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# The EMWater project — promoting efficient wastewater management and reuse in Mediterranean countries

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**Abstract**

Given the fact of water shortage in the Mediterranean countries, the EMWater project (efficient management of wastewater, its treatment and reuse in the Mediterranean countries) aims to increase the security and safety of water supply through creation of public awareness and implementation of innovative and suitable solutions in wastewater treatment and reuse. The main target countries of this 4-year project are Jordan, Lebanon, Palestine and Turkey.

The EMWater project contributes to these goals through training programmes (local, regional and web-based) for technicians, engineers and employees of authorities and non-government organizations; public awareness campaigns; design and construction of pilot plants applying low-cost techniques, as well as through the development of policy guidelines for wastewater treatment and reuse. Such activities will contribute to general objectives of promoting transfer of appropriate wastewater treatment technologies, such as low-cost technologies for rural areas; strengthening local capacities and regional co-operation through the creation of co-operative professional networks; enhancing public awareness of the insufficient and inproper wastewater treatment to the need for hygienically safe disposal, and the potentials of water reuse.

The paper is aimed to present the state of implementation of the EMWater project after 3 years, especially focusing on the main steps in pilot plants design and construction activity and in development of guidelines for decision-makers in wastewater management and planning. It further addresses the progress in implementation of capacity building programs.

*Keywords:* Optimal water management; Wastewater reuse; Policy guidelines; Capacity building

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## 1. Introduction: the EMWater project

Water shortage is currently one of the biggest concerns of human being worldwide and it becomes a global problem that affects seriously the lives of high numbers of the world population. Water is an essential element for the economic development and political stability and limited water resources are recognised as the most important obstacle to the development of the agricultural sector [1].

The Mediterranean region belongs to the countries most affected by water scarcity in the world. The MEDA programme (Euro-Mediterranean partnership) started in 1995 aiming at infrastructure improvement and the establishment of the Euro-Mediterranean Free-Trade Area in 2010. One important milestone in this process has been the establishment of the Euro-Mediterranean Water Network in 1999, in order to strengthen regional cooperation between the MEDA Countries in the field of water supply and wastewater management. In this framework, the project EMWater — efficient management of wastewater, its treatment and reuse — started on May 2003, with the primary aim to highlight innovative solutions for wastewater management, treatment and reuse in the Middle East.

In more detail, the following general objectives can be highlighted:

- Strengthening long-term regional co-operation and sustainable development in the Mediterranean countries through creation of expert networks and cross-border knowledge transfer.
- Defining a sustainable approach to prevent water shortages and water deterioration in the Mediterranean region, involving experts from the field, decision-makers, interested citizens and civil organisations.
- Improving efficiency and effectiveness in integrated water resource management while taking decentralisation concepts into consideration.
- Promoting transfer of innovative wastewater treatment technologies and improving technologies currently used in rural areas.
- Encouraging reuse-oriented wastewater management.
- Enhancing public awareness of the insufficient respectively wrong wastewater treatment and reuse and the need for hygienically safe disposal.
- Providing decision-makers with up-to-date, relevant information in order to help them in choosing the most suitable technology.
- Exchange of experience and know-how between the European and Mediterranean partner countries as well as among the Mediterranean partner countries.

All actions to be implemented within the EMWater Project are designed to create long-term positive effects in the region. The above listed general objectives will be pursued by the following specific tasks:

- Elaboration of country studies about water and wastewater management in the beneficiary countries.
- Adapted training and capacity building programs for technicians, engineers and employees of authorities and non-government organizations in the field of wastewater treatment and reuse.
- Design and construction of pilot plants for demonstration and training purposes.
- Elaboration of Regional Policy Guidelines for wastewater treatment and reuse.

The EMWater project consortium consists of four EU partners — InWEnt Capacity Building International, Germany; Hamburg University of Technology (TUHH), Germany; Adelphi Research, Germany; and the National Agency for New Technology, Energy & Environment (ENEA), Italy — and five Mediterranean partners — Yildiz Technical University, Turkey; University of Balamand and Lebanese American University (LAU), Lebanon; Al al Bayt University, Jordan; and Birzeit University, Palestine.

The responsibilities of the Mediterranean partners include: (i) collection and evaluation of relevant data on water topics; (ii) dialogue with the local authorities and other stakeholders, and (iii) organising the implementation of local measures and follow-up activities. The European partners assist the Mediterranean partner countries in all steps of implementation. Local and regional steering committees consisting of different stakeholder representatives advise the EMWater partners in project implementation.

## 2. Country studies

As one of the first activities of EMWater, the current situation and future perspectives of the water and wastewater sector in the target countries have been assessed. Herewith the following main results are summarized.

While Jordan and Palestine are already seriously affected by water scarcity, Turkey and Lebanon are likely to face water shortages within the next decades. High population growth, rising living standards and augmentation of irrigation, increase the pressure on the resources. Agriculture is by far the largest consumer of water in the region, counting for about 70% of total water use. Not only increasing demand but also the deterioration of the water resources is of great concern. Many water resources are being contaminated by excessive use of fertilizers and uncontrolled discharge of municipal sewage. While a considerable number of wastewater treatment plants has been built (Jordan and Turkey) or is planned (Palestine and Lebanon), there are vast accumulated needs and the majority of the wastewater is still inadequately managed and treated. In rural areas several decentralized, small-scale wastewater treatment systems have been built in recent years. Most of them entail secondary treatment resulting in an effluent water that may be suitable for reuse. Such alternative water resources are needed, but reuse applications are still very limited (except for Jordan). Successful demonstration projects and public awareness programs are necessary to convince people of the benefits. To gain acceptance, effective treatment systems and quality standards are most important. Turkey and Jordan have adopted standards for wastewater treatment and reuse, but they are not fully enforced. Palestine and Lebanon are still waiting for the adoption of standards.

The information collected in the country studies is based on local experience and supports the development of appropriate solutions for wastewater management, treatment and reuse. The surveys have been published and the full text versions of the four country studies can be obtained from the project website [2].

## 3. Pilot plants

Within the framework of the EMWater project, 5 pilot plants are intended to be built in order to apply suitable low-cost technologies for wastewater treatment and reuse in local context, for both demonstration and training purposes. Treatment technologies to be applied have been selected according to two main criteria: they should (i) allow compliance with local legislation on wastewater reuse in each of the benificiary countries and (ii) be easy to operate and maintain.

The chosen treatment schemes differ from one plant to another plant. They have been defined in order to test different options and to provide for comparison of effectiveness and reliability of each one of the treatment systems.

In the following table, average input data (design flows and influent concentration) and effluent standards required for each pilot plant are reported [3,4].

In two cases — Lebanon and Jordan Pilot Plants — traditional suspended growth activated sludge systems have been foreseen. In these cases, the main target of pilot plant application is to test different tertiary systems downstream to traditional biological treatments, in order to provide water to be reused in agriculture.

In Lebanon, two pilot plants are planned to be built in two university campuses: in the Lebanese American University (LAU), biological treatment shall be provided through a contact-stabilization process, with aerobic sludge digestion, while an extended-aeration process with excess sludge storage shall be applied in University of Balamand (UoB) site. In both cases, tertiary treatment shall be accomplished by disinfection, sand filtration and activated carbon filters, with a final water storage tank for irrigation purposes.

In the Jordan case, biological treatment consists of activated sludge extended aeration process, with a pre-denitrification section in order to provide nutrients removal from wastewater. Tertiary treatment is accomplished through multilayer sand filtration followed by a disinfection step using UV (recommended) or chlorination.

In the other two pilot plants (to be built in Turkey and Palestine), anaerobic pre-treatment has been foreseen. Indeed, over the last few years, the search for "sustainable" treatment systems capable of minimizing energy consumption has encouraged the use of anaerobic biological systems especially for intensive and high-loaded wastewater treatment, where the main goal is to eliminate the biodegradable dissolved fraction in carbonaceous substrates [5,6]. Accordingly, a two-stage biological integrated system has been proposed for the Palestinian and Turkish pilot plants. In both cases, the first stage shall consist of an anaerobic reactor (Upflow Anaerobic Sludge Blanket, UASB or Anaerobic Baffled Reactor, ABR) according to the hydraulic configuration and the need to provide for a denitrification step), feeding the second stage represented by an aerobic reactor. In Palestine, an attached growth reactor (Rotating Biological Contactors, RBCs) has been expected, in Turkey the aerobic step shall consist in a Vertical Flow Sub-Surface Constructed Wetland. As an example, Fig. 1 shows the Palestinian pilot plant treatment cycle, including the recycling of the biologically treated wastewater (to be denitrified) into the 3rd ABR tank.

These considerations have been taken into account for the definition of a suitable treatment scheme to be applied for the wastewater from rural areas in temperate climate countries that is characterized by medium to high organic concentration.

The pilot plant to be realised in Ein Sinia (Palestine) will treat the wastewater collected from Al-Jalazoun refugee camp, in order to solve the environmental and groundwater pollution caused by its uncontrolled disposal. The plant design has been performed according to the raw wastewater characteristics, as resulted from a 4 days sample campaigns performed on site [7]. As shown in Table 2, reporting average values

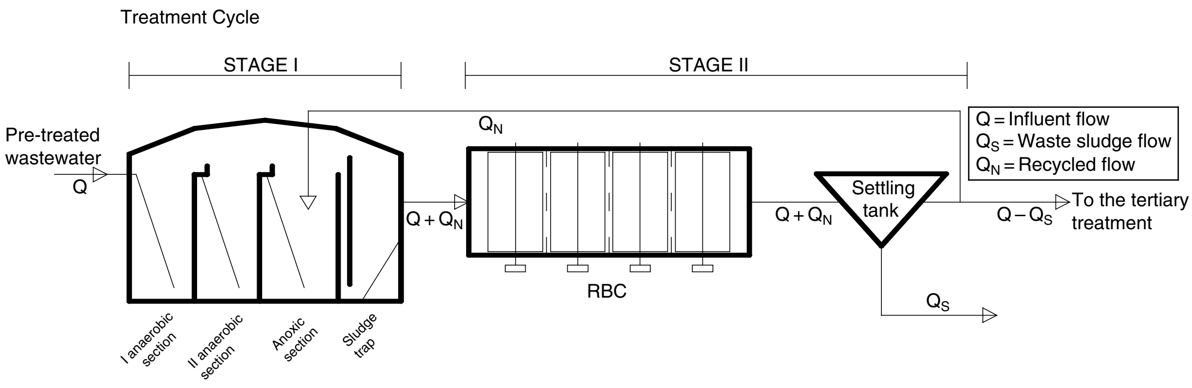


Fig. 1. Treatment scheme of pilot plant to be realised in Ein Sinia — Palestine.

of composite samples (every 2 h each day), the wastewater to be treated is of high-strength, due to low water consumption, industrial discharges and local people's habits.

As preliminary treatments, the wastewater is first subjected to a micro-screening and a degritting step, using a drum filter and a channel basin, respectively. The wastewater is then uniformly distributed over the bottom of the first section of the ABR beneath the sludge blanket via a system of six PVC pipes. Similar distribution systems feed the effluent into the second ABR section and then into the anoxic section, where also the clarified effluent is recycled via a self-priming centrifugal pump. The total volume of the anaerobic ABR sections (first + second ABR tanks, $14.4\,m^3$) have been calculated according to an organic loading rate of $0.5\,kg\ COD\ m^{-3}\,d^{-1}$ introducing a safety factor equal to 1.2. The anoxic section volume (third ABR tank, $7.4\,m^3$) has been defined assuming a denitrification rate equal to $3\ g\ N\text{-}NO_3\ m^{-3}\ h^{-1}$. The biogas collection system is done through an air-tight, twin-wall PVC dome. By regulating the air pressure it is possible to control the internal pressure of gas produced by the anaerobic and anoxic processes, in order to ensure that it can be collected safely. The RBC total surface ($390\,m^2$) has been designed assuming a specific organic load equal to $5\,g\ BOD_5\ m^{-2}\ d^{-1}$ and assuming a $BOD_5$ load removal rate of 50% within the first biological stage. The specific nitrogen load is $1.9\,g\ TKN\ m^{-2}\ d^{-1}$. The settling unit has been designed based on the overflow rate, assumed equal to $1\ m^3\ m^{-2}\ h^{-1}$. Finally, a tertiary treatment unit consisting in a sand filtration unit followed by a UV irradiation unit, will allow the compliance with wastewater reuse standards reported in Table 1.

An international open tender according to the EU rules for works and supplies of 150,000 € or more has been announced for all the pilot plants to be realised (4 different lots). All the tenders encompass the executive design, delivery, construction and commissioning of the pilot plants including inlet pumping station and pipe connection from an existing sewer to the plant. The tender also includes the start up and testing of the equipment, a staff training period of 1 month until take over, spare parts, chemicals and other peripheral equipment. All the tenders have been awarded to local companies, except for the plant to be build in Turkey whose tender did not receive acceptable local offers. The expected duration of the construction phase is 6 months.

Table 1
Input data and effluent standards for the pilot plants design

| | | Partner | | | | |
|---|---|---|---|---|---|---|
| | | Jordan | Lebanon (LAU) | Lebanon (UoB) | Palestine | Turkey |
| Influent | Average flow ($m^3$/d) | 15 | 50 | 50 | 10 | 10 |
| | Peak factor | 3 | 3 | 3 | 3 | 3 |
| | TSS (mg/L) | 900 | 400 | 400 | – | 128 |
| | COD (mg/L) | 1600 | 600 | 600 | 1100 | 380 |
| | TKN (mg/L) | 70 | – | – | 71 | 30 |
| Effluent | BOD (mg/L) | 10 | 10 | 10 | 10 | 10 |
| | SS (mg/L) | 10 | 10 | 10 | 10 | 10 |
| | *Escherichia Coli* (CFU/100 mL) | 100 | – | – | – | – |
| | Faecal coliforms (MPN/100 mL) | 50 | 200 | 200 | 200 | 20 |
| | Residual chlorine (mg/L) | 1 | – | – | – | – |

Table 2
Ein Sinia pilot plant design input data

| | | Symbol | Value |
|---|---|---|---|
| WWTP Influent | Mean hourly flow rate | Qnmh ($m^3$ $h^{-1}$) | 0.42 |
| | Mean daily flow rate | Qnm24 ($m^3$ $d^{-1}$) | 10 |
| | TKN | $TKN_{IN}$ (mg TKN/L) | 71 |
| | $NO_3$-N | $NO_{3IN}$ (mg $NO_3$/L) | 0 |
| | SS | $x_{INFL}$ (mg SS/L) | 200 |
| | COD | $COD_{IN}$ (mg COD/L) | 1100 |
| | $BOD_5$ | $BOD_{IN}$ (mg $BOD_5$/L) | 600 |
| | Temperature | T (°C) | 12 |
| WWTP Effluent | $N_{TOT}$ ($NO_3$-$N_{out}$ + $TKN_{OUT}$) | $N_{OUT}$ (mg N/L) | 15 (10 + 5) |
| | $BOD_5$ | $BOD_{OUT}$ (mg $BOD_5$/L) | 10 |

## 4. Policy guidelines

In order to support political decision-making in wastewater management and to assist in planning and implementing related projects in the MEDA region, the EMWater project is developing policy guidelines on wastewater management. The aim of the EMWater guidelines is to provide a manual that guides its users when taking decisions in wastewater management at an early stage of project planning. Main target groups are officials on the municipal level, who do not necessarily have a background in engineering or natural sciences. Therefore, the guidelines do not aim to present detailed information on technical aspects of wastewater management. Rather, they intend to present the main criteria for decision making in a concise way — easy to understand and in short form, using figures and tables as much as possible. Like this, the manual aims to enable decision-makers to take into account all relevant framework conditions, consider all relevant impacts in respective projects, and to do a pre-selection of appropriate technologies for wastewater treatment and reuse. The users of the guidelines will be referred to existing literature for detailed information. It is important to point out that the guidelines will not replace in depth analyses of the existing framework conditions, feasibility studies and other surveys. For implementing wastewater projects the consultation and involvement of experts from different disciplines remains crucial.

The policy guidelines will consist of two parts, one on wastewater treatment and a second on wastewater reuse. The general outline has been developed according to the results of a questionnaire survey, which was conducted among different stakeholders in order to develop guidelines of high practical relevance. In response to the survey, 50 filled-in questionnaires were received. Respondents included staff at municipalities, authorities, ministries, universities, utilities, user groups, etc. thus representing a broad range of different stakeholder groups.

More specifically, the policy guidelines provide concise information about the following issues (not exhaustive):

- Criteria to consider when selecting the appropriate technology for wastewater treatment,
- Different treatment solutions with focus on small scale solutions for rural areas, including their specific advantages and risks,
- Decision-support matrices,
- Options for wastewater reuse including their respective quality and quantity needs,
- Selection processes for appropriate reuse applications,

- Different ways to prevent health and environmental risks,
- Importance of awareness raising, education, and capacity building

The guidelines also provide lists of references and other sources of information for planning and implementing wastewater projects. For example it compiles information on existing legal frameworks in the MEDA region and elsewhere as well as reference-lists on regional and international experience with wastewater reuse (case studies/ success stories). It could, therefore, also be useful for other stakeholders such as non-governmental organisations (NGOs) or consultants active in the field, or authorities on the national level.

Data and information for developing the guidelines were gathered from experience on the site as well as from existing guidelines in the region and elsewhere. The EMWater policy guidelines recommend a selection process for reuse applications consisting of six main steps:

(1) Inventory of potential sources of wastewater for reuse.
(2) Identification of the widest possible selection of potential uses.
(3) Identification of legal requirements and responsible institutions.
(4) Detailed analysis of reuse alternatives.
(5) Economic evaluation of alternatives.
(6) Financial feasibility check of most promising alternatives.

With a special focus on agricultural reuse, important criteria such as suitability of soils and crops, risks of environmental impacts, health related requirements, needs for additional infrastructure, and public acceptance are discussed within the policy guidelines. With respect to health related requirements the guidelines follow the recommendations of the latest WHO Guidelines for the safe use of wastewater [8], excreta and greywater, thus suggesting a multi-barrier approach. The EMWater policy guidelines discuss the potentials of wastewater treatment, crop restriction, irrigation technique, human exposure control, and microbial standards, with regard to prevent negative health effects of wastewater reuse in agriculture.

## 5. Capacity building programs

Capacity building interventions include training courses on the local and regional level as well as moderated e-learning courses. The training courses are open to members of local institutions and authorities and cover some theoretical but mainly practical aspects such as operation and maintenance of wastewater treatment plants, laboratory techniques, public awareness, institutional and project management. These courses enables the transfer of an up-to-date knowledge to technicians and administrative staff as well as other stakeholders with practical experience in the field. In the last two project years, a total of more than 600 participants attended at 38 local training, and a total of around 70 participants attended at 8 different regional training modules. Further training courses are planned for 2006–2007 period.

The EMWater e-learning platform offers advanced training for professional engineers. In approximatively 40 h of distance learning, participants can improve their knowledge in construction and design of wastewater treatment plants, appropriate treatment and reuse technologies, cost recovery planning, quality standards, etc. Around 45 participants actively attended at the two training courses organised in 2004 and 2005. Another three e-learning programmes are planned for the years 2006–2007.

Participants for all training courses were selected by the local steering committees in the partner countries according to the participants' CVs and filled-in application forms. The topics of the training were chosen based on the training needs, analyses conducted by the EMWater project in 2003 and continuously updated by the local steering committees.

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