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Reuse of Treated Effluent in Cyprus

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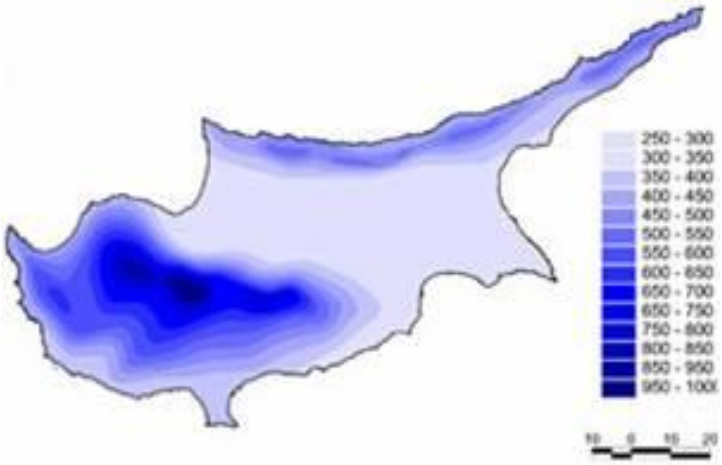
Cyprus at a Glance

- Area: 9250 km²
- Population: 850,000 (under Government control)
- **Semi arid climate**
- **Numerous small catchments**
  - No perennial flow
- **Limited water resources**
  - Depend mainly on rainfall
  - Scarce & expensive to exploit
- **Unevenly distributed rainfall**
  - Temporally and geographically
- **Frequent and prolonged droughts**
- Water Stress Index = 65%
  (abstraction/availability ratio)

Annual Rainfall Distribution (mm)

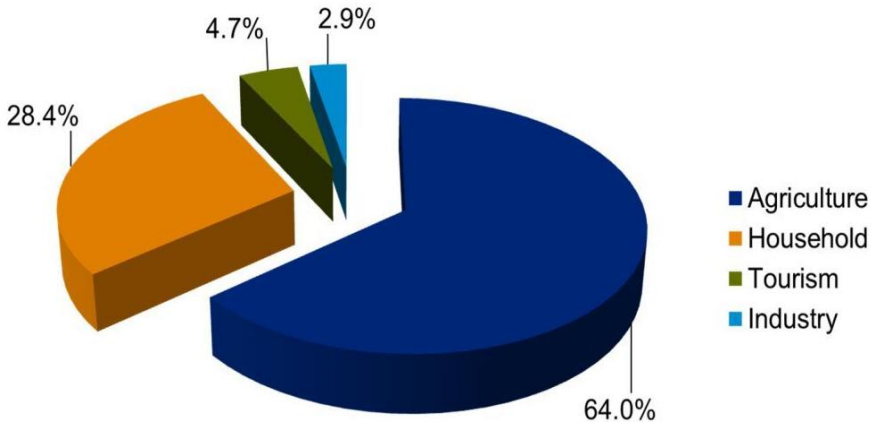


Declining Rainfall in Cyprus

Statistical analysis reveals a stepped drop of 15% in precipitation since the early 70's, resulted in a drop of 40% in river runoff

Use of Water in Cyprus

- Domestic sector
  - Increasing demand for water (population, tourism, lifestyle)
- Agricultural sector
  - the largest water user
- Priority is given to the domestic sector
- Irrigation water restrictions to agriculture could reach up to 70% in periods of droughts
- Climate change is expected to impact adversely fresh water availability



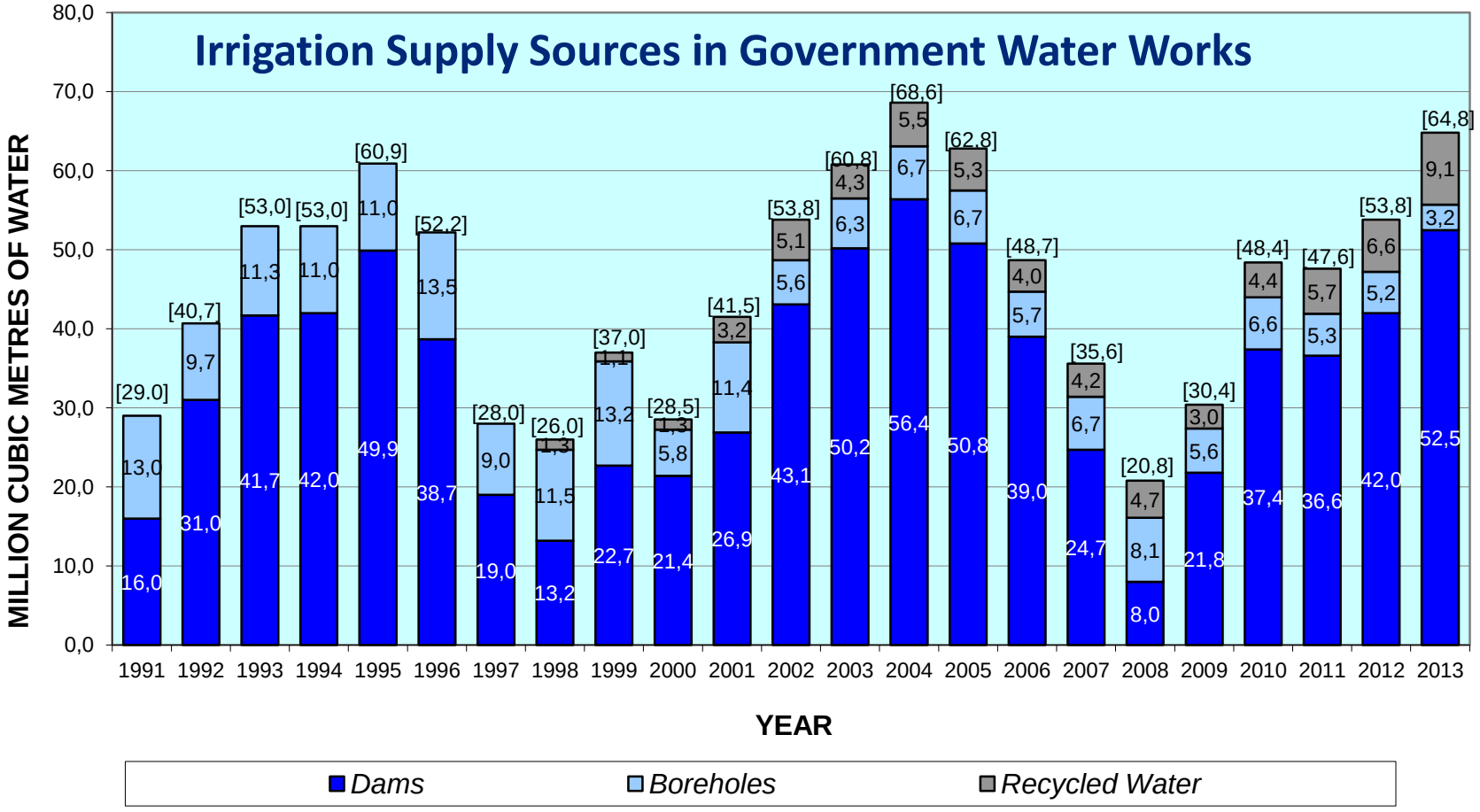
Augmentation with alternative sources is an absolute necessity:

- **Desalination for domestic use**
- **Effluent reuse for irrigation and other uses**

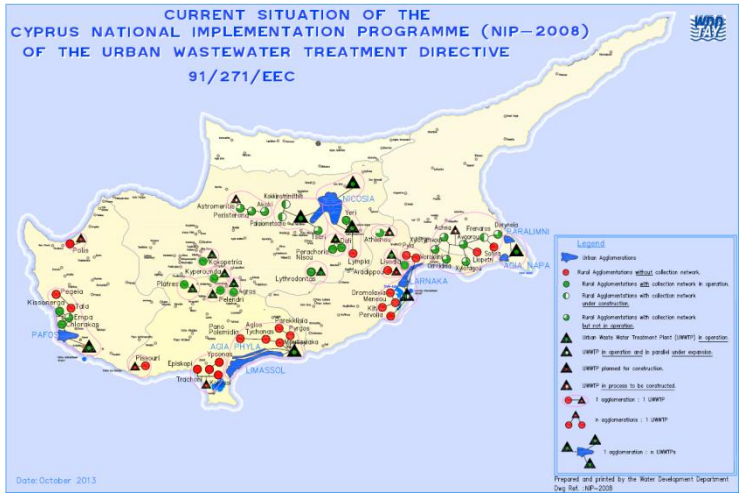
Need for Water Reuse

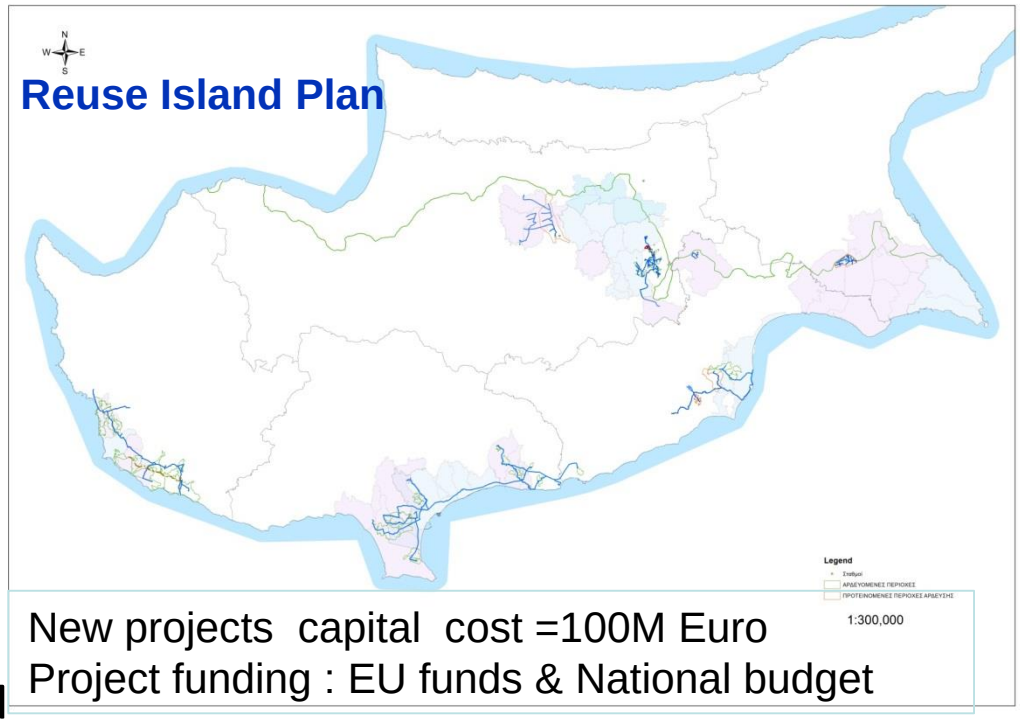
UWWTD 91/271/EEC Article 12: Treated wastewater shall be reused whenever appropriate

Treated effluent is a growing resource in Cyprus



Effluent Reuse Perspective





Total irrigation needs = 160 MCM

Today effluent Vprodused = 28MCM

Vreused = 18 MCM

Effluent reuse satisfies 11 % of the irrigation needs

New projects capital cost =100M Euro

Project funding : EU funds & National budget

In 2023 following implementation of the island reuse plan effluent reuse will satisfy 25% of the irrigation needs

The objective is the replacement of fresh water used in agriculture by treated effluent up to 40 %

Benefits of Treated Effluent Reuse

A reliable source of water which enhances the water balance

Domestic Sector - Cities

- Freshwater can be reserved to satisfy the increasing demand for potable water

Agricultural Sector- Farmers

- Constant source of water
- Savings in fertilizers
- Increase crop yield
- Maintain traditional agriculture

Environment

- Reduce discharge to WBs
- Reduce abstraction
- Groundwater replenishment
- Control saltwater intrusion

- Need for fewer desalination plants
- Lower carbon footprint
- Less dependence on oil prices

Keep water prices at reasonable levels

Risks of Treated Effluent Reuse

- Health risk from associated pathogens
- Health risk from other contaminants (e.g. metals, chemicals, pharmaceuticals)
- Decrease in soil quality from accumulation of metals and acidification
- Infiltration of groundwater

Cyprus Minimizes these Risks through:

- **Strict Regulation**
- **Advanced Treatment**
- **Mandatory Code of Practice**
- **Quality Control**
- **Research**

Legislative Framework in Cyprus

In Cyprus the use of the discharge of effluent from urban wastewater treatment plants is regulated by:

- The Environmental Impact Assessment **Law** (No. 140(I)/2005)
- The Water Pollution Control **Laws** (106(I)/2002 to 2009)
- *The Water* Pollution *Control (Discharge of Urban Waste water)* ***Regulations*** *of 2003* (No. 772/2003)
- *The Water* Pollution *Control (Sensitive Areas for Disposal of Urban Waste Water) Ministerial* ***Decree*** *of 2004 (*No. 111/2004)
- *The* Code of Good Agricultural Practice **Decree** (No. 263/2007)
- *The Ministerial* **Decree** *of small-scale wastewater treatment plants < 2000 p.e*. (No. 269/2005)

Advanced Treatment

- According to the Law, sewage treatment is of **Tertiary Degree**, which is higher than the requirements of Directive 91/271/EEC.
  - **Tertiary Treatment** consists of:
    - **Activated Sludge with Sand Filtration and Chlorination**
    - ***Membrane Bioreactor with UV Disinfection (2 Urban WWTPs)***
- Tertiary treatment is **mandatory** irrespective of its use in irrigation, recharge of aquifers or disposal to the sea, in order to:
  - **Eliminate the possibility of any health incident** including pathogens in the treated water
  - **Reduce the risk of possible eutrophication** when discharging to the eastern Mediterranean Sea, the most oligotrophic sea in the world
  - **Reduce farmers skepticism and barriers to reusing**
  - **Encourage public acceptance – enhance marketability of crops**

Code of Good Agricultural Practice

Mandatory Guidelines to make the use of treated effluent safe for irrigation

Main provisions include:

- ***Restriction on the type of crops irrigated***
  - **Irrigation of all crops is allowed <u>Except *for Leafy Vegetables, Bulbs and Condyles that are eaten raw*</u>** (e.g. lettuce, carrot, celery, parsley)

- ***Safety precautions for the proper use of water*** (The use is prohibited by unauthorized persons, Marking pipes with red line, Clear signaling to alert the public that the water is undrinkable, Hydrants and distribution systems should have protection, etc)

- ***Irrigation practices*** *according to the methods of irrigation (subsurface /drip / sprinklers) and to the kind of crops*
- Main uses (in order of "preference")
  - Forest trees
  - Fodder crops
  - Fruit- tree Orchards
  - Green areas
  - Vegetables

Quality Control of the Treated Effluent

Quality Control is specified in the Law

- **Quality Control for Urban and Rural Agglomerations above 2.000p.e.:**
  Sampling and analysis are being executed by:

  - **Urban Sewerage Boards**
  - **Water Development Department**
    (is *responsible of the disposal of the Treated effluent produced by the Urban Sewerage Boards (government policy)*

) Following the quality of
) treated effluent according
) *to the requirements of their*
) *Discharge Permits (L.106(I)/102)*

  - **Department of Environment**
    (is responsible of issuing the Discharge Permit)

) Following up whether every
) Plant meets the requirements
) of their Discharge Permits

- **Quality Control for Rural Agglomerations less than 2.000p.e.:**
  Sampling and analysis are being executed by Water Development Department

Quality Characteristics and Frequency of Controls of the Treated Effluent for Urban Agglomerations- according to Discharge Permit

A/A	PARAMETERS	MAXIMUM PERMITTED VALUE	FREQUENCY OF ANALYSIS – BY WDD	FREQUENCY OF ANALYSIS – BY USB
1	BOD_5	10 mg/l	4/year	1/15 days
2	COD	70 mg/l	4/year	1/15 days
3	Suspended Solids (SS)	10 mg/l	4/year	1/15 days
4	Conductivity	2500 μS/cm	4/year	1/15 days
5	Total Nitrogen (TN)	15 mg/l	4/year	1/15 days
6	Total Phosphorous (TP)	10 mg/l	4/year	1/15 days
7	Chlorides (Cl)	300 mg/l	4/year	1/month
8	Fat and Oil	5 mg/l	4/year	1/month
9	Zinc (Zn)	1 mg/l	2/year	2/year
10	Copper (Cu)	0,1 mg/l	2/year	2/year
11	Lead (Pb)	0,15 mg/l	2/year	2/year
12	Cadmium (Cd)	0,01 mg/l	2/year	2/year
13	Mercury (Hg)	0,005 mg/l	2/year	2/year
14	Chromium (Cr)	0,1 mg/l	2/year	2/year
15	Nickel (Ni)	0,2 mg/l	2/year	2/year
16	Boron (B)	1mg/l	2/year	2/year
17	E. Coli	5 E.Coli / 100ml	4/year	1/15 days
18	Eggs of Intestinal Worms	Nothing	4/year	4/year
19	Residual Chlorine	1 mg/l	4/year	1/15 days
20	pH	6.5-8,5	4/year	1/15 days
21	Toxicity		1/year	1/year

Quality Specifications of the Treated Effluent for Rural Agglomerations < 2000 p.e.- Regulation KDP 269/2005

	Species Allowed to be Irrigated	BOD_5 (mg/l)	Suspended Solids (mg/l)	E. Coli /100ml	Intestinal Worms***
1	All Crops and Green Areas with Restricted Use (a)	10* 15**	10*	5* 15**	NIL
2	Green Areas and Cooked Vegetables (b)	10* 15**	10* 15**	50* 100**	NIL
3	Green Areas with Restricted use by the Public	20* 30**	30* 45**	200* 1000*	NIL
4	Fodder Crops	20* 30**	30* 45**	1000* 5000**	NIL
5	*Industrial crops*	50* 70**	-	3000* 10000**	-

* 80% of the samples, 24 samples/year

** Max acceptable value

*** sampling frequency once a year/summer months

(a) No vegetables with leaves, bulbs and condyles eaten raw

(b) Potatoes, Beetroots

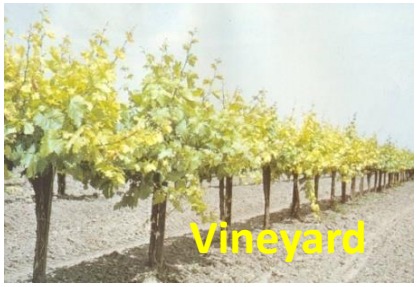
Pricing System for Irrigation Water in Cyprus

Provides for economic incentives that make treated effluent more competitive

		Water Selling Rate	
A/A	Use	**Tertiary Treated Effluent**	**Fresh not filtered water from government water works**
		EURO Cent/m^3	EURO Cent/m^3
1	For Irrigation divisions for agricultural production	**5**	**15**
2	For Persons for agricultural production	**7**	**17**
3	For sports	15	34
4	For irrigation of hotels green areas and gardens	15	34
5	For pumping from an aquifer recharged by the treated effluent	8	-
6	For **over consumption** for the items 1 to 5	**Increase by 50%**	**56**

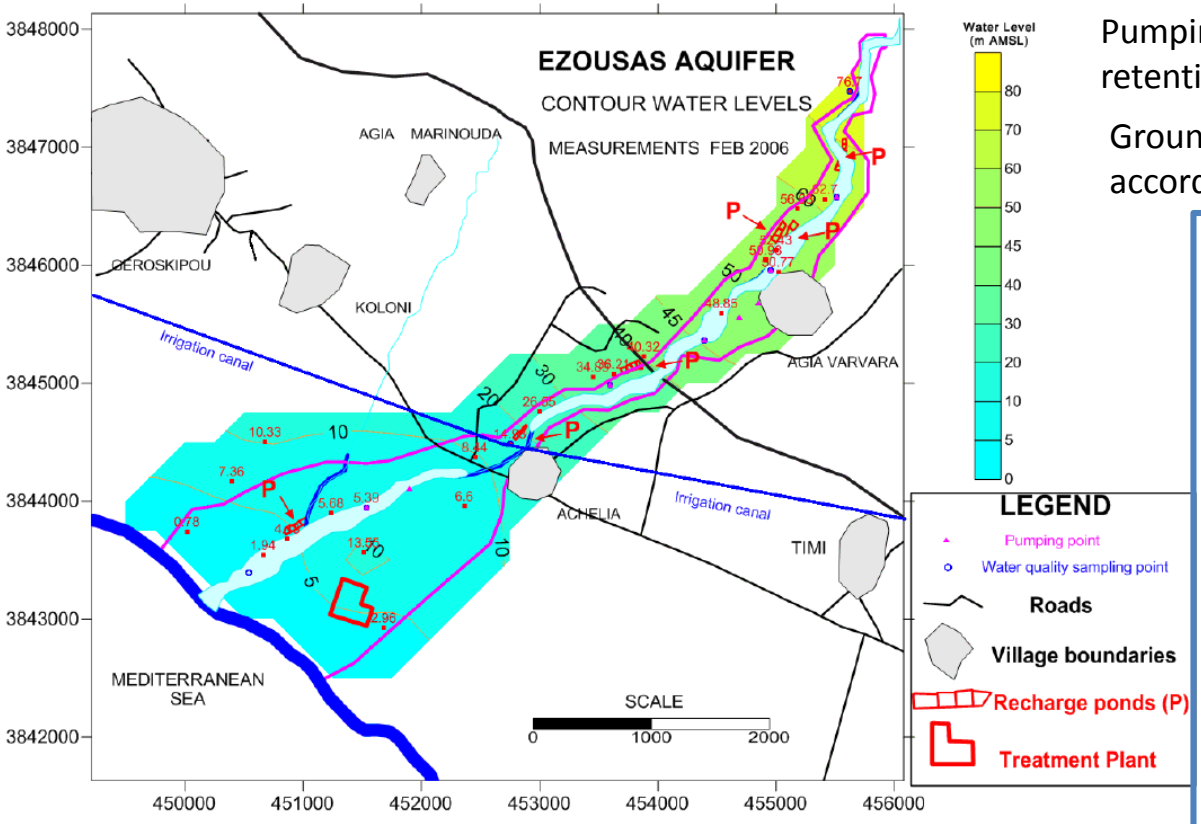
Agricultural Irrigation with Recycled Water

- To date, recycled water **satisfies the needs of 5.000 ha** in total, through existing and new irrigation networks
- **The government policy is to bear the cost of tertiary treatment and the cost of infrastructure** to take reclaimed water to agricultural areas
  - Infrastructure includes pipelines, pumping and storage ponds (for winter) (high cost)
- The farmers bear the cost of transferring water from the distribution pipeline up to their farm outlet in the case of new irrigation networks
- **Main crops irrigated** :
  - Citrus trees,
  - Olive trees,
  - Vineyards,
  - Fodder (e.g. Corn, Alfalfa),
  - Vegetables (e.g. spinach, potatoes, tomatoes, watermelons),
  - Flowers (e.g. carnations)



Artificial Recharge of the Ezousa River Alluvial Aquifer

Disinfected tertiary treated water, is being used for **artificially recharging an aquifer** with low quality water (natural high sulphate and boron concentrations), since 2004. This **water after natural purification is pumped again from the aquifer for irrigation**. (Combine effluent with natural resources)



The water level in each pond reaches up to 0.5 m from where it slowly seeps into the ground. Pumping is carried out strategically so that retention time in the aquifer is maximized.

Groundwater quality is monitored regularly in accordance with the Discharge Permit

BENEFITS

- ✓ Seawater intrusion is being controlled
- ✓ Provides storage of effluent water for subsequent retrieval and reuse
- ✓ The aquifer serves as an eventual natural distribution system
- ✓ Further purification of effluent water is made (reduce biological load)
- ✓ Saving of equal quantities of fresh water for domestic use.

Overcoming Psychological Barriers

A lot of reaction and skepticism from farmers at the early days of implementing water reuse projects in Cyprus, due to ignorance, misconceptions and psychological fear

Acceptance issues were addressed through:

- Information / consultation campaigns
- Education of the farmers in small groups
- Regulating effluent reuse through the Code
- Making recycled water much cheaper than freshwater
- **Demonstrating benefits in practice**:
  - A **Pilot irrigation** area of 30 ha close to Limassol WWTP was initiated to demonstrate that recycled water enhances agricultural productivity and is safe to use by the farmers
  - **Sorghum, alfalfa and corn** were used as verified crops irrigated with effluent water for a period of 2 years
  - Agricultural Research Institute was responsible for the collection and analysis of all data and verification of the results
  - **Results: Crop yield increased by 30% on average**

Quality characteristics of treated effluent

BOD_5	mg/l	5,0
COD	mg/l	35,0
S.S	mg/l	0,0
NH_4^+-N	mg/l	0,7
NO_3^-N	mg/l	4,0
Total N	mg/l	6,0
PO_4^{3-}P	mg/l	3,0
Total P	mg/l	5,0
Cl	mg/l	232,0
HSO_4	mg/l	traces
CO_3	mg/l	-
HCO_3	mg/l	576,0
Na	mg/l	165,0
Ca	mg/l	96,0
Mg	mg/l	43,0
K	mg/l	22,0
B	mg/l	0,2
EC	dS/m	1,5
PH		7,7

Nowadays, there is a steady upward trend in overall water reuse in Cyprus

Further Research

- Research is on going by the Agricultural Research Institute of Cyprus and the University of Cyprus
- Research results, concerning the long-term wastewater irrigation of **forage and citrus** revealed that there are **no impacts** of wastewater reuse **on** both **soil physicochemical properties** and **heavy metal** content, as well as on agricultural produce heavy metal content
- Research concerning wastewater irrigation of **tomato crops** highlighted that there is **no accumulation of heavy metals** in tomato fruit, whereas examination of the presence of **various pathogens** related to public health revealed that **total coliform** and **fecal coliforms** were **not quantified** in both fruit flesh and fruit peel, while ***E. coli*, *Salmonella spp*** **and** ***Listeria spp*****. were not detected** in fruit homogenates
- An on going research concerning **pharmaceutical compounds**, made by the University of Cyprus, detected **traces** in treated effluent and has been shown that PHACs **may be up taken** and bio accumulated in tomato fruits under field conditions
- **Next step is further research under field conditions**

Tomato plants were drip irrigated in accordance with the Code of Good Agricultural Practice

Concluding Remarks

- Tertiary treated water has **great potential for agriculture** especially in water scarce countries like Cyprus – think of it as **a resource** and **not a waste**

- It has proven to be an **effective** way for water **conservation** and for increasing **availability** in periods of droughts

- **Public perception** and willingness to accept its use in agriculture is a critical success factor – build public confidence and trust in transparency

- More **funding and research** is needed to further investigate possible emerging issues for public health and understand exposure risks

- Effluent **reuse if exercised properly** (regulations, advanced treatment, controls, safety measures, consultation) **is a safe and reliable source of water**

Thank you for your attention

http://www.moa.gov.cy/moa/wdd

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