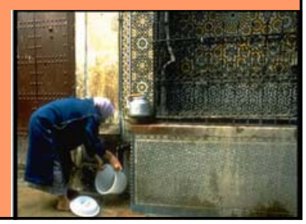
INNOVA – MED
Innovative Processes and Practices for Wastewater Treatment and Re –Use
Ankara, October, 8 – 11, 2007

Mohamed Tawfic Ahmed
Suez Canal University
Egypt



Presentation Highlights

- This presentation would cover the following points:
- A bird's eye view on global water, with special reference to MENA
- Information about WW in MENA
- A Case Study,Gravel Bed Hydroponic, experimental and application levels

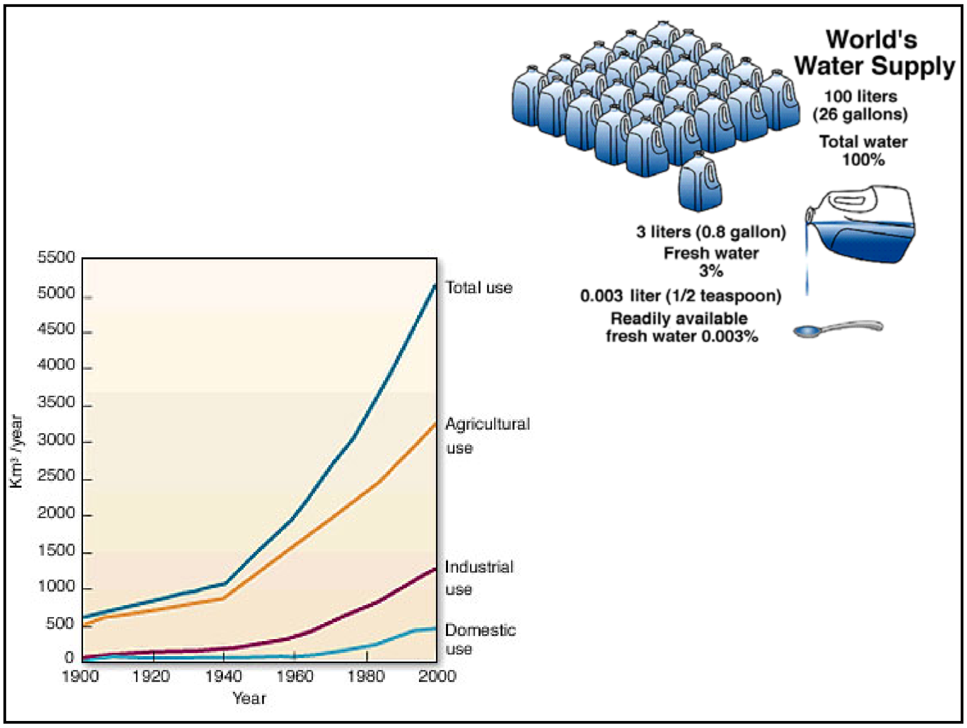
Water is more critical than energy. We have alternative sources of energy. But with water, there is no othe choice.
-Eugene Odum

Water Budgets

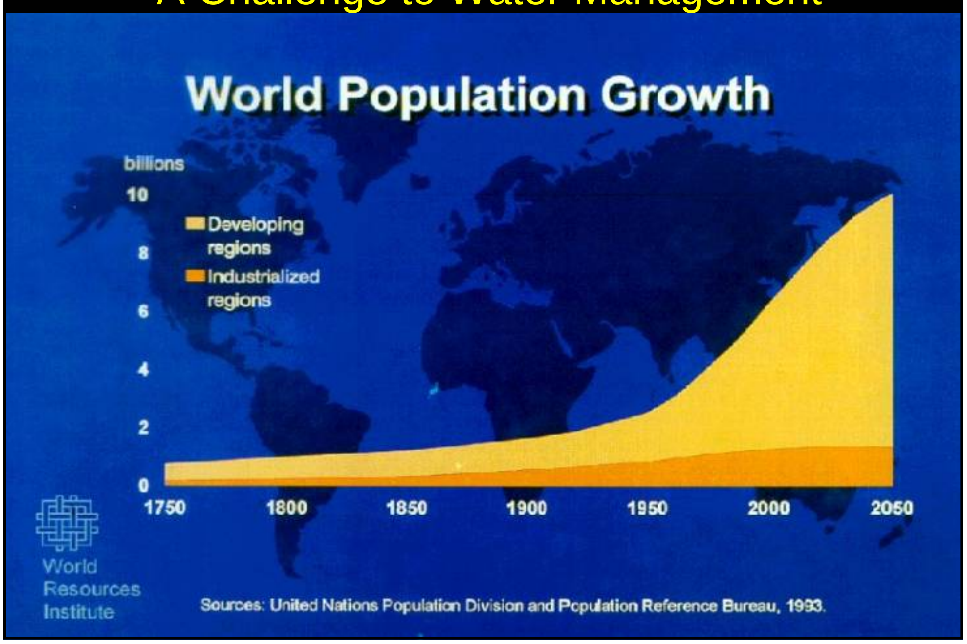
Global
- 97% Salt Water
- 3% Fresh Water

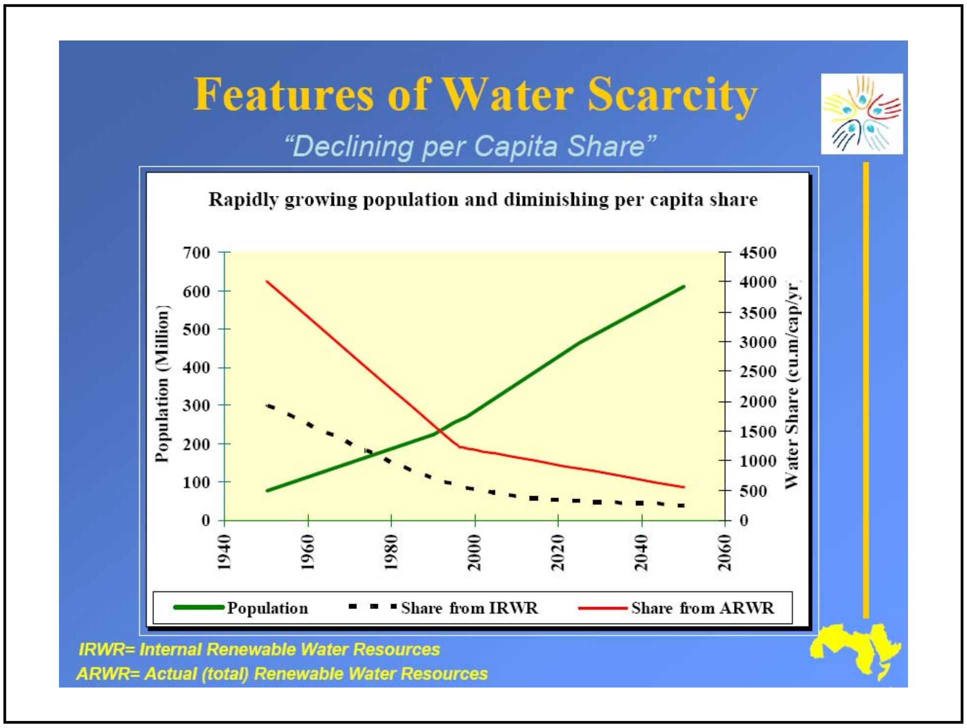
Freshwater
- 87% Not Accessible
- 13% Accessible

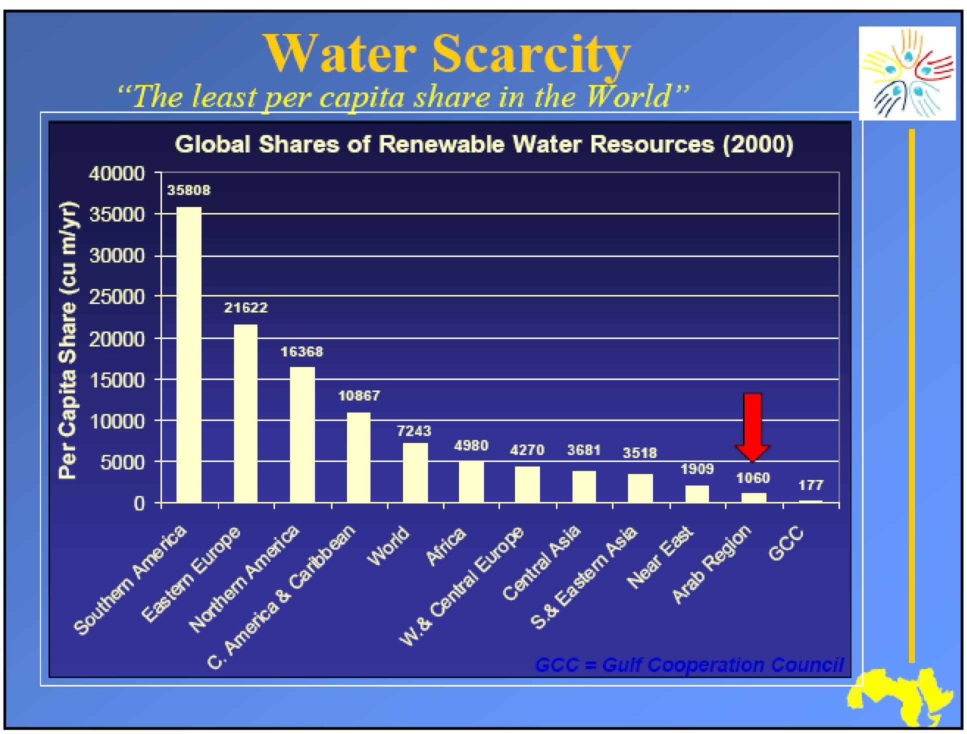
MENA
- 1% of Accessible Freshwater
- 5% of World Population



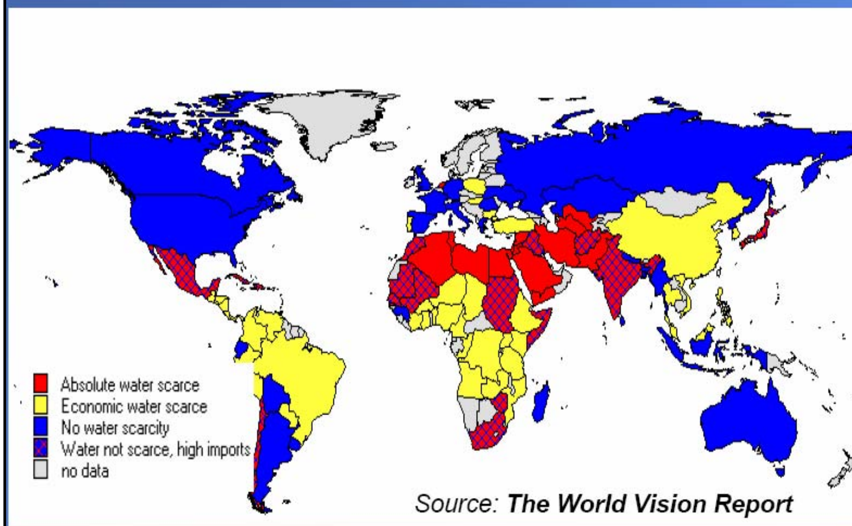
A Challenge to Water Management




Features of Water Scarcity
"Declining per Capita Share"
Rapidly growing population and diminishing per capita share
Population (Million)
Water Share (cu.m/cap/yr)
0
100
200
300
400
500
600
700
0
500
1000
1500
2000
2500
3000
3500
4000
4500
1940
1960
1980
2000
2020
2040
2060
Population
Share from IRWR
Share from ARWR
IRWR= Internal Renewable Water Resources
ARWR= Actual (total) Renewable Water Resources


Water Scarcity
"The least per capita share in the World"
Global Shares of Renewable Water Resources (2000)
Per Capita Share (cu m/yr)
0
5000
10000
15000
20000
25000
30000
35000
40000
35808
21622
16368
10867
7243
4980
4270
3681
3518
1909
1060
177
Southern America
Eastern Europe
Northern America
C. America & Caribbean
World
Africa
W.& Central Europe
Central Asia
S.& Eastern Asia
Near East
Arab Region
GCC
GCC = Gulf Cooperation Council

Absolute Water Scarcity by 2025



Per Capita Availability Shows Huge Variation

Country/region	Water availability
North America	> 10,000 m^3/year
Egypt	1,100
Jordan	260

Syria's water table has been declining one meter every year for the past 30 years!

Water Scenarios and Regional Perspective

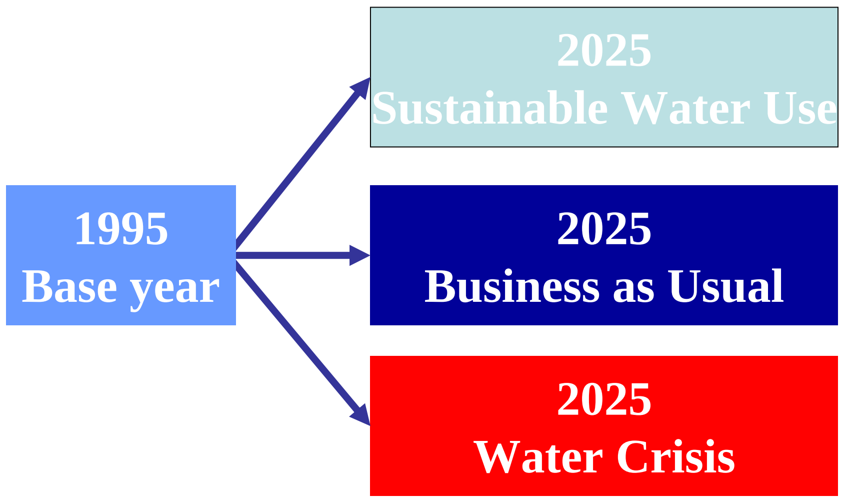
The Future of Water and Food in the Middle East and North Africa: Outlook to 2025

International Food Policy Research Institute International Water Management Institute

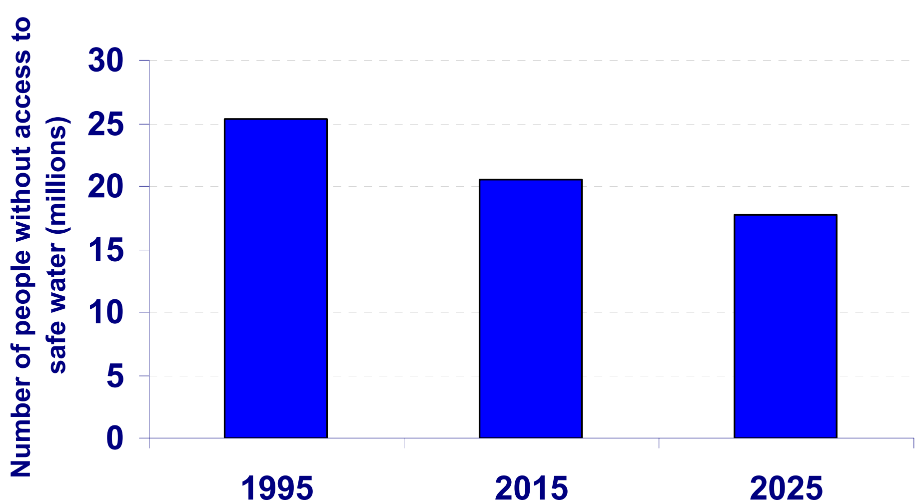
IFPRI

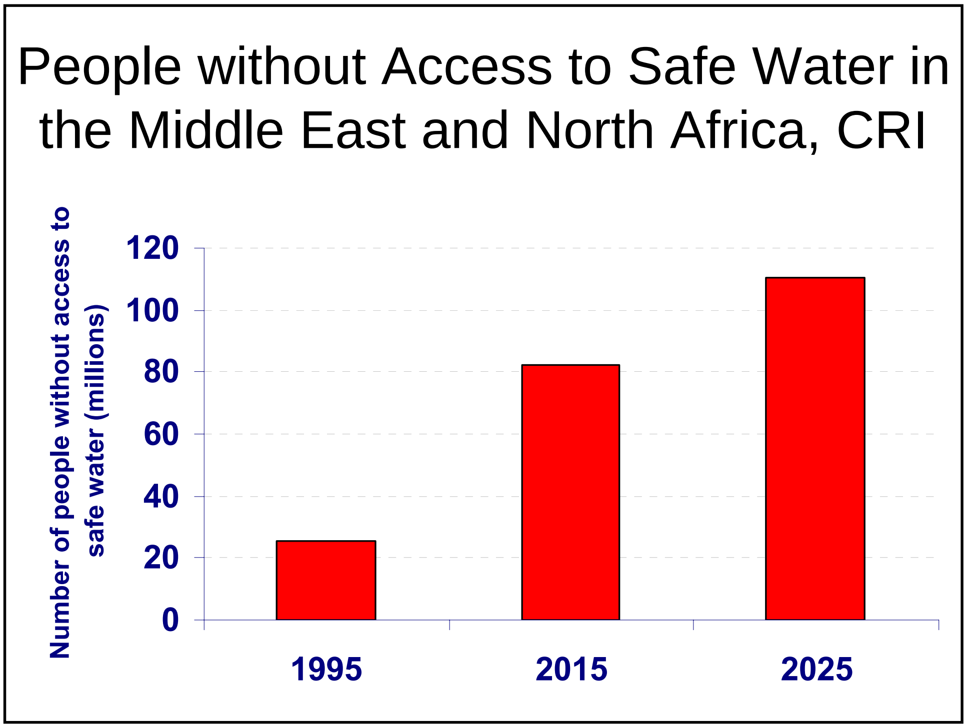
IWMI International Water Management Institute

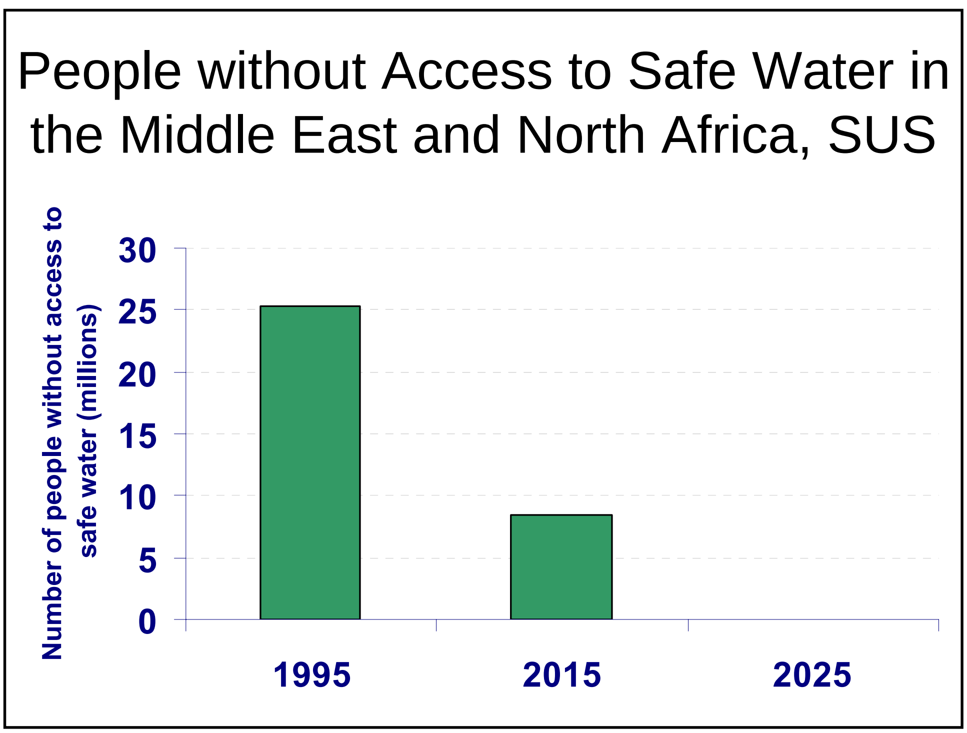
Scenario Approach



People without Access to Safe Water in the Middle East and North Africa, BAU




People without Access to Safe Water in the Middle East and North Africa, CRI
Number of people without access to safe water (millions)
120
100
80
60
40
20
0
1995
2015
2025


People without Access to Safe Water in the Middle East and North Africa, SUS
Number of people without access to safe water (millions)
30
25
20
15
10
5
0
1995
2015
2025

Wastewater Treatment and Re Use is The Backbone of Water Sustainability

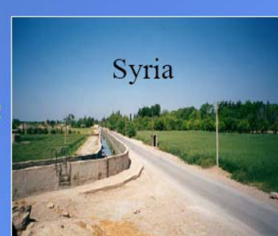
New Water Sources
(US cents /cu.m)

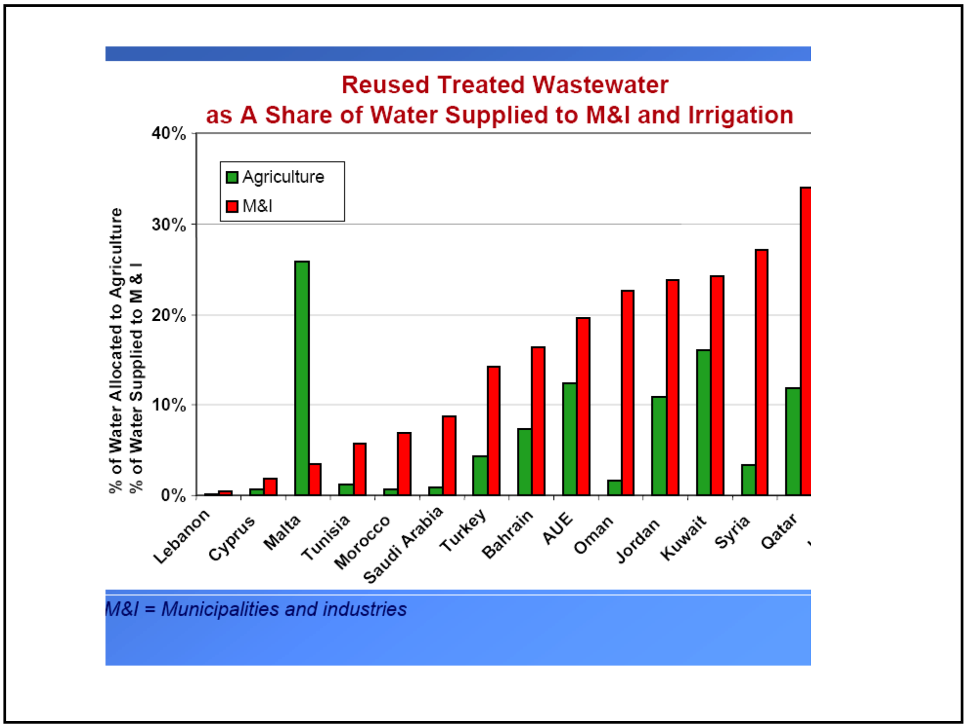
• Reduce demand	=	10 - 70
• leakage repair	=	10 - 70
• Desalination – (brackish water)	=	20 - 40
• Wastewater reuse – (Only for irrig. & some industry)	=	10 – 50
• Desalination – (sea water)	=	50 – 90

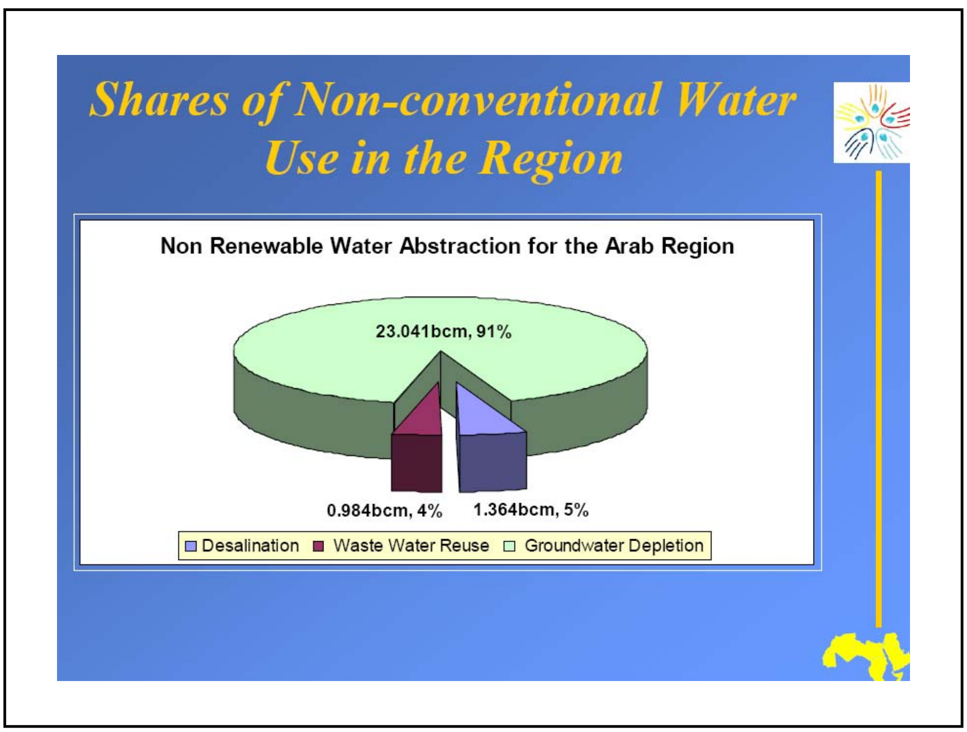
Source World Bank est. 2003 in WB,from scarcity through reform to Security, for WWF3, Kyoto Japan 2003, p.13

Wastewater Reuse

- *Kuwait, Saudi Arabia, Oman, UAE, Syria, and Egypt practice municipal wastewater treatment and reuse*
- *In Tunisia, the volume of treated wastewater available in the year 2000 exceeded 125 million m³, and by 2002 had reached 170 million m³*
- *In the Arabian Peninsula (GCC Countries), about 0.4 km³ are being reused for irrigating*




Reused Treated Wastewater
as A Share of Water Supplied to M&I and Irrigation
40%
30%
20%
10%
0%
% of Water Allocated to Agriculture
% of Water Supplied to M & I
Agriculture
M&I
Lebanon
Cyprus
Malta
Tunisia
Morocco
Saudi Arabia
Turkey
Bahrain
AUE
Oman
Jordan
Kuwait
Syria
Qatar
M&I = Municipalities and industries


Shares of Non-conventional Water Use in the Region
Non Renewable Water Abstraction for the Arab Region
23.041bcm, 91%
0.984bcm, 4%
1.364bcm, 5%
Desalination
Waste Water Reuse
Groundwater Depletion

Water Reuse in MENA I: Sewerage Generated and Reused, Wastewater Treatment Plants and other Quantitative Parameters

		Unit	Algeria	Egypt	Jordan	Morocco [1]	Syria	Tunisia	Yemen	West Bank Gaza
Total Water Resources		MCM/year	11,000	67,800	900	21,000	14,000	4,700	3,600	276
Total Sewage Collected [2]		MCM/year	n.a.	3,300	72	292	260	240	33 *	~15 *
Total Sewage Treated [3]		MCM/year	Limited	1,640	72	~ 6	260 *	156	33 *	~13 *
Total Sewage Discharged to the Sea		MCM/year	Substantial	1,000	0	Most	Limited	100	~8 *	~7 [4]
Total Sewage Reused	Planned or Semi-Planned	MCM/year	Very small share	Yes	Large share	Very small share	Yes	> 28 [5]	Small share	Negligible
	Unplanned	MCM/year	Yes	Yes	Very small share	~ 70	Yes	Officially none	Large share	Limited
Share of Treated Sewage Reused		%	n.a.	Large share	All, minus evaporation losses	n.a.	All, minus evaporation losses	18 %	~75 %	< 25 %
Municipal Wastewater Treatment Plants		Number (Extensive / Intensive)	44 (including 16 to be scrapped)	121	18 (9 ext + 9 int)	19 (7 ext + 12 int) + 27 out of order	4 (4 int.)	61 (14 ext + 47 int)	9 (6 ext + 3 int)	8 (7 ext +1 int)
Total Area Irrigated with Treated Wastewater or Blended Water		Hectare	n.a.	42,000	10,600	7,000	36,370	7,100	n.a.	n.a.

* World Bank Estimate. For Syria, Yemen and West Bank Gaza: Calculated as the sum of the daily sewage load of individual treatment plants, converted to an annual basis.

n.a. = not available

Water Reuse in MENA III: Types of Reuse, Crop Restrictions, Participation and Project Examples

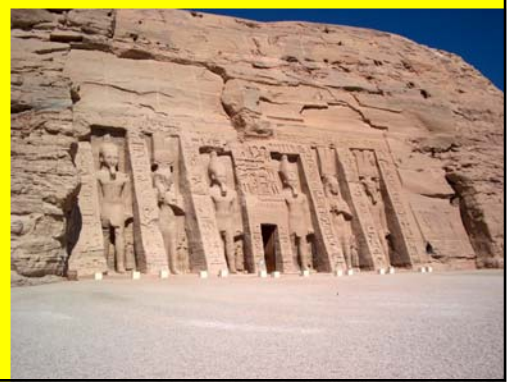
		Algeria	Egypt	Jordan	Morocco	Syria	Tunisia	Yemen	West Bank Gaza
Type of Reuse	Current	Ag	Ag, LS, Trees	Ag, Trees	Golf	Ag	Ag, Golf, LS	Ag, Trees	Ag
	Future (on top of current)	LS, Ind, Trees	Timber Trees, Industrial Crops	LS, Ind, GR	Ag	n.a.	GR, Ind, unrestricted agricultural reuse	--	LS, Ind, GR
Crop Restrictions for Irrigation with Treated WW		Yes, applied in at least some schemes	Yes, applied in at least some schemes	No (in Jordan Valley) Yes (in other schemes)	Yes (planned)	Yes, applied in at least some schemes	Yes	No (under discussion)	Planned (WB) No (Gaza)
Participation by WUAs		Yes, in some schemes	n.a.	Planned	n.a.	n.a.	Yes	Yes, in some schemes	Planned
Reuse of Untreated WW		n.a.	No	No	Yes	Yes	No	Yes	Yes
Pre-Treatment of Industrial Wastewater		Yes, but often not functioning	Yes, has recently been enforced more vigorously	Yes	n.a.	n.a.	Yes	n.a.	n.a.
Current Projects		Setif	Gebel Asfar (Cairo) Ismailia	Samra, Mafraq, Aqaba Madaba etc.	Benslimane (Pilot)	Damascus	Numerous	Sana'a Others	--
Planned Projects		n.a.	2.5 BCM/year from Cairo and Alexandria to irrigate 115,000 ha of trees and industrial crops	Upgrading of existing schemes, Northern Jordan Valley	Agadir	n.a.	Tunis-West and many others	Upgrading of existing schemes (e.g. in Sana'a)	Al Bireh, Gaza (3 WWTPs) as part of IAMP

Ag = Agriculture; LS = Landscaping; Ind = Industrial; GR = Groundwater Recharge; WUA = Water User Association
IAMP = Integrated Aquifer Management Program

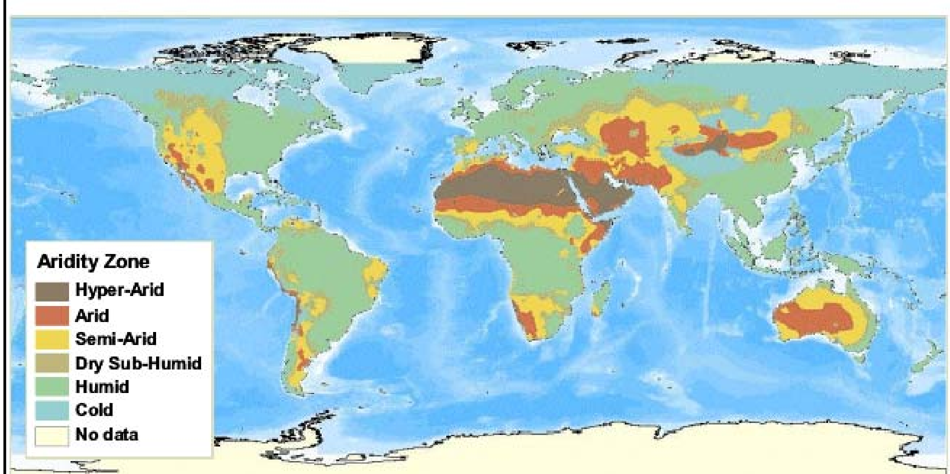
key figures

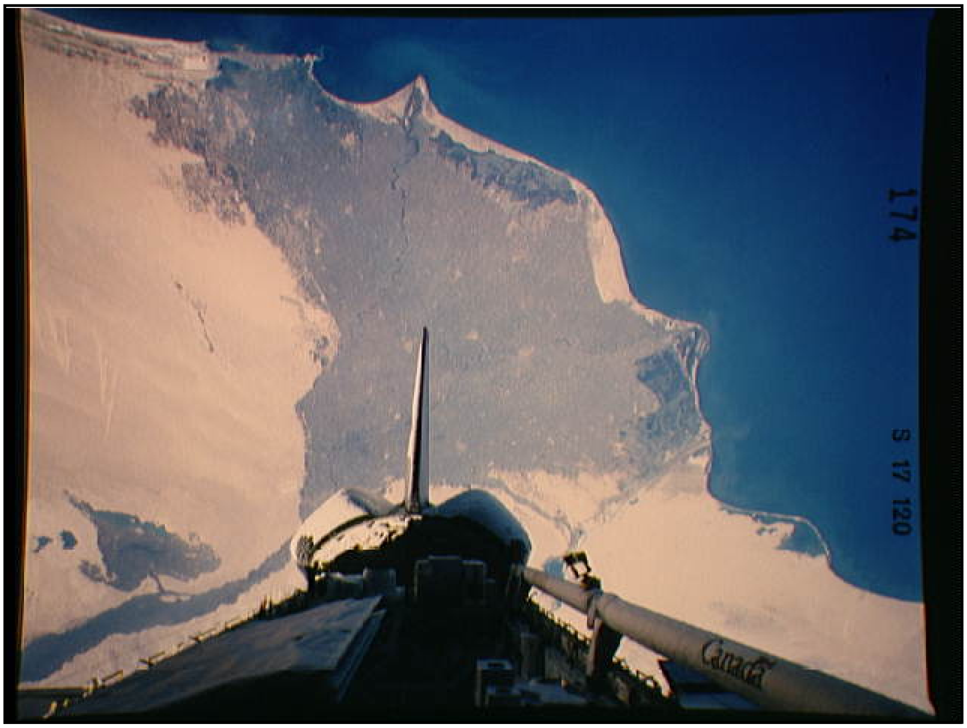
• Land area, thousands of km²	1 001
• Population, thousands (2001)	69 080
• GDP per capita, $ (2001)	1 426
• Life expectancy (2000-2005)	68.3

Egypt

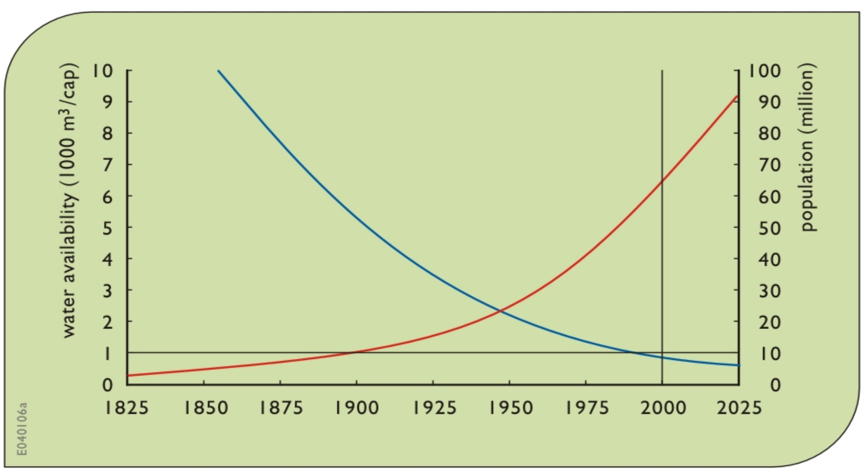


Egypt is Not An Arid Country

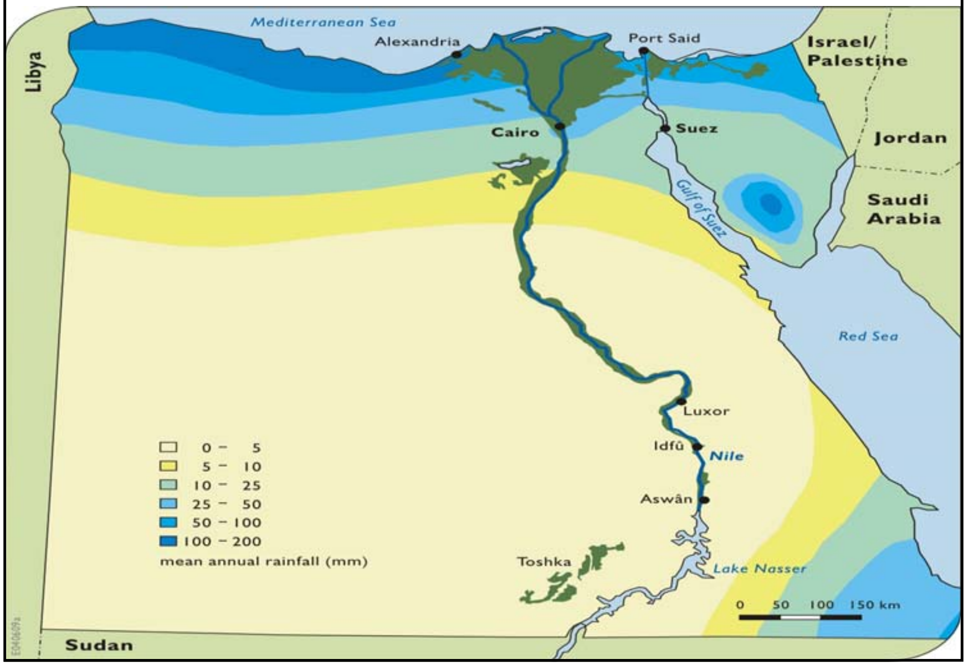




Egypt Water Per Capita
More than one sign



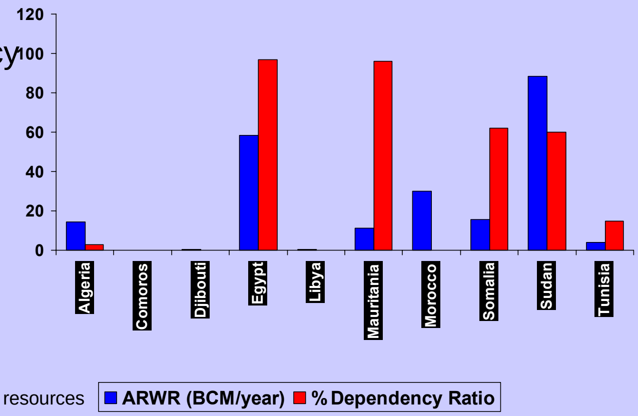
Rainfall, Egypt



Billion cm/year		Source
2017	**2000**	
57.50	55.50	**River Nile**
1.50	1.00	**Rain**
8.40	5.06	**Agricultural Drainage**
7.50	4.80	**Groundwater, Nile Valley and Delta**
3.50	0.57	**Groundwater, Sinai and W Desert**
2.50	0.70	**Treated Municipal Wastewater**
7.00	0.00	**Irrigation improvement programme**
87.90	**67.63**	**Total**

Actual Renewable Water Resources & Dependency Ratio On Neighbors

Average Dependency Ratio of 60%



Annual renewable water resources

Criticality Ratio, 1995 and 2025, BAU

	Criticality Ratio (ratio of water withdrawal to total renewable water)	
	1995	2025
Egypt	0.89	1.08

Wastewater Treatment

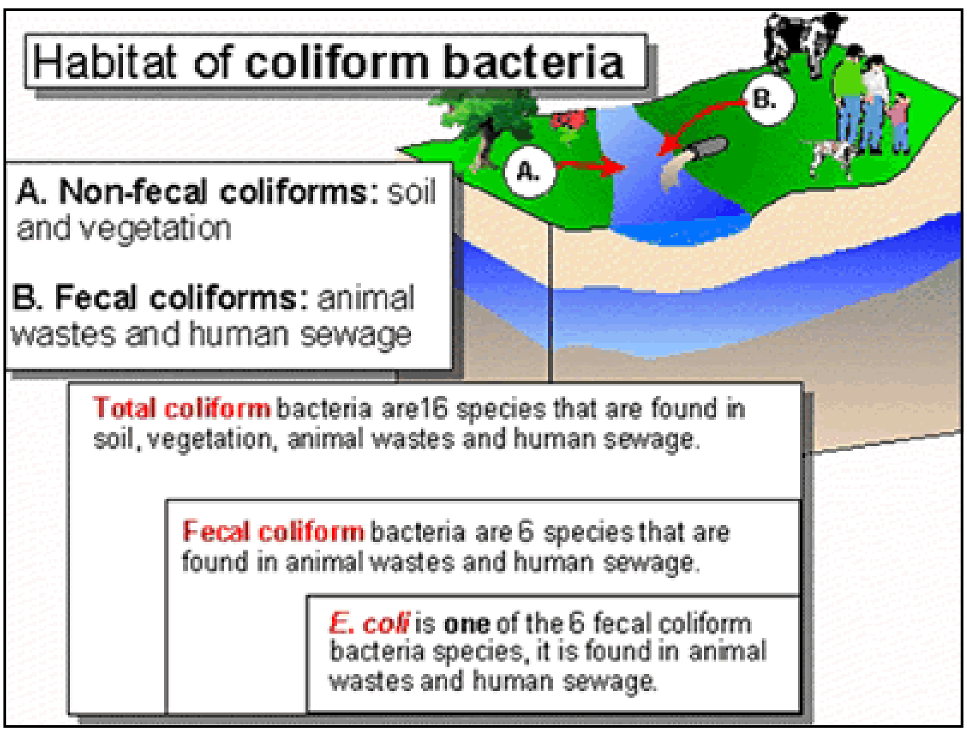
- **Wastewater generated by all governorates = 3.5 BCM/year**
- **50% of the urban population has access to sewerage services**
- **5% of rural areas has access to sewerage services.**
- **75% of rural population uses septic tanks, cesspits and latrines**
- **More than 15% of rural areas have no access to sanitation**
- **Current treatment capacity = 1.6 BCM/year.**
- **An additional treatment capacity of 1.7 BCM targeted by 2017**

Wastewater Treatment Facilities in Egypt some Figures

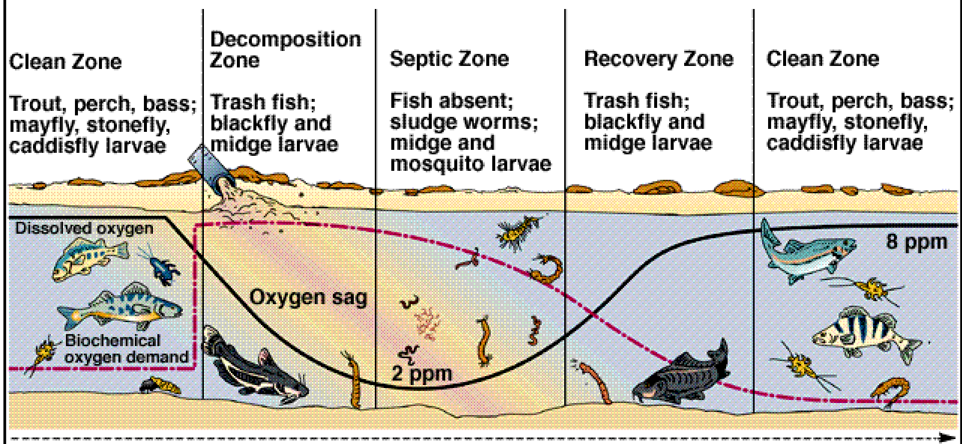
- In Egypt, 217 urban city, 24% of them are covered by WWTF
- About 5000 village, 4% of them are covered by WWTF
- 24 billion LE were spent on drinking water supply projects
- 44 billion LE were spent on wastewater facilities projects

Some of the Main Contaminants in Municipal Wastewater

Pollutant	Risk to:	Common Path
Nitrate	Human/Animal Health	Leaching to Groundwater
Ammonia	Fish Kills	Surface Runoff
P	Eutrophication	Erosion/Surface Runoff
Pathogens	Human Health	Surface Runoff
Organic Matter	Reduced oxygen-fish kills	Surface Runoff



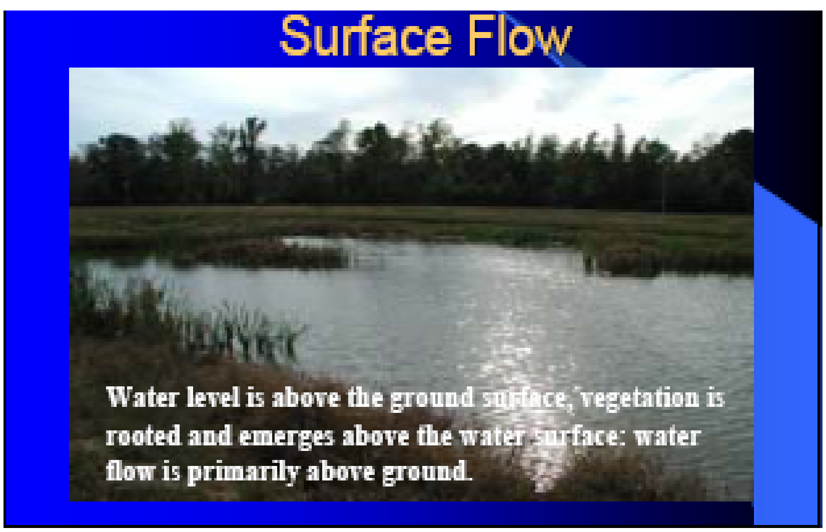
Oxygen sag downstream of an organic source.



Many species, including fish, are sensitive to low oxygen levels and die as a result.

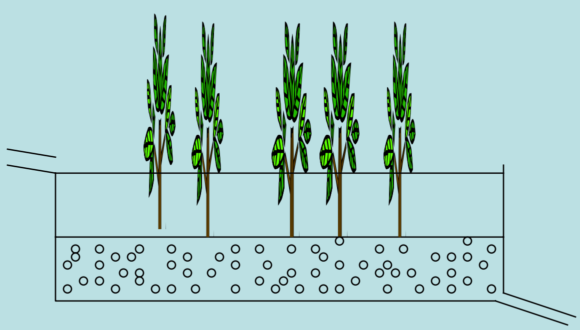
Constructed Wetlands, A Simple, Viable, Highly Efficient And Cost Effective Way to Treat Wastewater

Constructed Wetlands
A - Surface Flow Wetlands



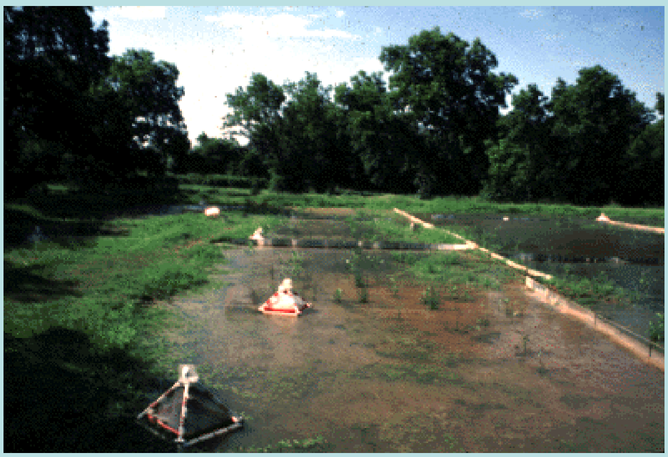
TYPICAL VIEW OF CONSTRUCTED WETLAND

1. Surface Flow



Surface Flow

Surface Flow

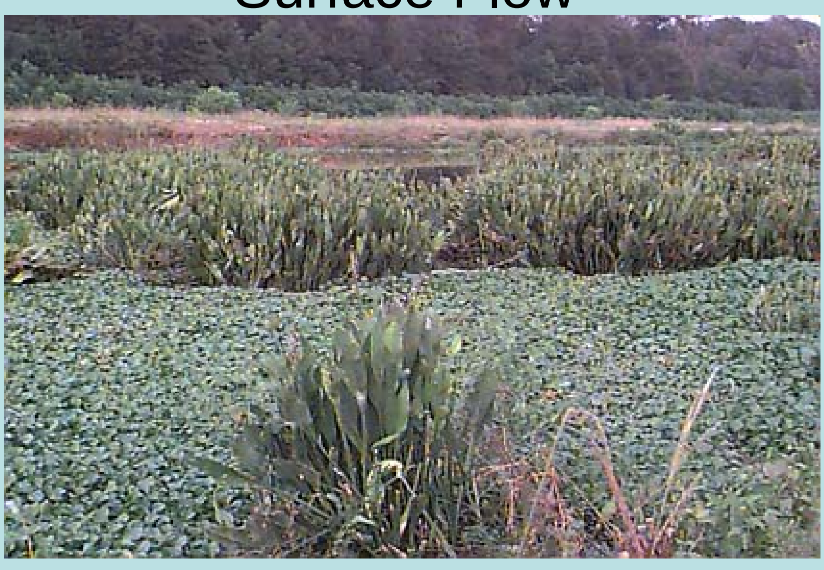


Surface Flow

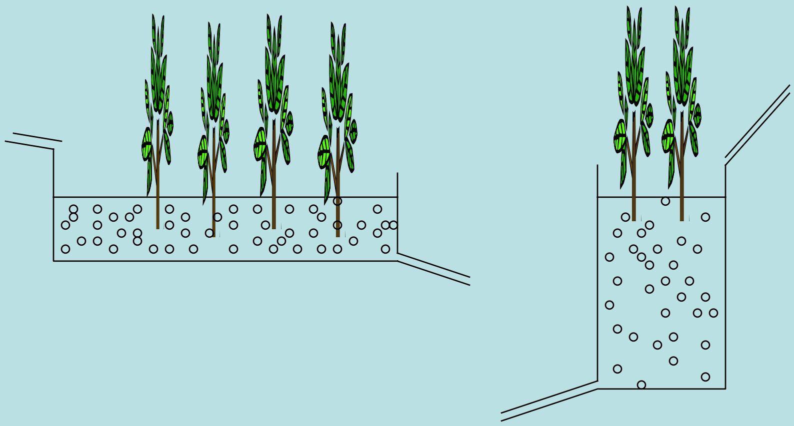
Surface Flow

Surface Flow

Surface Flow



2. Sub-surface Flow



Examples of Subsurface Flow, Ismailia, Egypt

Sub-surface Flow

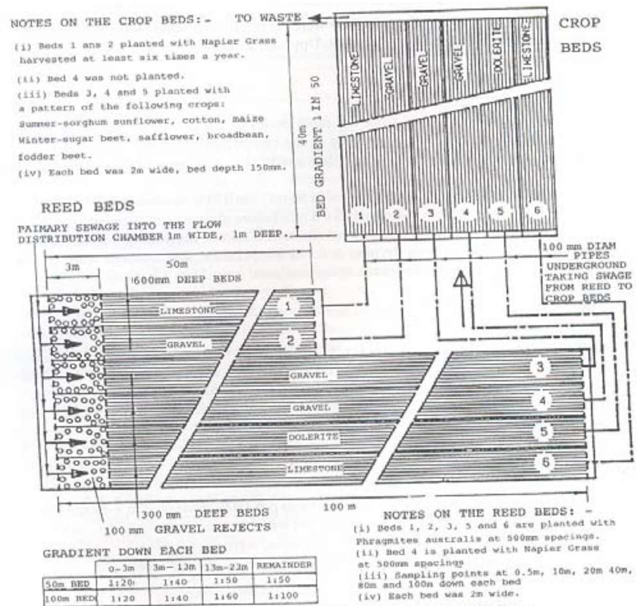
Municipal Wastewater, Treatment, A Small Community, Low Cost Technology

An Egyptian Perspective

- The gravel bed hydroponic system, developed by Suez Canal University and University of Portsmouth, England, UK
- Currently used with remarkable success in upper Egypt for grey water within a framework of the GEF

The GBH System
System Highlights

•Gravel Bed Hydroponic (GBH) reed bed systems, consist of channels sealed with geomembrane.
•The channels are filled with gravel, and wastewater is percolated horizontally below the surface of the gravel.
•This subsurface flow reduces the potential for breeding sites of insects, especially mosquitoes and aquatic snails.
• Reeds, predominantly Phragmites australis, are planted in the gravel and grow hydroponically using nutrients in the sewage.
•The reeds maintain the hydraulic pathways and their rhizospheres support intense microbial activity which ensures sewage treatment.



	0–3m	3m–13m	13m–23m	REMAINDER
50m BED	1:20	1:40	1:50	1:50
100m BED	1:20	1:40	1:60	1:100

Fig. 1. Details of the reed and crop beds at Abu Attwa, Ismailia, Egypt.

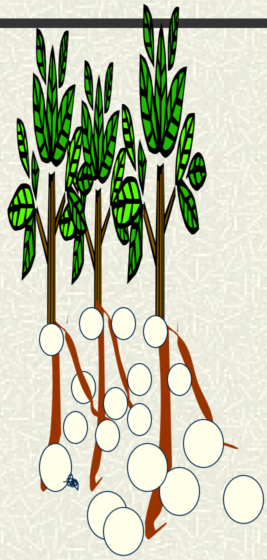
Advantages of GBH

- Easy to operate and capital cost is reasonable
- Excellent efficiency of removing pathogens at a level almost similar to WHO standard.
- High efficiency of removing nutrients, many organics
- Effluent comply with Egyptian regulation
- Land requirements are not ideal but could be afforded at village level
- Effluent could be used straight for agriculture
- Bed length, wastewater retention time, and gravel size have significant bearing on the performance of the system

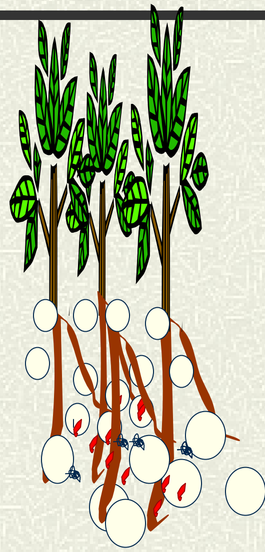
Industrial wastewater treatment

The GBH beds at 10th Ramadan City received a complex mixture of wastewater from a wide range of industries with BOD:COD ratios fluctuating between 0 and I (values below 0.2 indicate a toxic wastewater with poor prospects for biological treatment). The GBH beds were able to remove long chain hydrocarbons and fatty acids, but more recalcitrant compounds, including aromatics such as phthalates, remained. This suggests that GBH beds have applications for industrial wastes but may require a longer residence times or further treatment stages.

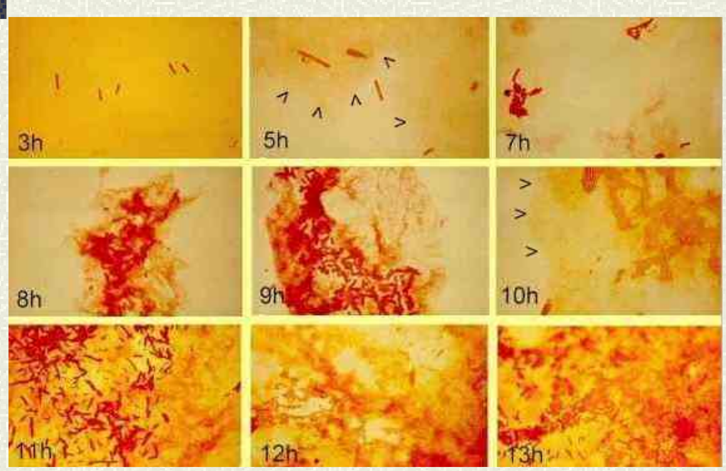
Gravel-root Matrix



Gravel-root Matrix



Establishment of Biofilm...



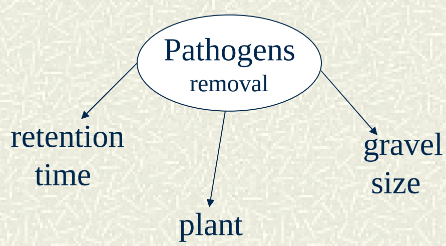
Preferred Treatment:

Aerobic Biodegradation in Root Zone

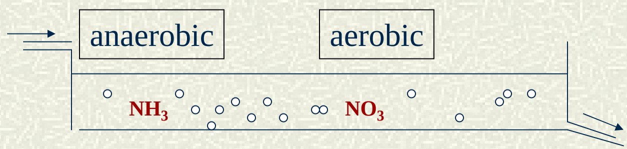
Oxidation "halo" around roots creates aerobic zone

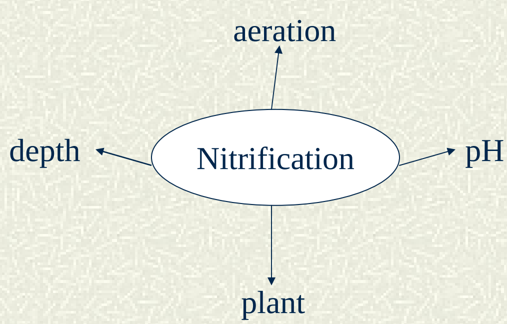
Removal of Pathogens

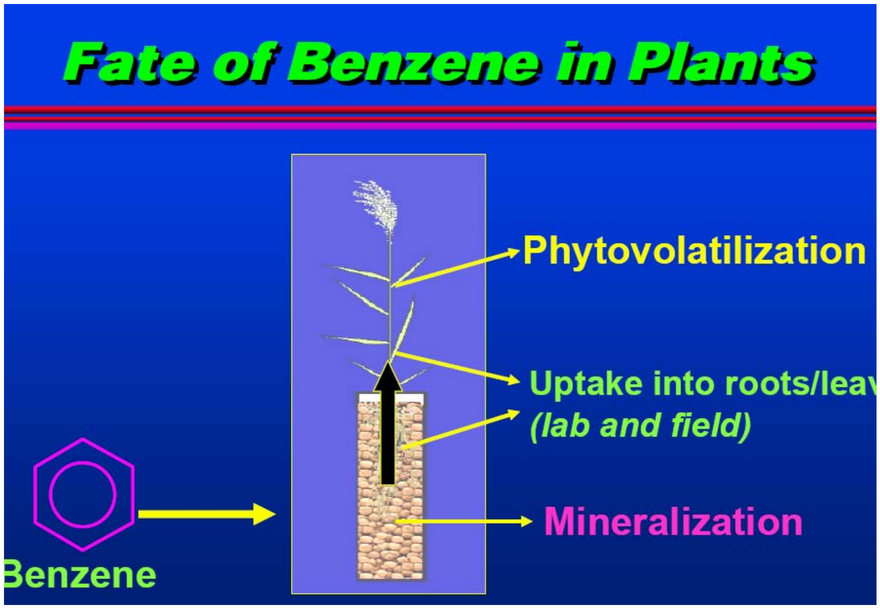
Adsorption – sedimentation – inactivation - predation



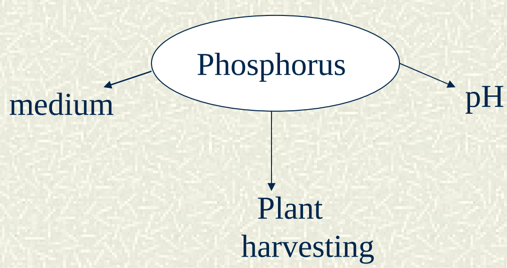
Removal of nitrogen





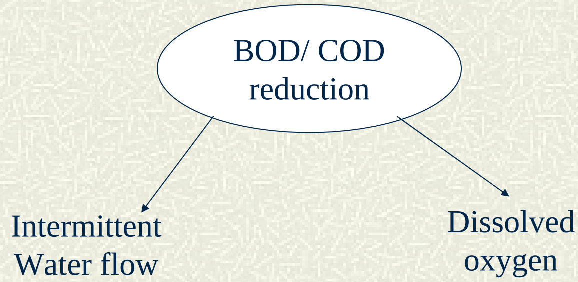


Removal of Phosphorus

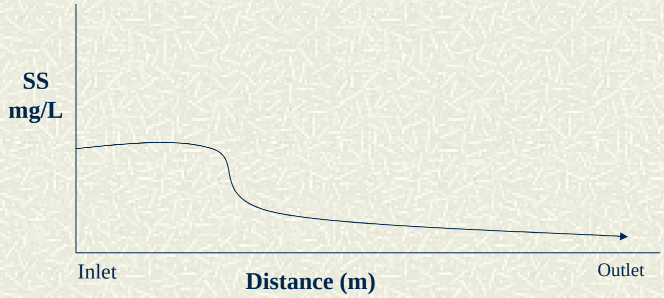


Removal of BOD/ COD

Microorganisms - adsorption



Removal of Suspended Solids



Removal of Heavy Metals

- Absorption
- Precipitation

Treatment Indicators

- BOD & COD
- Suspended solids
- Nitrogen, phosphorus & sulphur
- Hydrocarbons, heavy metals
- Pathogens

Reprinted from

resources, conservation and recycling

Resources, Conservation and Recycling 14 (1995) 47–52

The efficacy of gravel bed hydroponic system in the removal of DDT residues from sewage effluent

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Received 7 March 1991; revised 22 July 1994; accepted 3 January 1995

ELSEVIER

Table 1
Residues of DDT and its metabolites detected in sewage effluent and at the end of each channel and frequency of detection

Compound	Frequency	Main reservoir	Channel 1	2	3	4	5	6
p,p-DDT	32	2.64 ± 1.09	0.57 ± 0.164	0.57 ± 0.248	0.36 ± 0.192	0.29 ± 0.306	0.56 ± 0.213	0.40 ± 0.29
o,p-DDT	30	1.88 ± 0.99	0.44 ± 0.309	0.28 ± 0.272	0.75 ± 0.260	0.62 ± 0.472	0.41 ± 0.33	0.51 ± 0.21
p,p-DDD	21**	2.98 ± 1.22	0.11 ± 0.310	0.34 ± 0.401	0.174 ± 0.19	0.31 ± 0.35	0.168 ± 0.31	0.184 ± 0.27
p,p DDE	33	3.98 ± 1.103	3.13 ± 3.24	2.45 ± 3.7	0.63 ± 0.232	0.518 ± 0.20	0.59 ± 0.212	0.608 ± 0.12

Concentration/$\mu g\, l^{-1} \pm$ SD.
**Statistically different at $P < 0.5$.

Effect of Wetland on Biologically Treated Wastewater

	Input	Output	%Difference
Color (ADMI units)	35	35	0
pH	7.6	7.4	-
Total COD (mg/L)	53	38	-28
Soluble COD (mg/L)	38	35	-7
Copper (μg/L)	6.2	4.8	-22
Zinc (μg/L)	19.2	12.9	-33
Chloride (mg/L)	182	179	-2
Sulfate (mg/L)	1024	1004	-2
Sodium (mg/L)	615	589	-4

Mineralisation and pathogen removal in gravel bed hydroponic constructed wetlands for wastewater treatment

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The efficacy of an oxidation pond in mineralizing some industrial waste products with special reference to fluorene degradation - a case study

Authors: Tawfic Ahmed M.1; Dewedar A.; Mekki L.; Diab A.

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Application of GBH, A GEF Initiative in Some Egyptian Villages

- GBH technique is currently applied in a number of villages in some parts of Egypt. The initiative is fostered by Global Environmental Facility of the World Bank GEF

Main Environmental Problems
Nasseria Village, Menia Governorate
Egypt

Problem Description	Priority List
Grey water	1
Animal farm houses	2
Solid waste	3
Home ovens problems	4
Poultry houses	5

Villagers indicated that their most urgent problems is grey water. They cannot dispose it in their septic tanks because this would fill the tanks much too soon

Community Initiative
Nasseria Women NGO

Community Initiative
Behira Governorate

Raw Sewage Treatment
Anaerobic Digestion
People’s Own Initiative
Joint Initiative of Ministry of Water Resources

- Septic tank to collect raw sewage, sedimentation, liquid waste is allowed through a number of chambers
- Each chamber is furnished with gravel of plastics cups (matrix), to increase surface area.
- Chlorination process, using sodium hypochlorite
- No sludge problems
- Methane !!!!?????

Thank you!