planning and construction of desalination plants to meet urgent needs of communities for domestic water supplies.
3. Water and sanitation as a human right adopted by the UN General Assembly resolution (GA-10967) in July 2010, may be considered when formulating desalination policies.

4. **Virtual value of water**, if needed, can be utilized as a tool in assessing technical and allocative efficiencies and in calculating the opportunity cost of supplying water through desalination.

> Virtual water (or embodied water) is a measure of the total water used in production of a good or service.

5. The approval of a desalination plant needs to be **consultative**, **transparent**, **participatory**, **subject to mandatory public consultation** and justified on solid socio-economic and environmental grounds.
6. The selected desalination technology needs to be mature, low cost, energy efficient and with limited environmental impacts.
7. It is critical for Mediterranean countries to **develop regulations** and **establish discharge criteria and standards** for brine physical and chemical characteristics in line with the "Land-Based Sources" protocol of the Barcelona convention as appropriate. It is the responsibility of the national regulating authorities to also **develop adequate monitoring, inspection and enforcement capacities** to ensure compliance with these standards. The status of biodiversity in the mixing zone need to be regularly monitored.
8. Mediterranean countries need to join efforts in **planning and institutionalizing a Research and Development** (R & D) regional mechanism to collectively develop and manufacture desalination and renewable energy equipment and components.
9. As desalination is an energy intensive technology, its Green-House Gases (GHG) emissions must be mitigated. Mediterranean countries need to ensure that desalination plants are energy efficient and sited close to points of water use. Countries need to put in place the right conditions for the development of renewable energy sources, that would make desalination climate neutral.
10. Support, when needed, should be provided by financial institutions given the high capital costs of bankable desalination projects. Proper legal and institutional frameworks are required to encourage Public-Private Partnerships.

References:

1. GWI-Desaldata: http://desaldata.com/projects/analysis (2013).
2. UNEP/MAP: (2012) State of the Mediterranean Marine and Coastal Environment, UNEP/MAP – Barcelona Convention, Athens.