Wastewater recycling and reuse in Mediterranean region as a potential resources for water saving

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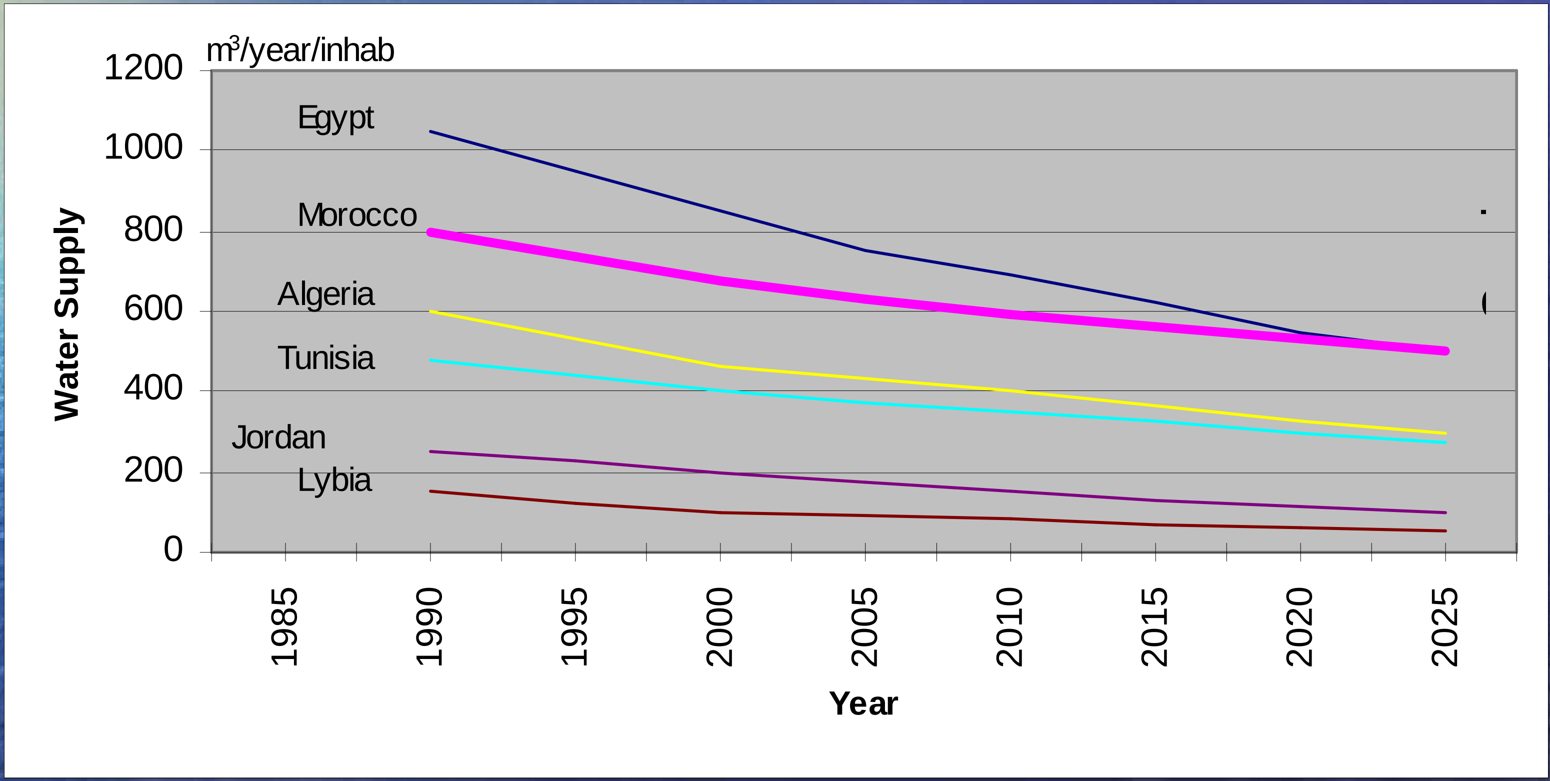
PROBLEMATIC

Scarcity of water resources and needs for protecting the environment and the natural resources are the main factors leading the Mediterranean countries to introduce TWW as additional water resources in the national plan of water resource management.

Supply of available waters per capita and per year in some Mediterranean countries



Volume of wastewater generated annually in some countries of the Mediterranean countries

(Qadir and al. 2006)

Country	Reporting year	Wastewater volume ($\times 10^6$ m^3 yr^{-1})
Algeria	2004	600
Egypt	1998	10012
Tunisia	2001	240
Jordan	2004	76
Lebanon	1990	165
Libya	1999	546
Morocco	2002	650
Syria	2002	825

Wastewater Reuse in Agriculture, Why?

- Typical wastewater effluent from domestic sources could supply all of the nitrogen and much of the phosphurus and potassium that are normally required for agricultural crop production (FAO 1992).

- The demonstration that health risks and soil damage are minimal if the necessary precautions are taken

QUESTIONS?

- What are the appropriate treatment technologies to be used?
- what are the most salient constraints (both technically, institutionally and financially)?
- what are the viable options for reuse of waste water? and
- how can we move forward with the use of treated waste water for agriculture within the parameters of the Mediterranean region, including sustainability issues?

CHARACTERISTICS OF THE SOUTHREN MEDITERRANEAN REGIONS

- Need for wastewater reuse and for seasonal storage
- Availability of inexpensive land area adjacent to the community.
- Abundant Sunlight
- Relatively concentrated wastewater due to limited per-capita water consumption rate.
- Relatively high pathogenicity of the wastewater
- Shortage of capital investment.
- Need for minimal, simple and inexpensive operation and maintenance of facilities.

CRITERIA FOR SELECTING APPROPRIAT TECHNOLOGY

- Efficiency and performance of the technology;
- Reliability of the technology;
- Institutional manageability, financial sustainability;
- Wastewater characteristics,
- Desired effluent quality which is mainly related to the expected uses

Potential cost effective alternatives

- Stabilization ponds or lagoons,
- Sand filters,
- Land treatment systems, and
- Constructed wetlands


Anaerobic basin


Denitrification basin

Flow regulation basin


SAND FILTERS

SAND FILTERS

Maintenance of sand filters

SAND FILTERS


Storage basin

Sewage performances: Reduction percentage

Plant	Ouarzazate		BenSergao	Drarga	BenSlimane	Marrakech	Bouznika
Processing System	Lagoon	High Out put Lagoon	Infiltration Percolation		Aerated Lagoon	Optional Lagoon	Lagoon
Period of Stay (Days)	25	21.9	-	-	30-40	30	-
DBO5 (mg/l)	81.7	65.3	98	98.5	78	97	75
DCO (mg/l)	72	65.4	92	96	79	76	71
MES (mg/l)	28	-	100	96.6	-	69	76
NTK (mg/l)	31.5	48	85	96.8	75	71	14
P total (mg/l)	48.5	54	36	95.9	41	85	-
CF /100ml	99.9	99.9	99.9	99.9	100	99.4	99.9
O. Helminthes/L	100	100	100	100	100	100	100

Source: ONEP-FAO (2001)

CONSTRAINTS OF THE REUSE

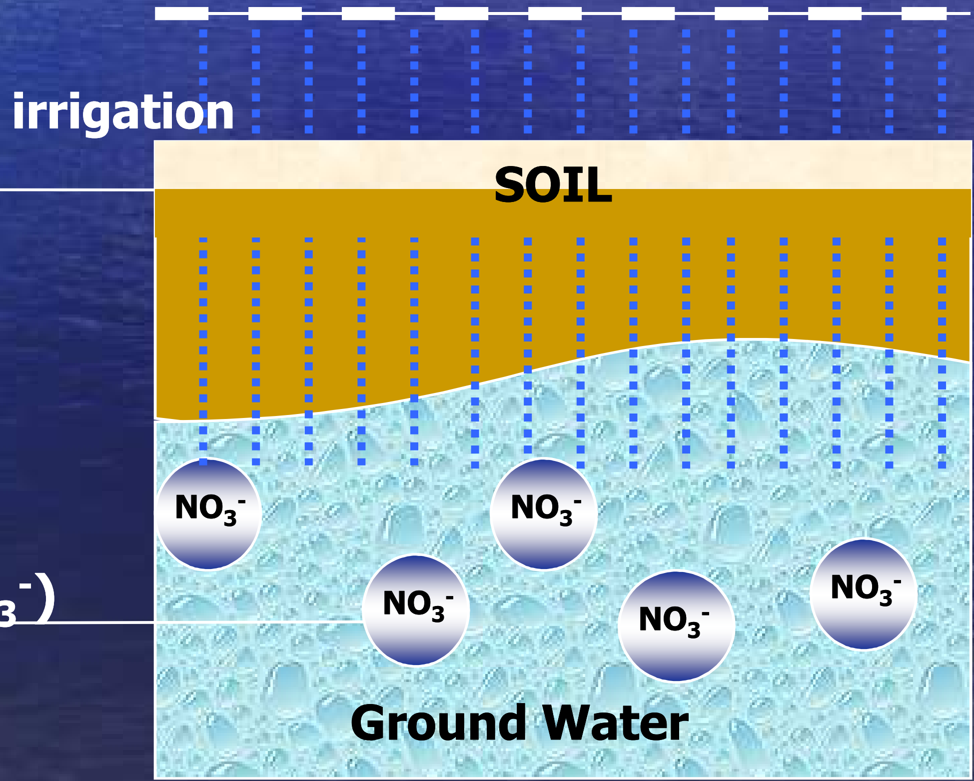
- Wastewater quality and health issues
- Financial considerations
- Monitoring and Evaluation
- Public awareness and participation
- Realistic Standards and Regulations

Salinization and Nitate Polution

watewater: *high EC
*high nitrate level

* Soil salinzationl (EC)
100% ETM

* Ground watercontamination (NO_3^-)
120% ETM



STRATEGIES FOR SUSTAINABLE REUSE

- Adequate treatment technology
- Crop selection
- Irrigation techniques and scheduling
- Control of nitrogen pollution and salt accumulation

Impact of treated wastewater on the soil electrical conductivity

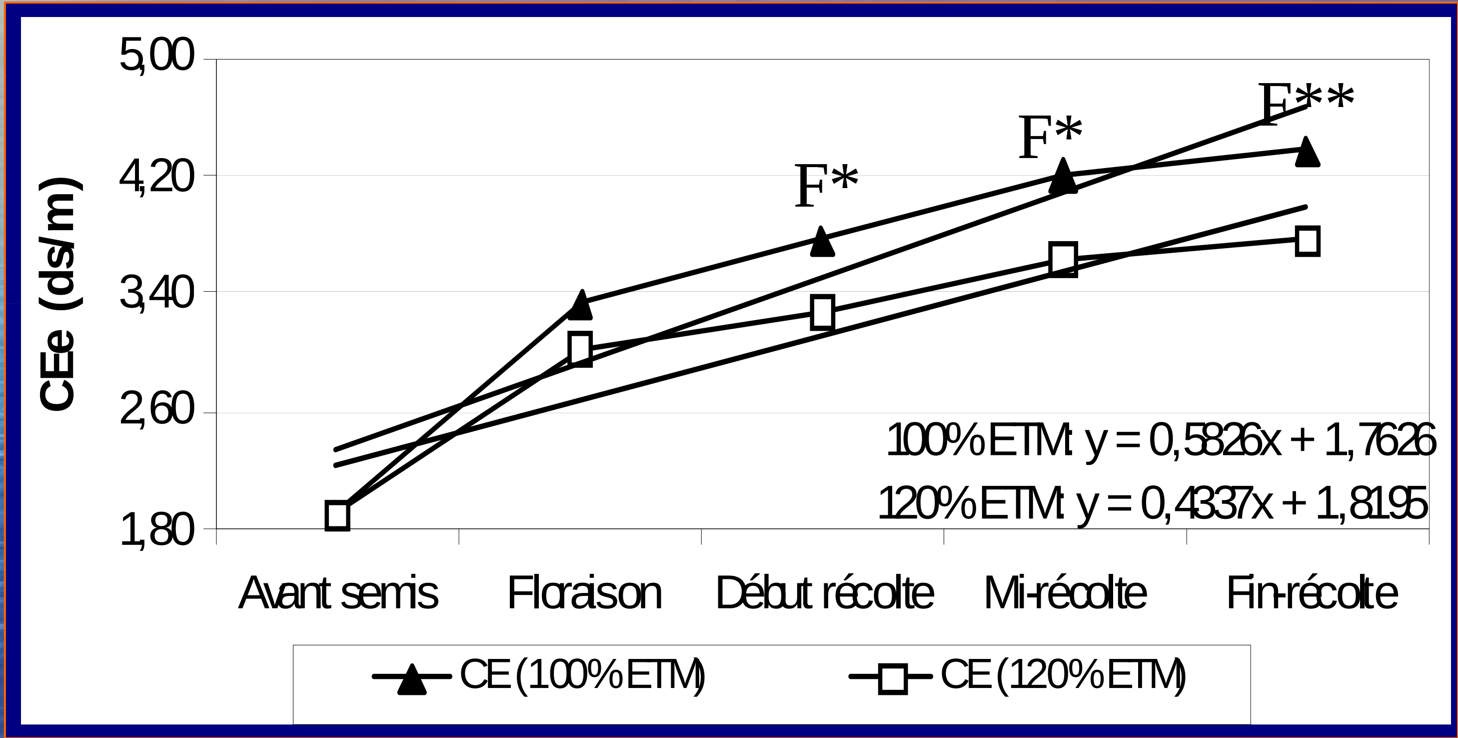


Figure : Evolution of the soil EC

The application of an equal amount of the crop requirement induces salt accumulation and reduces the nitrogen leaching and yields.

impact of treated wastewater reuse

- The use of drip irrigation and plastic mulch eliminated the risk of coliforms contamination of the harvested products.

- The high infiltration rate of sandy soil and the high nitrate concentration in the treated effluent contribute to high nitrate leaching potential

- The amount of nitrogen lost to the underground water vary depending on the crop, the water depth, and the quality of the treated wastewater.

Using treated wastewater as supplemental irrigation for Stabilizing rain fed wheat yield

Wheat production under supplementary irrigation

- Wheat production in arid regions of Morocco depends on rainfall.
- Drought periods took place during the spring, which corresponds to flowering or grain filling stage according to the planting date.
- Supplementary irrigation is widely practiced in several mediterranean countries to stabilize and improve the crop yield.

Impact of treated wastewater as supplemental irrigation

- Equal amount of supplemental irrigation (125mm) at flowering and grain filling stages produced satisfactory yield (41.4q/ha).
- Maximum yield(48.1q/ha) were obtained when 70% of supplementary irrigation(175mm) is applied at the flowering stage.
- Less than 50mm at flowering stage recorded a drastic reduction in the grain yields.
- Flowering stage is the most critical growth stage.

Impact of treated wastewater as supplemental irrigation

- Using 2410 m3 per hectare for wheat production can save 30-35% of the nitrogen fertilizer, 10% of P fertilizer, and 70-82% of K fertilizer, of the whole plant exported nutrients and increase the farmer income.

Wastewater reuse project planning

- Implementation of strategy and policy to promote reuse
- Participation of the end users in all phase of the project
- Selection of durable site

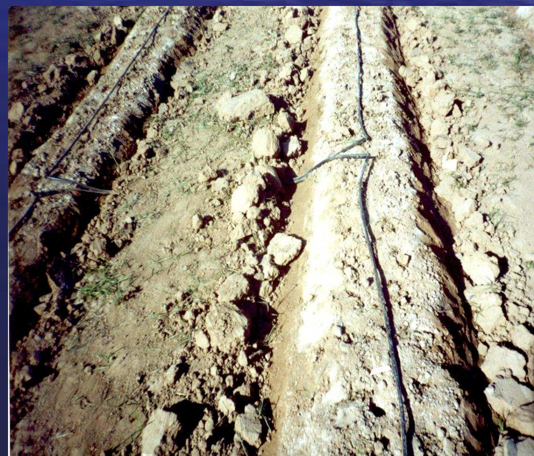
Wastewater reuse project planning

- Selection of treatment system based on the type possible reuse
- Need to diversify different reuse
- Cost-benefit analysis should include socio-economic and environmental aspects
- Constant dialogue between all relevant partners

Irrigation systems

- Problems faced were not linked to the irrigation method but rather to the piloting of the irrigation
- Drip irrigation and the use of plastic mulch reduce considerably the health risks

CROPING SYSTEMS



Treated wastewater resulted in similar to better growth and yield as well as the same quality of crop irrigated with Fresh water (control).

Treatment	Crops						
	Chrysanthemum	Melon	Zucchini	Egg plant	Maize	Bread wheat	Hard wheat
	Flower/plt	T/ha	Kg/plt	Kg/m^2	Qx/ha	Qx/ha	Qx/ha
Control *	69	26.2	1.29	3.17	12.43	5.107	0
Treated wastewater	80	34.6	2.18	3.41	12.62	48.69	31.83

Treated wastewater price

Price assessment components:

- Pumping cost
- Transport cost
- Storage cost
- Operation and maintenance cost

Costs of different wastewaters treatment plants in Morocco

Plant	Capital Investment Cost (millions of Dirham)	Running Cost (Dirham / an)	Cost per Inhabitant / year (Dirham)	Cost / m3 (Dirham)
Ouarzazate	5	108.500	643	1,43
Ben Sergao	5	307.500	250	1,12
Benslimane	96,44	935.000	1.928	1,45
Drarga	20,3	260.000	1.000	1,70

Cost recovery

- Methane gas is recovered from the anaerobic basins and converted to energy
- Treated wastewater is sold to farmers for irrigation
- Reeds are harvested and sold
- Residual sludge will be dried and used with organic solid wastes from Drarga to make compost

Awareness raising

- Establish a Awareness and sanitary education programs for farmers, engineers and technicians
- Develop handouts on different aspects of the reuse of treated wastewater

Sanitary Aspects

- Develop simple analytical methods for monitoring coliforms and helminths eggs
- Develop a methodology and monitoring evaluation system of the impact of the reuse on the soil, crops and ground water

Technical Options for health Protection

- Treatment of Wastewater.
- Crop Restriction
- Application methods of wastewater.
- Control of human exposure.

Conclusion

- The wastewater treatment and reuse is demonstrating the use of non-conventional water sources in a water scarce environment
- The lessons learned from these can serve as a useful model for replication of similar technologies and approaches in many areas

  of the Mediterranean region

Thank you for your attention

Directives de qualité microbiologique recommandée pour l'usage d'eau usée en agriculture (OMS, 1989)

Caté-gorie	Conditions de réalisation	Groupe exposé	Nématodes intestinaux[a] (nbre d'oeufs/litre) moyenne arithmétique	Coliformes intestinaux (nbre par 100 ml) moyenne[b] géométrique	Procédé de traitement susceptible d'assurer la qualité microbiologique voulue
A	Irrigation de cultures destinées à être consommées crues, des terrains de sport, des jardins publics[c]	Ouvriers agricoles consommateurs public	Maximum 1	Maximum 1.000[d]	Une série de bassins de stabilisation conçus de manière à obtenir la qualité microbiologique voulue ou tout autre procédé de traitement équivalent
B	Irrigation des cultures céréalières, industrielles et fourragères, des pâturages et des plantations d'arbres[e]	Ouvriers agricoles	Maximum 1	Aucune norme n'est recommandée	Rétention en bassins de stabilisation pendant 8-10 jours ou tout autre procédé d'élimination des helminthes et des coliformes intestinaux
C	Irrigation localisée des cultures de la catégorie B. si les ouvriers agricoles et le public ne sont pas exposés	Néant	Sans objet	Sans objet	Traitement préalable en fonction de la technique d'irrigation, mais au moins sédimentation primaire

(Source : OMS, 1989)

[a] Espèces *Ascaris* et *Trichuris* et ankylostomes.

[b] Pendant la période d'irrigation.

[c] Une directive plus stricte (< 200 coliformes intestinaux par 100 ml) est justifiée pour les pelouses avec lesquelles le public peut avoir un contact direct, comme les pelouses d'hôtels.

[d] Cette recommandation peut être assouplie quand les plantes comestibles sont systématiquement consommées après une longue cuisson.

[e] Dans le cas d'arbres fruitiers, l'irrigation doit cesser deux semaines avant la cueillette et les fruits tombés ne doivent jamais être ramassés. Il faut éviter l'irrigation par aspersion.