How to efficiently manage food production systems under water and land constraints

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Extension Service

Sustainable use of treated wastewater (TWW) in agriculture

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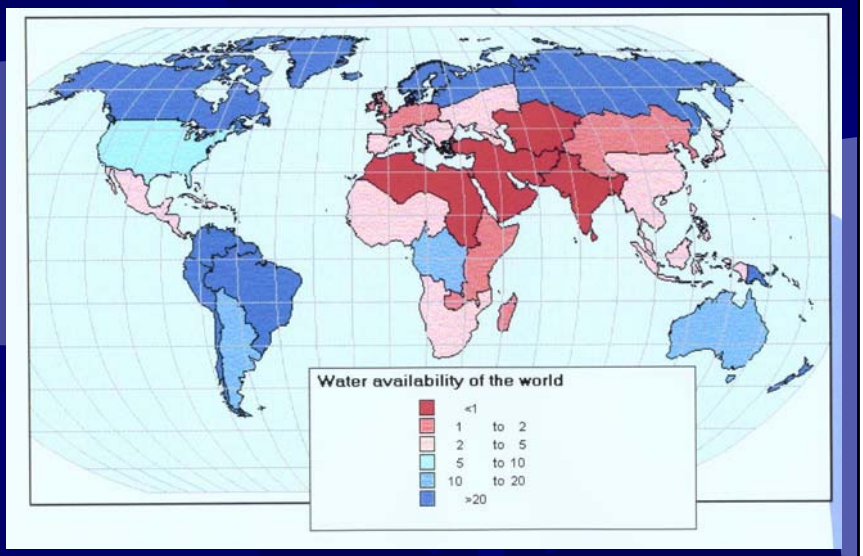
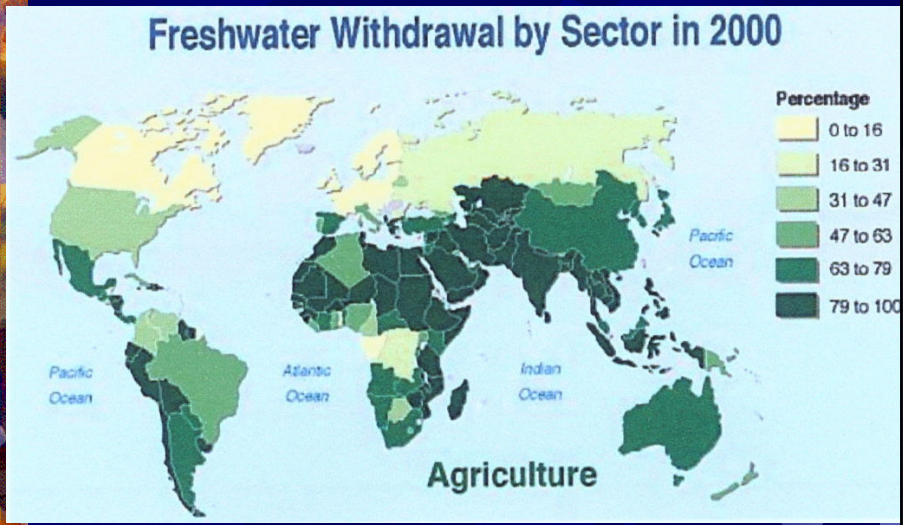
Water availability- 2005- Thousand of cubic meter per year per person



Freshwater Withdrawal in agriculture



Confrontation with water shortage

- Developing new groundwater or surface sources
- Developing new water carriage systems
- “New” water production: saline and sea water desalination
- Recycling water: Treated Wastewater (TWW) reuse

Recycling water

Treated Wastewater reuse in agriculture

Why there is a need for wastewater reuse

The Reasons for Purifying Wastewater

- Treated Wastewater (TWW) disposal through reuse prevents underground and surface water pollution

A win-win situation

- TWW contribute a significant amount of water for all purposes (mainly agricultural), especially in water scarcity conditions

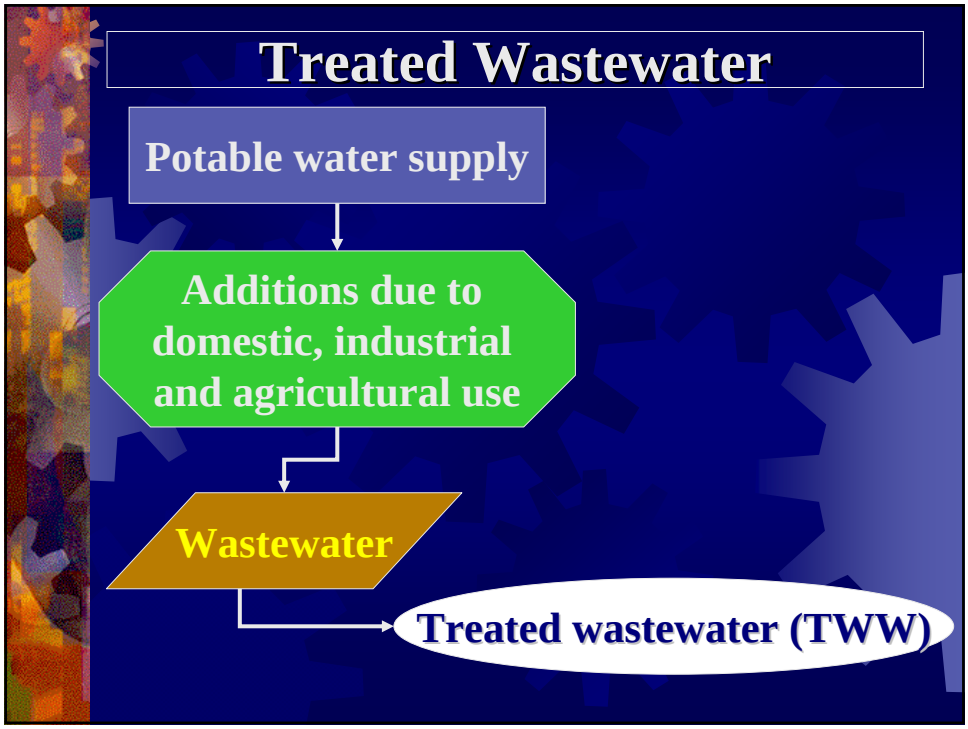
A feasible solution for all the sizes

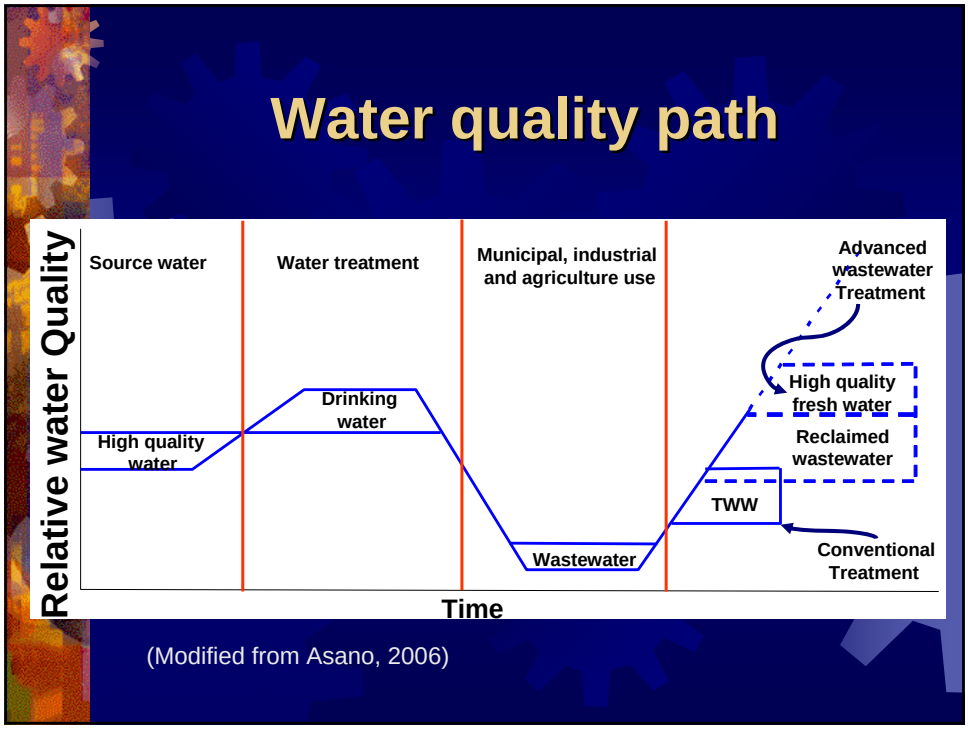
From big metropolitan areas…..

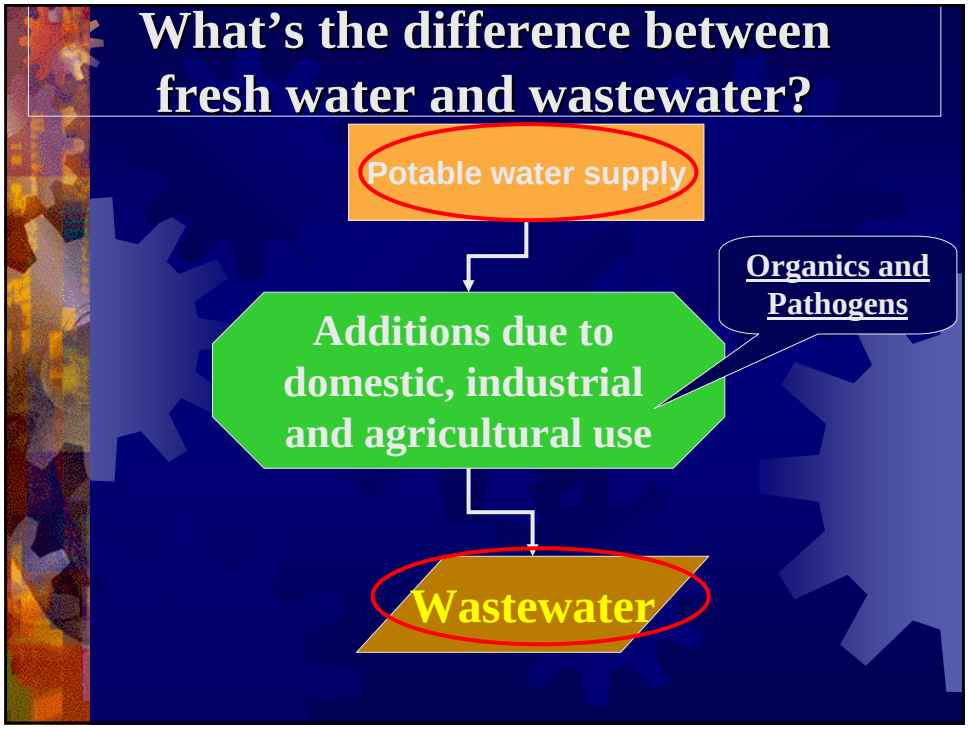
….to small villages

Main Aspects to Take Into Account

- **Health considerations: to the people who eat the agricultural product and for the farmers who come in contact with the water**
- **TWW chemical quality : nutrients content and salinity parameters (total salt content, sodium, chloride, boron, heavy metals and SAR) in order to prevent land degradation and damage to crops**
- **TWW storage and distribution (environmental considerations)**
- **The irrigation system selected , filtration, monitoring, clogging potential**


Treated Wastewater
Potable water supply
Additions due to domestic, industrial and agricultural use
Wastewater
Treated wastewater (TWW)


Water quality path
Relative water Quality
Source water
Water treatment
Municipal, industrial and agriculture use
Advanced wastewater Treatment
High quality fresh water
Reclaimed wastewater
TWW
Conventional Treatment
Drinking water
High quality water
Wastewater
Time
(Modified from Asano, 2006)

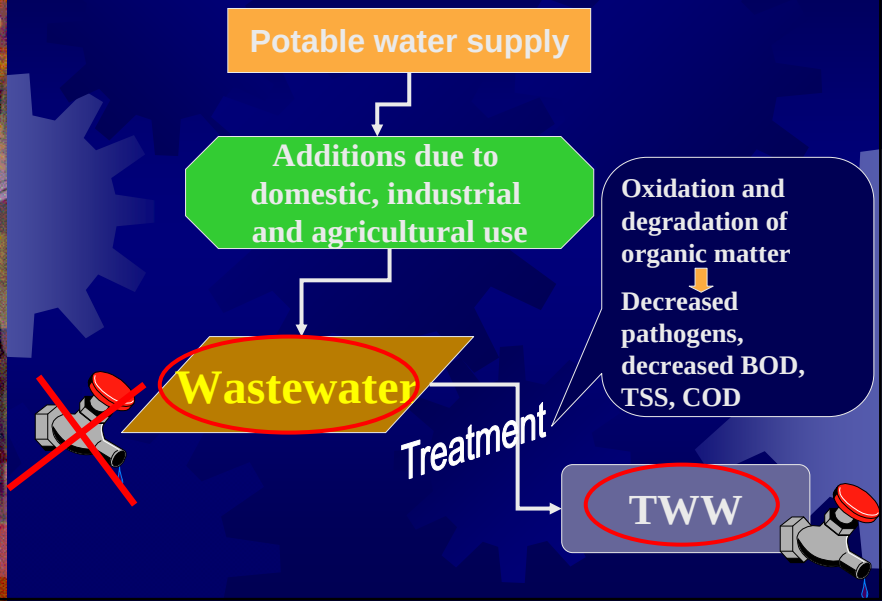


- A large variety of pathogenic microorganisms (bacteria, parasites and viruses) that may be present in raw domestic wastewater is derived principally from the feces of infected humans and primarily transmitted by consumption
- The main transmission route is referred to as the "fecal-oral" route

- **The primary means to ensuring reclaimed water can be used for beneficial purposes is:**

1. To provide the appropriate treatment to reduce or eliminate pathogens by removal or inactivation
2. To provide additional safeguards to reduce the level of contact with reclaimed water

How to improve the TWW quality Organic matter, Nutrients and Pathogens



Chloride Toxicity

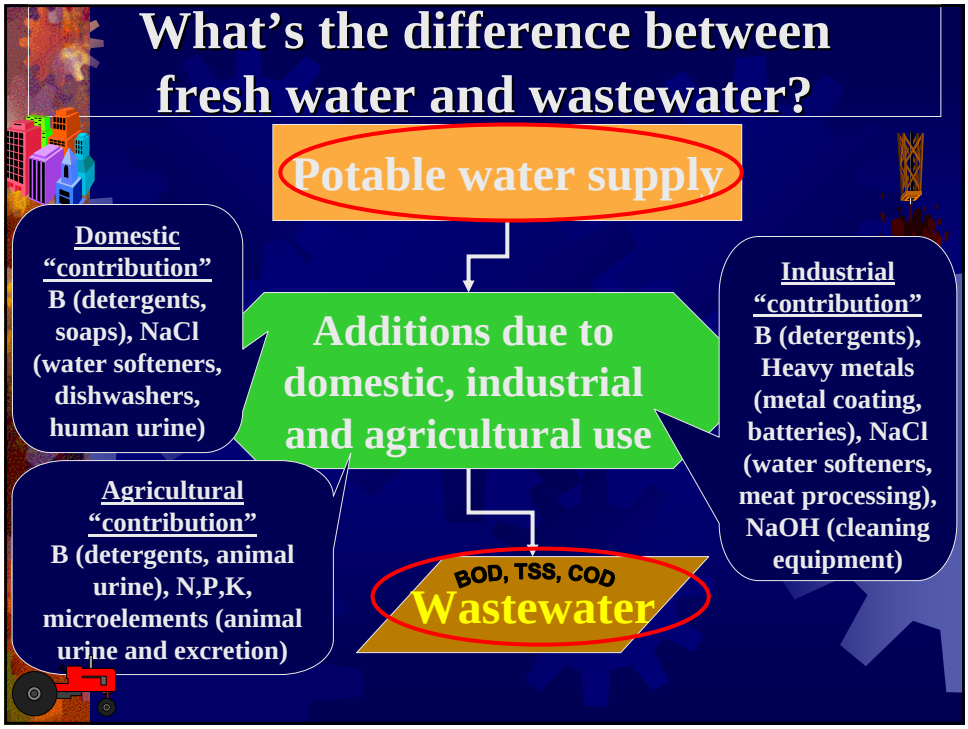
D, 4.9–5.9 percent

Boron toxicity

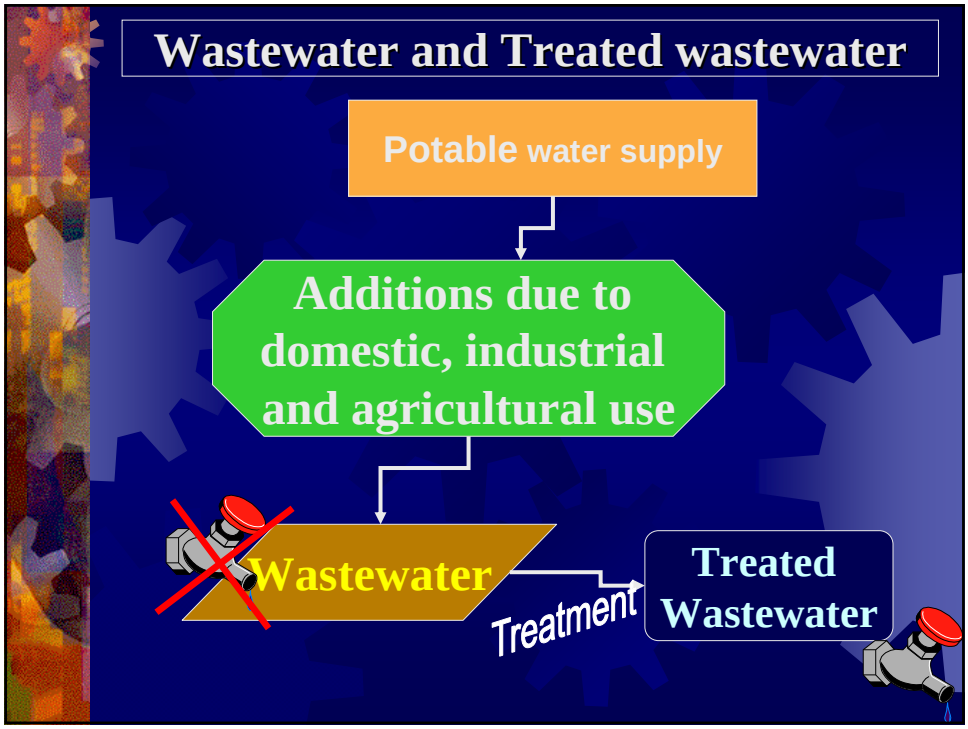
Toxicity symptoms

- Chlorotic or necrotic areas on tips or edges of mature leaves
- Defects in fruit (internal necrosis, rotten parts) and necrosis on bark


Treated Wastewater
Damage in Citrus by Boron and salinity
Aizenkot et al. – Mizra Experiment


What's the difference between fresh water and wastewater?
Potable water supply
Domestic "contribution" B (detergents, soaps), NaCl (water softeners, dishwashers, human urine)
Additions due to domestic, industrial and agricultural use
Industrial "contribution" B (detergents), Heavy metals (metal coating, batteries), NaCl (water softeners, meat processing), NaOH (cleaning equipment)
Agricultural "contribution" B (detergents, animal urine), N,P,K, microelements (animal urine and excretion)
BOD, TSS, COD
Wastewater

Wastewater and Treated wastewater



Sewage and Effluent composition as a function of treatment degree (mg L^{-1})

	Sewage	Primary	Secondary	Tertiary
BOD	100-350	70-220	10-40	1-3
N Total	20-85	20-50	10-40	1-5
$N\text{-}NO_3$	0-1.5	0-1.4	0-10	0
$N\text{-}NH_4$	10-50	12-40	1-40	1-5
P Total	4-36	6-25	7-14	0-1
Cl	+(40-300)	+(40-300)	+(40-300)	+(40-300)
Na	+(50-250)	+(50-250)	+(50-250)	+(50-250)
B	+(0.3-1.0)	+(0.3-1.0)	+(0.3-1.0)	+(0.3-1.0)
EC (dS/m)	+(0.5-1.0)	+(0.5-1.0)	+(0.5-1.0)	+(0.5-1.0)

How to improve the TWW quality Dissolved Salts and Heavy metals

Potable water supply

- Supplying higher quality water with lower salt content to municipal and industrial usage enable relatively lower salt content in TWW
- In Israel, the incorporation of desalinated sea water or saline water improved the TWW quality but the Boron concentration have to be taken in account

Reduction of Salts
Treatment at The Source
Detergents

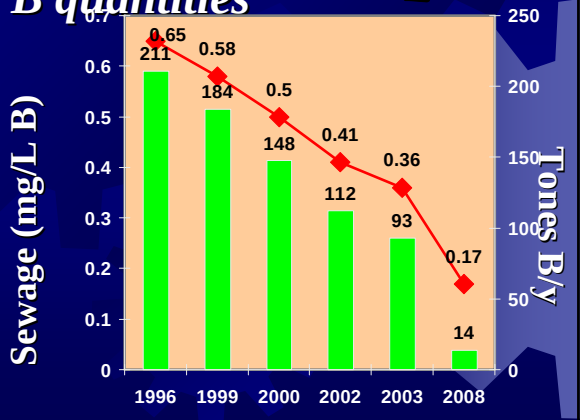
Contribution of Detergents to TWW

Sodium	**41%**
Chloride	**7%**
Boron	**80-90%**

Reduction of Salts
Treatment at The Source
Detergents

New Israeli Standard for Detergents (October 1999)

- *Reduction of B quantities*

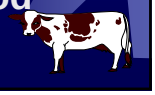


Encourage the use of "compact" & liquid detergents

Boron excretion in wastewater from cowsheds

Sample	Boron concentration (mg/kg)
Urine	3.02
Effluents – cowshed 1	0.96
Effluents – cowshed 2	4.69
Milk	6.51

- Humans and animals excrete 30-90% of all boron in food eaten
- Dairy cows excrete about 0.45 g of boron per day, about 57-71% of the boron from food



Regulations and Guidelines

Organics, Nutrients & Pathogens

Parameter	Units	Irrigation	Stream
BOD	ppm	10	10
TSS	ppm	10	10
COD	ppm	100	70
Fecal *coliforms*	MPN/100mL	10	200
Dissolved Oxygen	ppm	>0.5	>3
Residual Chlorine	ppm	1	0.01
Total Oil	ppm		1.0
pH		6.5-8.5	7.0-8.5
Total Nitrogen	ppm	25	10
Ammonia	ppm	20	1.5
Total phosphorus	ppm	5	0.2

Treatment at the Waste Water Treatment Plant

Salts

Parameter	Units	Irrigation	Stream
Electrical Conductivity	dS/m	1.4	
SAR	$(mmol/L)^{0.5}$	5	
Chloride	ppm	250	400
Sodium	ppm	150	200
Boron	ppm	0.4	
Fluoride	Ppm	2	

Treatment at the Source
Can't be treated at the WWTP

Heavy Metals

Parameter	*Units*	Irrigation	Stream
Arsenic	*ppm*	0.1	0.1
Barium	*ppm*		50
Mercury	*ppm*	0.002	0.0005
Chromium	*ppm*	0.1	0.05
Nickel	*ppm*	0.2	0.05
Selenium	*ppm*	0.02	
Lead	*ppm*	0.1	0.008
Cadmium	*ppm*	0.01	0.005
Zinc	*ppm*	2	0.2
Iron	*ppm*	2	

Treatment at the Source
Can't be treated at the WWTP

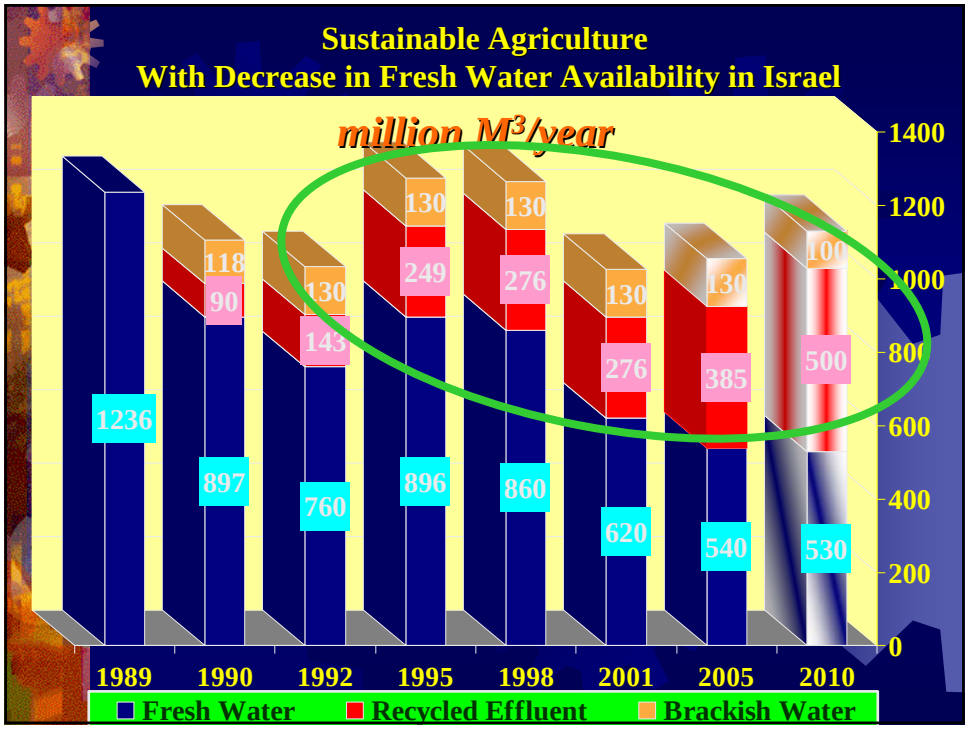
Research and Development

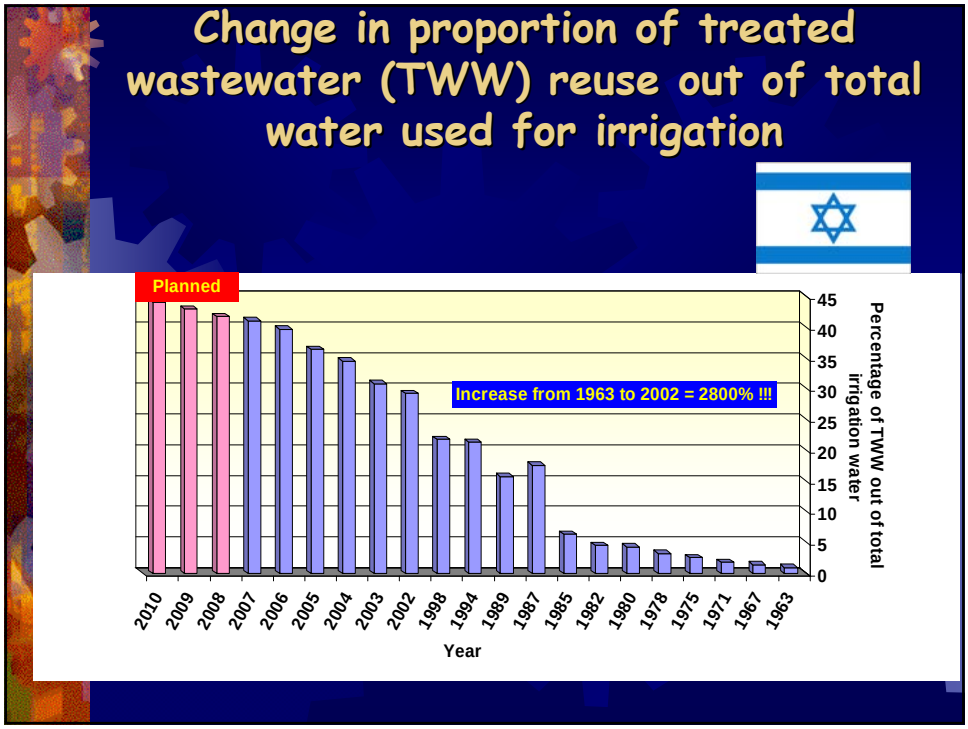
Research and Development

Enhancement of Research and Development on wastewater treatment and reuse – High priority :

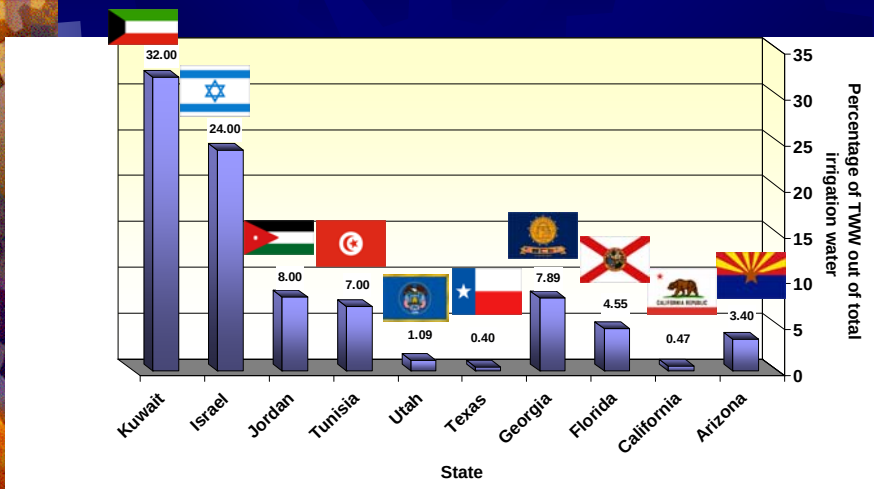
- A special budget was budgeted by the Ministry of Agriculture Chief Scientist;
- Wastewater influence on soil structure, water movement and hydrophobic conditions;
- The reactions and movement of phosphorus in soils (Total phosphorus in wastewater);
- Adsorption, desorption of Boron in soils

Agricultural Reuse

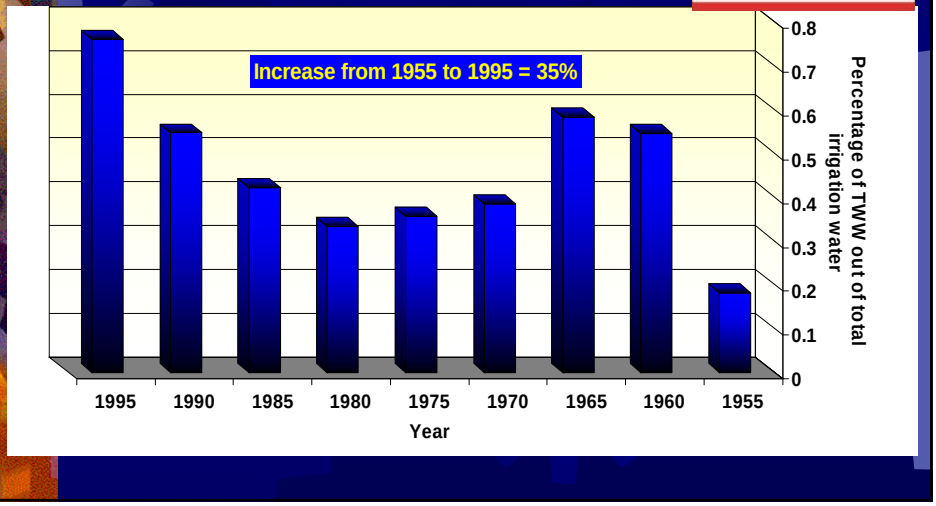

Sustainable Agriculture
With Decrease in Fresh Water Availability in Israel
million M3/year
1400
1200
1000
800
600
400
200
0
1236
118
90
897
130
143
760
130
249
896
130
276
860
130
276
620
130
385
540
100
500
530
1989
1990
1992
1995
1998
2001
2005
2010
Fresh Water
Recycled Effluent
Brackish Water


Change in proportion of treated wastewater (TWW) reuse out of total water used for irrigation
Planned
Increase from 1963 to 2002 = 2800% !!!
45
40
35
30
25
20
15
10
5
0
Percentage of TWW out of total irrigation water
2010
2009
2008
2007
2006
2005
2004
2003
2002
1998
1994
1989
1987
1985
1982
1980
1978
1975
1971
1967
1963
Year

Reuse of Treated Wastewater reuse out of total water used for irrigation

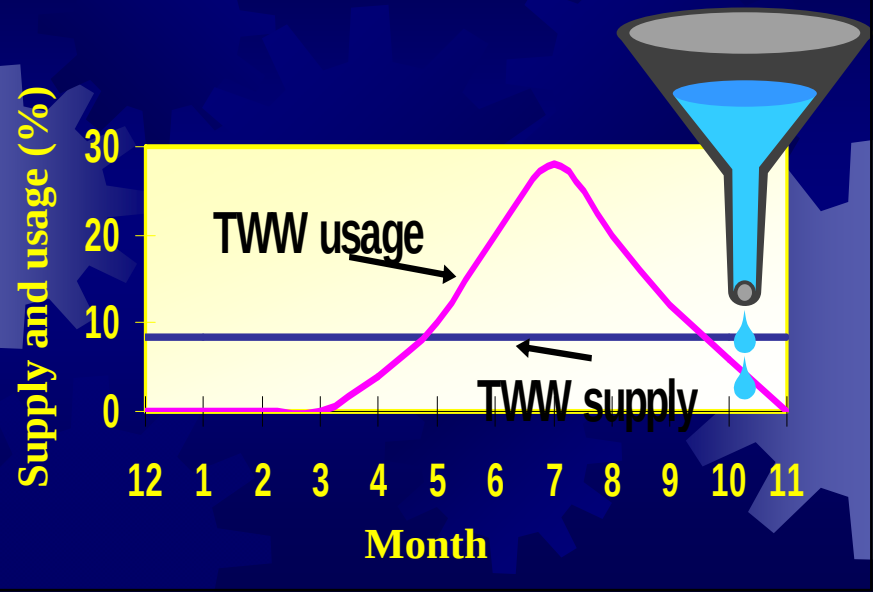


Change in proportion of Treated Wastewater reuse out of total water used for irrigation



TWW reclamation in Agriculture

Supply and Usage of TWW



Nutritional value of N,P,K in TWW

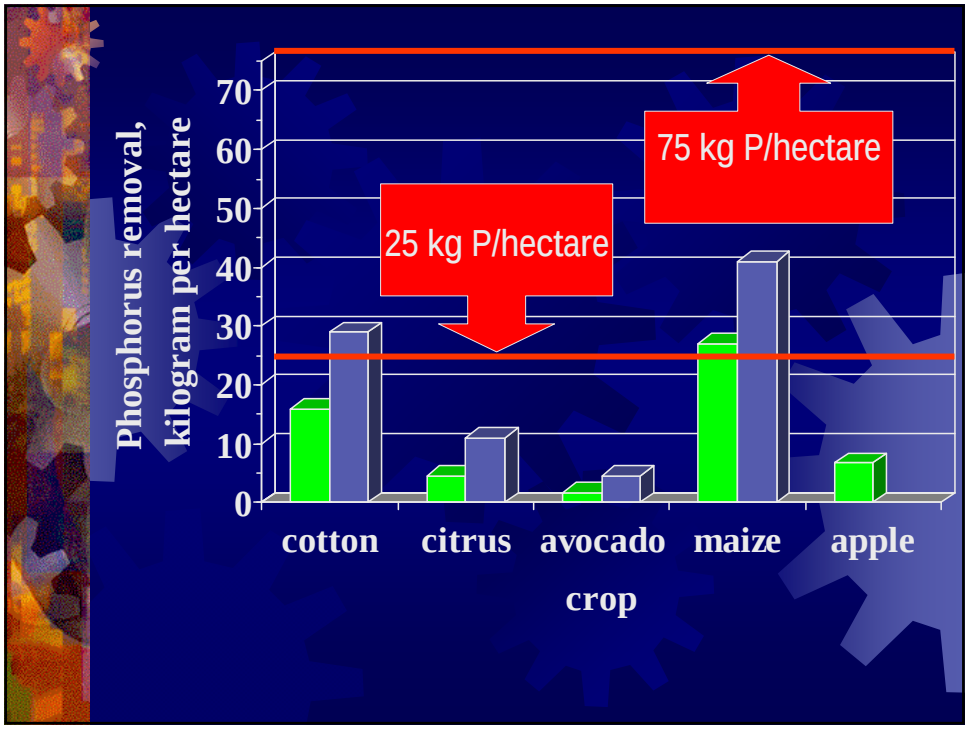
Nutritional Value of TWW

- Amount
- Timing
- Availability

AMOUNTS OF AVAILABLE NUTRIENTS IN EFFLUENTS (Kg/Ha)
(domestic sewage, secondary treatment)

Irrigation Application (mm)	N	P_2O_5	K_2O
300	132	72	72
500	220	120	120
700	310	170	170

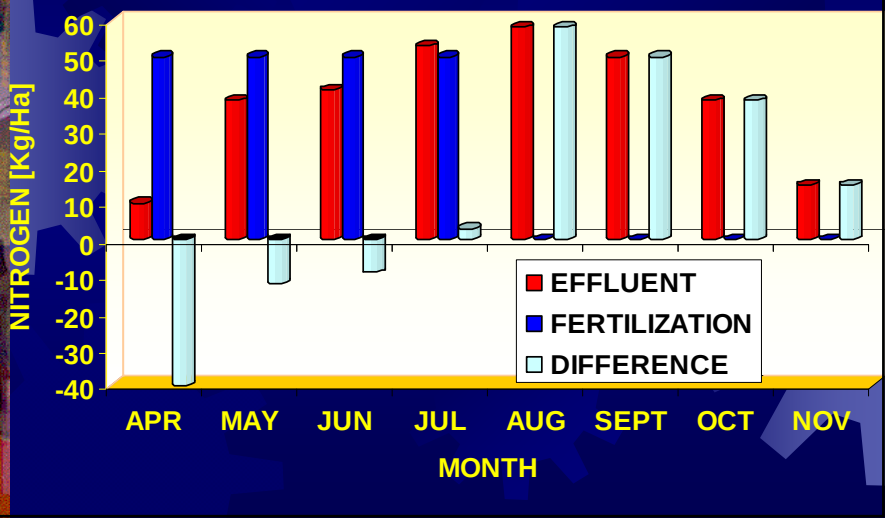
(N= 50 ppm; P= 11 ppm; K= 20 ppm)



TIMING
ADAPTATION TO NUTRIENT CROP REQUIREMENT

- CONSTANT CONCENTRATION
- THE QUANTITY DURING A PERIOD IS A RESULT OF WATER APPLICATION
- QUANTITY = CONCENTRATION x WATER APPLICATION
- EXCESS AND SHORTAGE PERIODS

NUTRITIONAL VALUE OF EFFLUENTS
Timing



Effect of TWW on corn fields

Main findings – Nutritional value of N,P,K

- N,P,K in effluent should be taken into account, according to their availability, and be part of the fertilization/fertigation program.
- Timing and concentration can not be controlled (newly built plants can change N and P concentrations).

Wastewater treatment Plant

Intensive Treatment

Extensive Treatment

Irrigation Systems

Irrigation Systems – Familiar system

Take a Home Message

- Water scarcity is one of the main limiting factors in agriculture
- Proper irrigation is crucial to the world's food production.
- TWW reclamation is a way to provide a renewable water source, "new water", which has different characteristics than potable water, such as plant nutrients, organics compounds and others that can change fertilizer use by providing an important source of production growth.

Take a Home Message

- TWW reclamation systems could be a solution for big metropolitan areas with intensive wastewater treatment plants, and big farms with advanced irrigation systems, as well as for family farms with extensive wastewater treatment plants and simple irrigation systems.
- Investment in TWW reclamation in agriculture means investment in health, sanitation and environment, obtaining a "new" water source and resulting in a win-win situation.

Take a Home Message

- However, since we deal here with a “new” water source, in order to use it successfully and in a sustainable manner, the circle of investment in research, technology, capacity building, extension and monitoring is needed.