Technologies for Advanced Wastewater Treatment in the Mediterranean Region

Sixto Malato, Isabel Oller, Pilar Fernández-Ibáñez, and Maria Fuerhacker

Abstract Research in and application of advanced wastewater treatment technologies in the Mediterranean Basin require public awareness of the need for sustainable water resources to be raised through local information programs. Since wastewater treatment and reuse systems are generally capital-intensive and require highly-paid specialized operators, this point must be given especial relevance when applying new techniques, such as membrane bioreactors, tertiary chemical oxidation processes, etc., in these countries. This chapter gives a general overview on research currently underway in the Mediterranean Basin countries on innovative technologies for wastewater treatment, and compares them to the conventional technologies currently employed in wastewater treatment plants. Moreover, not only water availability, but also water quality, is essential for human life, health and safety, especially if sanitary requirements are not met. A summary of disinfection applications and research activities under development in the South Mediterranean and Middle East Regions is presented.

Keywords Advanced oxidation technologies, Photocatalysis, Solar disinfection, Tertiary treatment

Contents

S. Malato (✉), I. Oller, and P. Fernández-Ibáñez
Plataforma Solar de Almería-CIEMAT, Carretera de Senes Km4, 04200 Tabernas, Almería, Spain
e-mail: sixto.malato@psa.es

M. Fuerhacker
Department of Water, Atmosphere and Environment, BOKU-University of Natural Resources and Applied Life Sciences, Muthgasse 18, 1190 Vienna, Austria

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1 Introduction

In developing and developed countries, rapid urbanization and the consequent growing demand for potable-useable and industrial water is necessitating costly, large-scale projects. This shortage of fresh water constitutes a severe problem in the Mediterranean Region and particularly in the arid and semi-arid areas to the South and in the Middle East, and is giving rise to serious parallel problems of effluents, which are treated with more or less success depending on the ability to develop effective, rational and affordable sewage strategies. However, water treatment is expensive and requires heavy financing. In view of the above, it is clear that not only efficient water management, but extensive research, education and consumer awareness programs are all of vital importance.

An analysis of industrial water consumption reveals the difficulty of making an overall assessment in a field where data are highly fragmented and scarce, as reflected in both international sources and the respective national services, often resulting in an absence of data surveys on specific parameters, sector studies, or industrial classifications. The trend for an increasing need of water is clear, especially in developing Mediterranean countries where industry has had enormous impact on the economy in the last few decades. In Tunisia, for example, the yearly water demand has been increasing with the growth of business by about 1.9% in recent years.

Almost all countries identify the most critical part of industrial water use with its pollution. Most threats of pollution come from oil extraction and refinery waste, heavy metals, heat and by-products. Therefore, industrial growth is bound to impact heavily on water quality, with potentially harmful follow-up on human health and posing severe social concerns. This impact could be enhanced by the overlapping effects of industry, urbanization and tourism, and the situation will predictably worsen if nothing is done about it.

This chapter includes an overview of innovative technologies for wastewater treatment – Membrane technology (MBR, nanofiltration, reverse osmosis); Advanced oxidation or reduction technologies (mainly catalytic or photocatalytic); Advanced bioactive technologies (aerobic or anaerobic); and new solutions such as electrolysis/electrodialysis, electron beam irradiation, electromagnetic treatment,

etc. – and a proposal for solutions to current problems or a friendlier alternative to present treatments in Mediterranean Basin Countries. It also contains a brief summary of existing industrial wastewater treatment technologies. Finally, considering the significance of disinfection applications for human health and hygiene, a review of disinfection of wastewater treatment plant (WWTP) effluents for water reuse in the Southern Mediterranean and Middle East Regions has also been included.

2 Research and Development of Innovative Technologies for Industrial Wastewater Treatment in the Mediterranean Region

It is estimated that in 1990, approximately 280 km^3 of water were consumed in the Mediterranean Region, including riparian countries and those bordering the Mediterranean Sea, of which 99% came from natural resources. The demand doubled in the twentieth century, and increased by 60% in the last 25 years. In recent decades, per capita water demand has developed differently in different countries, depending on the conditions of demographic growth and economic development. By the year 2025, practically no Southern Mediterranean country will have resources over an average of 500 m^3 per capita/per year which clearly shows an increasingly acute problem [1].

Conventional technology, particularly in terms of performance and available wastewater treatment options, cannot be expected to find a solution to all of the problems. Wastewater systems are generally capital-intensive and require expensive, specialized operators. Therefore, before selecting and studying a given wastewater treatment technology, cost effectiveness should be analyzed and all conceivable alternatives compared. The selection of technologies should be environmentally sustainable, appropriate to local conditions, acceptable to users, and affordable for those who have to pay for them. Simple, easily replicated solutions, allowing further upgrading with later development which can be operated and maintained by the local community are the most appropriate and cost effective. The choice of technology depends on the type of wastewater.

In developing countries, usually characterized by high population densities and a noticeable shortage of available water, the best wastewater technology to use under the prevailing local conditions is one of the critical issues which should be well defined.

Nevertheless, the quality of the effluent is not only defined by prevention of eutrophication as it is in the EU Urban Waste Water treatment Directive (UWWTD), but for irrigation reuse purposes the requirements of WHO (2006) standards for restricted and unrestricted use must also be considered. Any treatment or reuse system should be designed according to national and/or international regulations, specifications, standards, and guidelines on wastewater collection,

wastewater flow and effluent quality, and solve environmental and health problems. The technologies applied should remove a majority of pathogens. A secondary treatment (i.e., removal of settleable and suspended solids and biodegradable organics plus disinfection) is usually the minimum acceptable treatment level. The new concept for microbial safety of drinking water and wastewater (Quantitative Microbial Risk Assessment) requires quantitative data on the inactivation or removal of pathogenic microorganisms by water treatment processes.

For the local application of treatment techniques, studies undertaken must include detailed microbiological, chemical and biological risk assessment factors to identify necessary technologies, uses and control tools. For regional utilities, this minimum treatment level is expanded to include tertiary treatment. Rules and regulations need to be established for that, or adjusted to the new WHO (2006) requirements. Growers, who might benefit from wastewater or sludge reuse, should be involved in the project, as appropriately treated wastewater is a valuable resource that must be used to best advantage, and agriculture is given priority for water reuse.

Lack of personnel with the appropriate technical and managerial skills for the use of advanced technological tools and implementation of modern management strategies are among the major constraints for attaining more efficient wastewater management practices. There is a general need to transform the concepts of water efficiency improvement and water saving in industrial applications into ground-level implementation policies, programs and actions in countries particularly affected by water shortage problems, such as the arid and semiarid areas in the South Mediterranean and Middle East.

Many well known technologies are available, but it has been widely demonstrated that certain kinds of industrial wastewater require the application of innovative treatment technologies [2]. Moreover, any choice should not entail heavy costs and provide the best environmental practice. Accordingly, several research projects on new wastewater treatment processes applied to typical industrial effluents have been carried out in the Mediterranean Basin countries during the last 6 years. In this context, representative case studies carried out in Turkey, Tunisia, Egypt, Morocco, and Palestine are described below.

2.1 Research on Innovative Wastewater Treatment Technologies in Turkey

Industrial water consumption in Turkey was 4,100 million m^3 in 2000 (10% of the total). In 2003, water consumption in industry was calculated at 4.3 billion m^3, and the forecast for 2030 is 22 billion m^3 (Table 1) [3].

Turkish industry has been mainly private since the public share has been decreased through privatization in recent years. Over 80% of production and about 95% of gross fixed investment in manufacturing is currently private.

Table 1 Total water consumption in Turkey

	In 2003 (billion m^3)	In 2030 (billion m^3)
Irrigation	29.6	72.0
Drinking water	6.2	18.0
Industry	4.3	22.0
Total	40.1	112.0

75% of Turkey's industrial wastewater is discharged without any treatment, primarily into seas and rivers, 20% receives adequate treatment, and 5% receives only primary treatment. Moreover, approximately half of the 190,000 industrial enterprises in Turkey work in pollution-creating industries [4].

Furthermore, in Turkey:

- Only 9% of industry has WWTPs.
- 84% of businesses lacking WWTPs are government-owned and the rest are private.
- Only 14% of industrial zones have treatment systems.
- 81% of touristic facilities have treatment systems.
- There are 3,215 municipalities of which only 141 have sewage systems and only 43 have treatment plants. In other words, 98.7% of domestic wastewater is discharged into seas, rivers, and lakes without treatment.
- Only 22% of industrial wastewater containing poisoning heavy metals is treated and the rest is discharged into seas, rivers, and lakes without treatment.

Turkish industry is expected to produce in compliance with environmental standards, apply strategic management techniques, make R&D a priority concern, generate technology and create original designs and trademarks, thus taking its place in international markets. This would increase use of advanced technologies in industry, and enhance the competitiveness of traditional industries.

National Five-Year Development Plans (FYDP) are aimed at ensuring optimum distribution of resources among the various sectors of the economy. Under the eighth FYDP (2001–2005), one of the most important policies was to adopt the EU standards for water, wastewater, and solid waste management. The Turkish Law of the Environment (No. 2872, 1983) is based on the principle of the "polluter pays" and deals with the issue of environment in a very broad scope. The law considers the environment as a whole, and aims not only to prevent and eliminate environmental pollution, but also to allow for the management of natural and historical resources and land in a way that allows such richness to be used while conserving it for future generations as well [5].

In an endeavor to achieve successful wastewater management, Turkish researchers in recent years have studied new treatment technologies for highly polluted industrial wastewater.

Most of the research papers recently published deal with the application of advanced remediation processes for different types of textile effluents to alleviate their toxicity and recalcitrance at source. Some authors have simulated these effluents, which contain a nonionic surfactant, synthetic tannin, and an aqueous

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