Wastewater Treatment and Reuse: Creating Resources for Agriculture and Addressing Water Scarcity.

DUPC2 Webinar

8/6/2023.

Non-Conventional water treatment and reuse

NARC- Experience

Dr. Luna Al-Hadidi

Water Facts

- Jordan is characterized as a water-scarce country where the per-capita share from renewable water resources is less than 100 (m^3/capita)/year.

- The *Third National Jordanian Communication* report on climate change has estimated a significant decrease in precipitation of 1.2 mm/year and an increase in the mean air temperature by 0.02°C/year, which will be adversely reflected on the water resources potential.

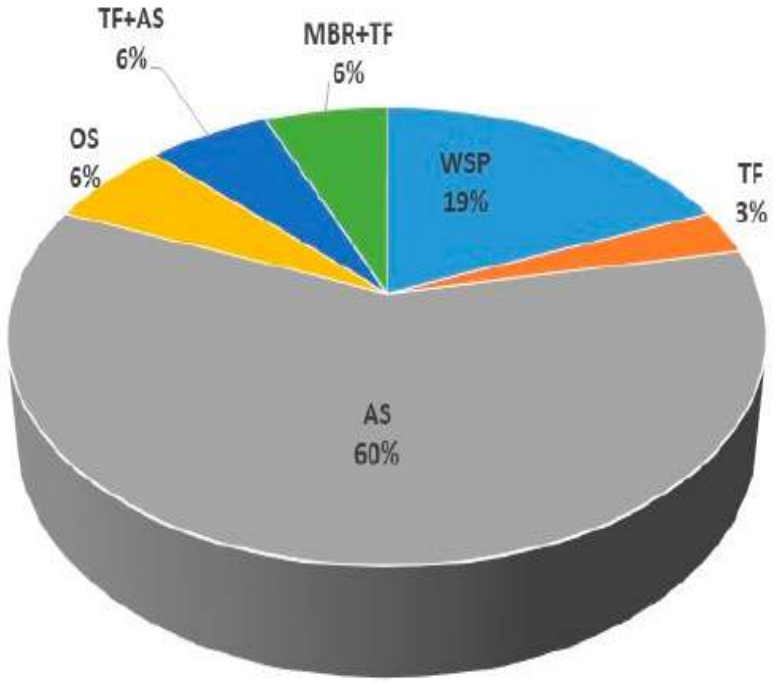
- To bridge the gap between water resources, supply potential and the demand, Jordan utilizes non-conventional water resources, such as wastewater reuse in irrigation.

- 91% of the treated wastewater has been reused either directly or indirectly, mainly for irrigation. In 2018 the amount was around 150 MCM.

- Jordan operates 33 central WWTPs which are expected to treat 240 (MCM/year) by 2025.

- The most widely used technologies are the activated sludge (AS) process with a share of 60%. Followed by the wastewater stabilization pond (WSP) process with a share of 19%.

- While the trickling filter (TF) and AS process, Membrane Bioreactor (MBR) and TF process, and oxidation sludge (OS) process were evenly having the same use share of 6%, respectively. The TF process was the least used technology with a share of 3%.



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PROSIM

Wastewater treatment and reuse projects

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Reuse of Treated Wastewater for Irrigation
Crop and Soil Responses

- Different Forage Crops
- Different Filtration Systems
- Different Treated Wastewater Quality

Abu-Nsair-Treatment Plant

1999-2001

Treatment and Reuse of Reclaimed Wastewater in Agriculture: NARC experience

- Construction of experimental sites to improve the quality and the reuse of reclaimed wastewater in Jordan: Activity - Reuse of Reclaimed Wastewater in the Production of Cut Flowers- Ramtha- Rose and Carnation. Based on the achievements of this project, NARC was succeeded in introducing the cut flower into the Jordanian standards in 2006.

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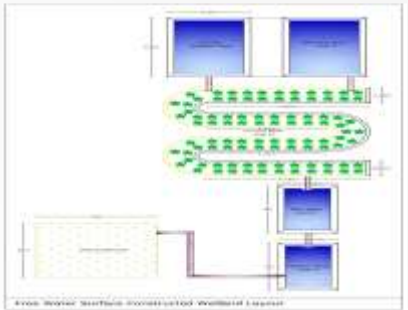
- Treatment and reuse of Reclaimed Wastewater Using surface and subsurface constructed wetlands –MERC-USAID grant.

- Advanced Wastewater Treatment Technology and Reuse- MERC-USAID Grant-Cut flowers, Forages, Medicinal plants.

- Prospective use of the salt tolerant wild rape native to Jordan in biodiesel production – Scientific Research Fund.

- Reuse of reclaimed wastewater for the production of industrial crops: **Soya bean, Sunflower and Olive.**





PROSIM

- Treatment and reuse of wastewater in agricultural production program: Cut flowers (*Gladiolus, Lilium,* and *Matthiola),* Forages (Sudan grass, Maize, Barely and Oat)-MERC-USAID grant.

- Upgrading treatment processes to improve effluent quality for irrigation-Using Membranes (cooked vegetables, Tomato, Potato and Eggplant)-MENA-USAID grant.




Cut flowers: Rose, Carnation, *Gladiolus, Lilium, Matthiola and others* Since 2001

Forages: Sudan grass, Corn, Barley, Berseem, Oat, and other salt tolerant species. Since 1998

Industrial and Biofuel crops: Soya bean, Sunflower, Olive, Rapeseed.

Host researchers , University students from Jordan and other countries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Wastewater treatment using membrane technology
Phase 1

Objective:

Improving the quality of secondary effluent by advanced membrane technologies, ultra-filtration and reverse osmosis.

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Reuse of treated wastewater in irrigation of cooked vegetables
Phase 2

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Adaptation to climate change through improved water demand management in irrigated agriculture by introduction of new technologies and best agricultural practices.

Location	# of farmers	Area per farm (ha)	Total area (ha)
Ramtha	10	1	10
Salt	18	1	12
Madaba	10	1	10
Total area covered by ACCBAT project is 32 ha			

List of Beneficiaries and Surface covered by ACCBAT project:

Implementation of activities:

ACCBAT

Salt site:

- **Design and construction of one water tank (concrete-metal) sheets with P.E lining of 1 mm thickness of 205 M^3.**

- **Design and installation of the network of irrigation systems for 18 farmers .**

- **Ramtha and Madaba sites:**
  - **Installation of metal water storage tanks (8 in Madaba and 7 in Ramtha) of around 115 M^3.**

  - **Design and installation of irrigation systems network for the farmers.**

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Sites: Implementation of activities in Ramtha and Madaba

ACCBAT








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NARC Implemented Projects Related to the Treatment and Reuse of Greywater in Agriculture

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Desalination of Brackish water Using Solar Energy

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- The solar energy potential in Jordan is enormous as it lies within the solar belt of the world with average solar radiation ranging between 5 and 7 KWh/m^2, about 300-320 days of sunshine / year.

- Membrane desalination - Photovoltaic (PV) technology: uses membranes to separate fresh water from saline feed-water. Three pilots RO desalination plants using solar energy were installed, in the brackish water zones, and the produced water was used to irrigate high value cash crops. Standard Product Rate: 10 m^3/hr, Standard Feed Water TDS: 3500 ppm.

- The maximum number of working hours will not exceed 6 hours and the effluent was mixed for the purpose of irrigation (< 0.7 dS/m, non restriction).

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Photovoltaic (PV) technology

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Membrane Desalination Technology:

- Photovoltaic (PV) technology : uses membranes (Reverse Osmosis (RO)), to separate fresh water from saline feed-water.

- Three pilots RO desalination plants using solar energy were installed, in the brackish water zones (2 in Deir-Alla & 1 in Khaldieh), and the produced water is used to irrigate high value cash crops. Standard Product Rate: 10 m^3/hr, Standard Feed Water TDS: 3500 ppm.

“Promoting Sustainable Irrigation Management and non-conventional water use in the Mediterranean” PROSIM

Project partners: Italy, Jordan, Lebanon, Tunisia and Spain.

Associated partners: Morocco and Egypt.

Location of interventions: Balqa and Aqaba Governorates.

Budget: 785,797.03 €

Duration: 3 years

Activities: Intervention technologies

In Balqa Governorate: innovative solutions to increase water use efficiency in irrigation (Subsurface, drip irrigation system, uses of pan evaporation, sensors, and weather stations to calibrate the real irrigation requirement, the use of filtration system and three different desalination technologies (RO, NF, CDI)) will be tested in 30 hectares, involving 100 farmers.

22,5 ha – 55 farmers

PLOT 1 (11.5 ha) 35 farmers		PLOT 2 (5 ha) 15 farmers	PLOT 3 (4 ha) 4 farmers-2 each	PLOT 4 (2 ha) 1 farmer
OPEN FIELD (10 ha)	20 GREENHOUSE (1,5 ha)	Sensors / weather stations: 11 units	Nano-filtration (2 systems 10m^3/h each with PV for 4	IS8 – Deionization system (5m^3/h) (Work in progress)
Drip irrigation (20 farmers)	Drip irrigation (15 farmers)	Reverse osmosis (2 systems 10m^3/h each managed by 4 farmers) (only 4 ha)	DSS Intermediate (Work in progress)	
Evaporation pan (20 farmers)	Evaporation pan (15 farmers)			
VEGETABLES			ADD VALUE CROPS	

7 ha – 19 farmers

Mixed Quality			
PLOT 5 (1 ha) ***2 farmers***	**PLOT 6 (1 ha)** ***2 farmers***	**PLOT 7 (3 ha)** ***11 farmers***	**PLOT 8 (2 ha)** ***4 farmers***
- Sub-subsurface: 2 units	**Drip: 2 units**		
Sensors: 2 units	**Sensors: 2 units**	**Sensors: 11 units**	
Filtration : 2 units	**Filtration: 2 units**	**Filtration: 11 units**	**Filtration: 4 units**
Addition: Irrigation system working with PV system for 30 farmers. 5 farmers will be provided with full irrigation system and the other 25 farmers will be provided with selected irrigation part (pump, fertilizer injector, pipes, …)			
PALM TREES/Fruit Trees		**PALM TREES / FRUIT TREES**	

Non Conventional Water Re-use in Agriculture in Mediterranean countries MENAWARA

- MENWARA is designed to enhance access to water through the treatment of wastewater to be re-used as complementary irrigation and to strengthen the capacity of governmental institutions, non-state actors operating in the sector, technicians and farmers.
- http://www.enicbcmed.eu/projects/menawara

General objective:

Contribute to increase the water availability for agricultural purposes through the use of nonconventional water in order to reduce the pressure on fresh water.

Specific objective(s):

- **Improve water use efficiency of non-conventional water for irrigation.**
- **Strengthen the non-conventional water governance by disseminating and capitalizing innovative and technological solutions**

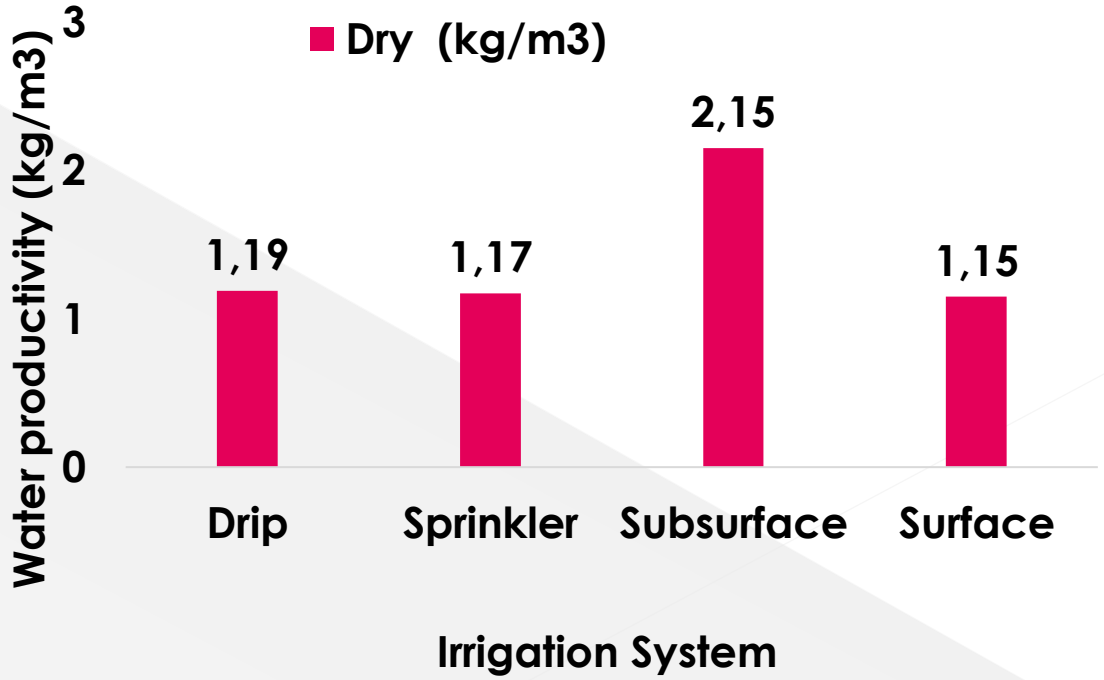
Activities:

Tertiary treatment unit to improve the quality of TWW of 62.5 m^3/hr.

Testing different irrigation systems (drip, subsurface and sprinkler).

Installation of 9 sub-surface drip irrigation systems-farmers

Alfalfa water productivity



Valley water project:

Improving water productivity and livelihood in Jordan Valley using treated wastewater and saline water in agriculture

Reuse of North Shunah Treated Wastewater Effluent in the Agricultural Production of Forages and Citrus Crop

Main objective: is to research and demonstrate the feasibility of generating effluent quality characterized by chemical and biological parameters suitable for restricted irrigation, and to establish regional cooperation and knowledge transfer through coordinated research, training and meetings of experts.

<u>The specific objectives are to enhance:</u>

- Farmers awareness regarding water saving techniques and technologies, re-use of TWW in irrigated agriculture, and related environmental impacts.

- Farmers' technical know-how regarding integrated agricultural resources management and production methods, economic and ecological advantages of the implemented solutions.

European Union
European Regional
Development Fund

ICU
Istituto per la Cooperazione Universitaria ONLUS

Water-efficient Innovative Solutions Portfolio for Enhancing Resilience WISPER Project

Funded by the European Union
Managed by the Institution Cooperation for University ICU
& implemented in partnership with the National Agricultural Research Center
NARC

Description of WISPER Project

- Countries involved: Tunisia and Jordan
- WISPER project works to introduce modern and innovative technologies to the project's partner countries. These technologies are known to be scarce in partner countries. Because the farmer follows traditional techniques and does not risk changing the agricultural pattern used on his farm.These techniques contribute to raising the water use efficiency of the farm to the optimum level.
- Project seeks to introduce modern technologies that save water, while at the same time making sure to introduce low cost technologies to achieve the possibility of acceptance and application of farmers.

Experiments and Activities Applied in WISPER Project

1. **TWW Treatment system**
2. **Soilless-System prototype**
3. **Fertilizer injector for an existing hydroponic-system**
4. **Polymer-water retention**
5. **Sub-surface Tape driplines**
6. **Water Boxes (Cocoon)**
7. **Full irrigation system**
8. **Selected pump, fertilizer,…with PV system**

Project Workplan

Stage	System	Number of Experiment		Area	Cultivation Pattern	crops	Locations
		Main Farms	Extra Farms				
A	Testing TWWP Decentralized System	3	1	-	Open Field	Olive Tree	Balqa Jarash Karak
A	Testing of Innovative Polymer	1	-	1 Dunum	Open Field	Squash	DierAlla Station-NARC
		1	-	240 M2 (greenhouse)	Greenhouse	Cucumber	
A	Testing of New Water Retention Boxes	1	-	20-30 trees per site	Trees Cultivation	Ziziphus, Fodder Tree	Karamah (Balqa Governorate)
B		1	-			Almond Trees	Salt (Balqa Governorate)
C		1	-			Olive Trees	Karak Governorate
A	New Irrigation Tape System	1		1 Dunum	Open Field	Maize (Corn)	NARC Plot station
A	Automation of the Fertigation Soilless System with Cooling Pads	1	-	1 Dunum	Greenhouse	lettuce and cucumber	NARC Plot station
A	Simple Soilless System Prototype	1	-	1 Dunum	Greenhouse	lettuce and cucumber	NARC Plot station

Price of Treated Wastewater

- Treated water price in Jordan:

- The main objective of MWI/WAJ is to encourage the farmers to reuse the treated water for restricted irrigation as stated in Jordan standard number 893/2021.

- In (22/4/2021) a new treated water price sold to farmers with (25 fills ≈ 0.035$) per m^3.

WWTP	Cost JD/ m^3
Alsamra	0.29
South Amman	0.25
Ma'an	0.91
Wade Moussa	0.97
Madhab	0.34
Al-Mafraq	0.22

Allowable limits and criteria for reuse in irrigation as Jordanian Standard No. 893/2021.

Allowable Limits and criteria for reuse in irrigation				
Parameters (mg/L)	Cooked vegetables, parks, playgrounds and road surfaces within cities.	Fruit trees, external roads and Landscape.	Field crops, field industrial, forest trees.	Flowers
	A	B	C	D
BOD	30	100	200	15
COD	100	200	300	50
TSS	50	100		15
NO_3	16			
T-N	70			
E-coli	≥ 1000			
FOG	8			2

Wastewater Management

Following are Government's key objectives associated to wastewater management:

- ❑ Sustainable Development.
- ❑ Public health and environmental protection.
- ❑ Coping with water scarcity.
- ❑ Improving quality of life.
- ❑ Improving wastewater services.
- ❑ Public & private sector participation.
- ❑ Adaptation to climate change impacts.

❖ It is very important to properly monitor and assess the effluent quality of wastewater treatment plants for sustainable water resources management and protection the public health.


Thank you