Irrigation of olive with reclaimed wastewater

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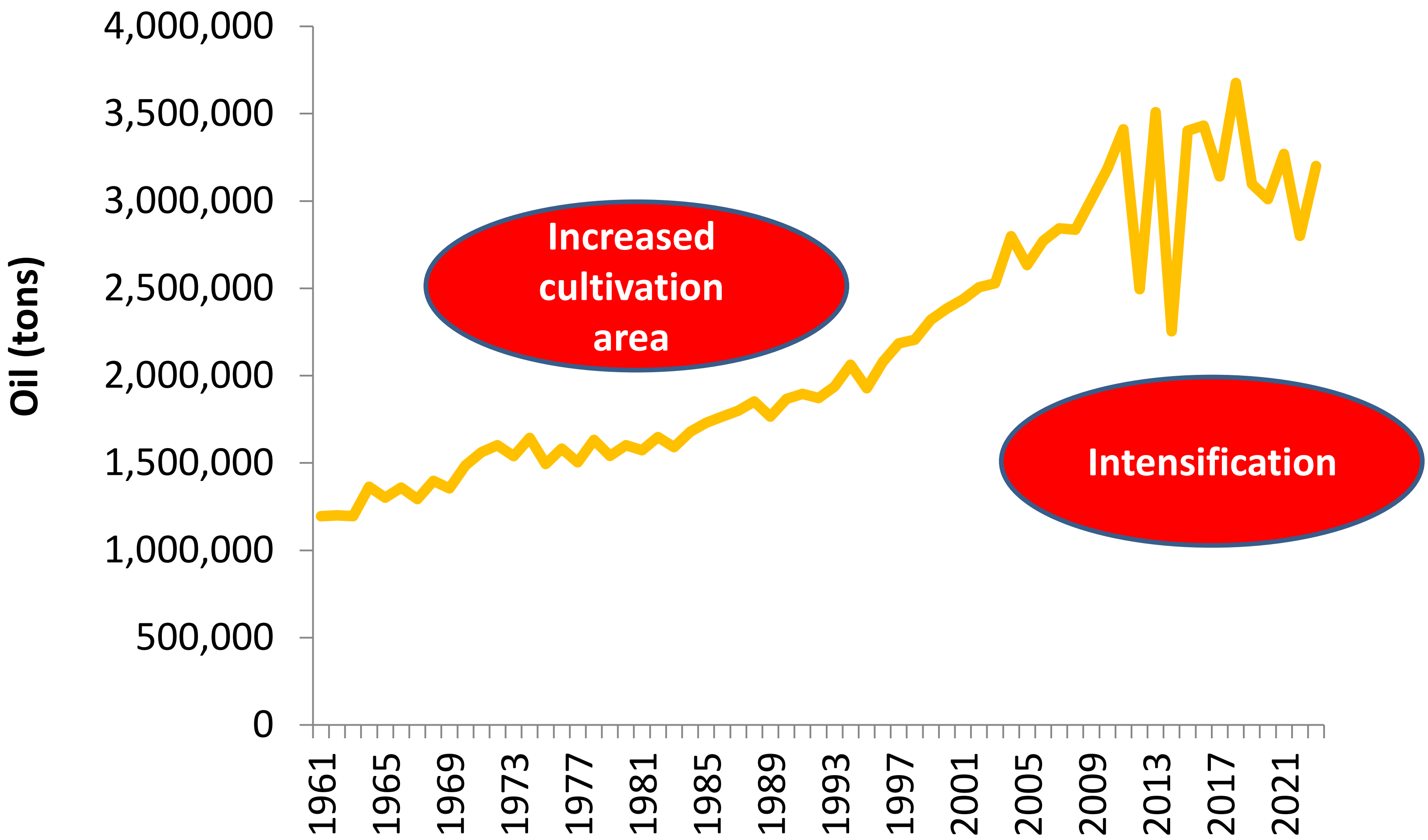
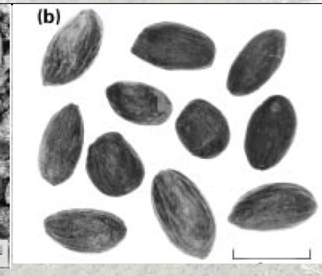
Development in world olive oil production



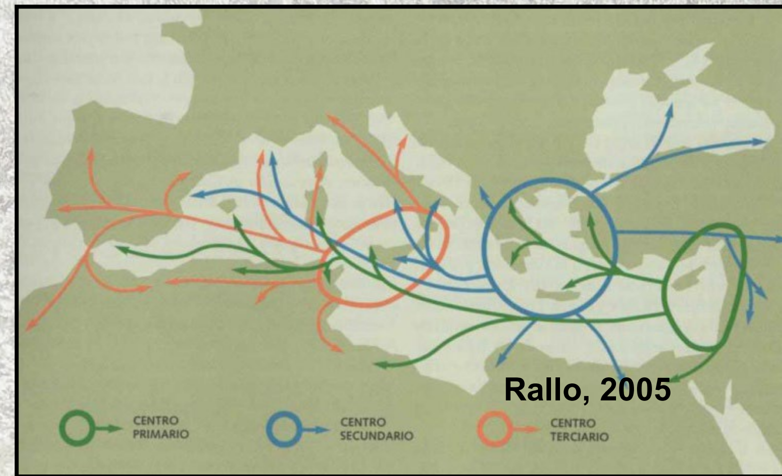
International Olive Council / FAO STAT

Domestication of olive started in the Middle East ca. 6500 years ago


Galili et al. 1997



~ 6,500 years



Rallo, 2005


scientific reports

Check for updates

OPEN **Early production of table olives at a mid-7th millennium BP submerged site off the Carmel coast (Israel)**

E. Galili[1,2,3], D. Langgut[4], J. F. Terral[5,6], O. Barazani[7], A. Dag[8], L. Kolska Horwitz[9], I. Ogloblin Ramirez[3], B. Rosen[10], M. Weinstein-Evron[11], S. Chaim[11], E. Kremer[4], S. Lev-Yadun[12], E. Boaretto[13], Z. Ben-Barak-Zelas[14] & A. Fishman[14]


Wild type
O. europea oleaster

Barazani, O., Westberg, E., Hanin, N., Dag, A., Kerem, Z., Tugendhaft, Y., Hamidt, M., Hijawi, T. and Kadereit, J.W, (2014) A comparative analysis of genetic variation in rootstocks and scions of old olive trees- a window into the history of olive cultivation practices and past genetic variation. BMC Plant Biol. 14: 146.

Limiting factors:
water and nutrients

Limiting factor:
Radiation

Close spaced planting

Traditional orchards → Intensive orchards

ca. 10 x 10 m

4 x 7 - 7 x 7 m

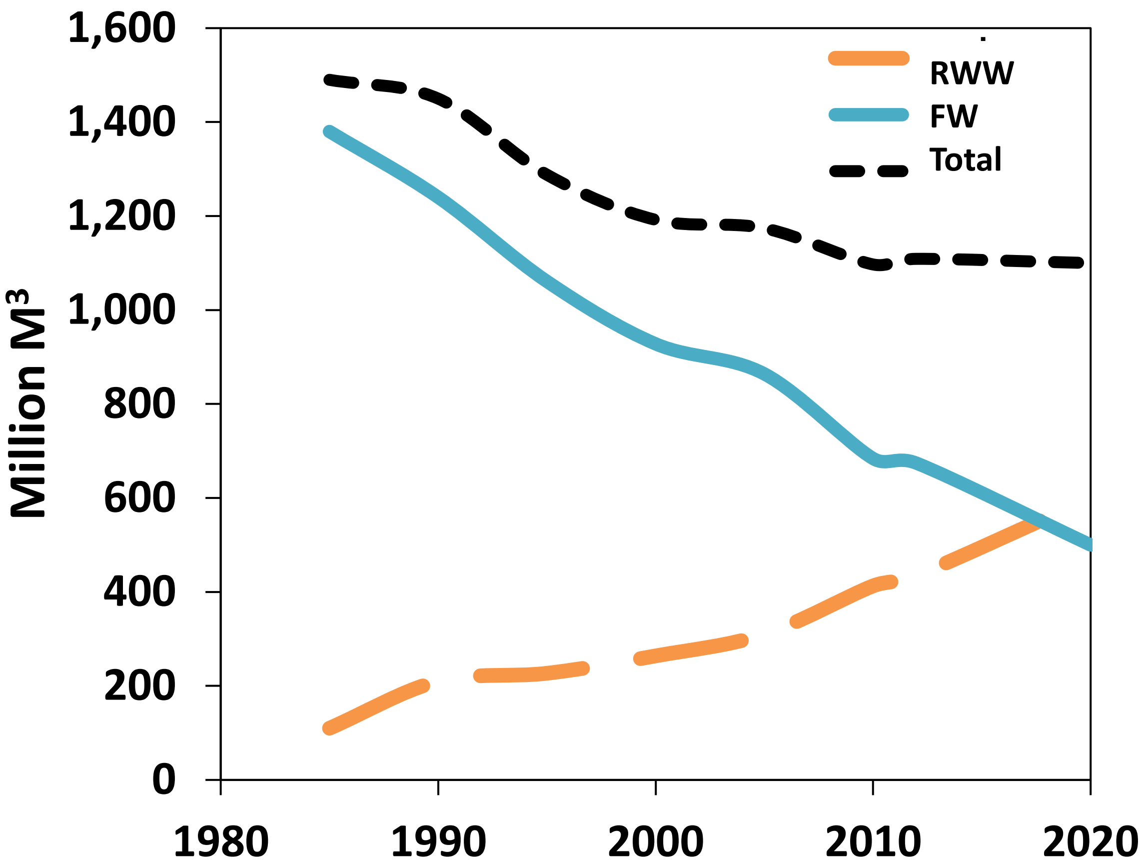
Intensification of olive cultivation

- Varieties (fast growing high yielding)
- Close spaced planting, orchard management
- Pruning, soil cultivation, plant protection
- **Irrigation - fertigation**

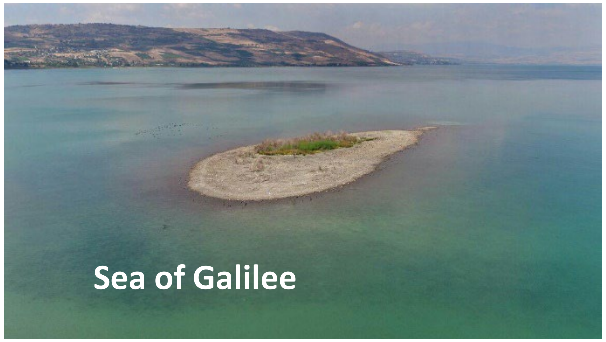
Water available for irrigating olives

- Scarce ⇨ optimize irrigation
- Low quality
  - Recycled wastewater
  - Saline water

Sources of water for irrigation in Israel



‘Shafdan’ treatment plant

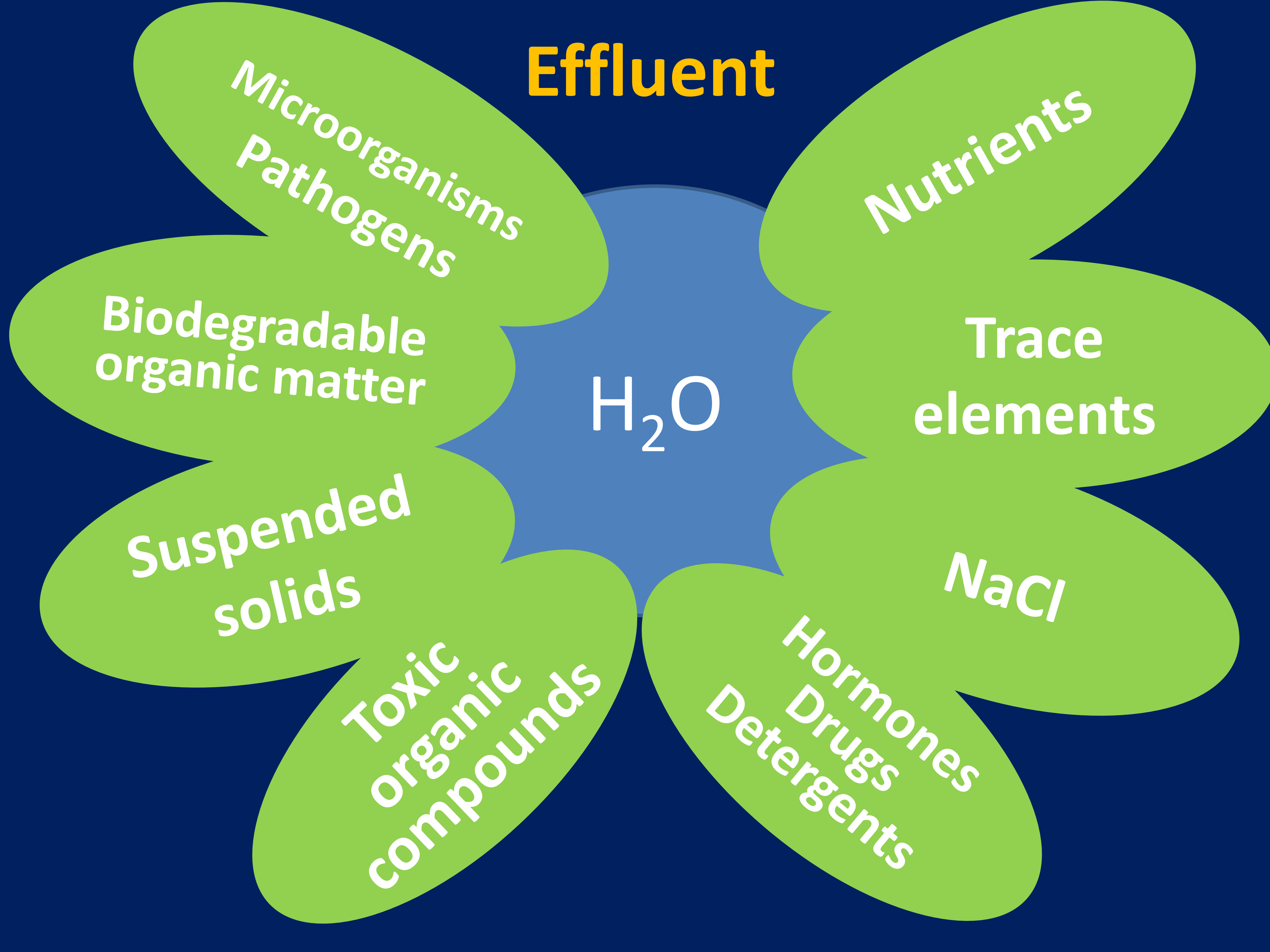


Reclaimed wastewater

Treated wastewater

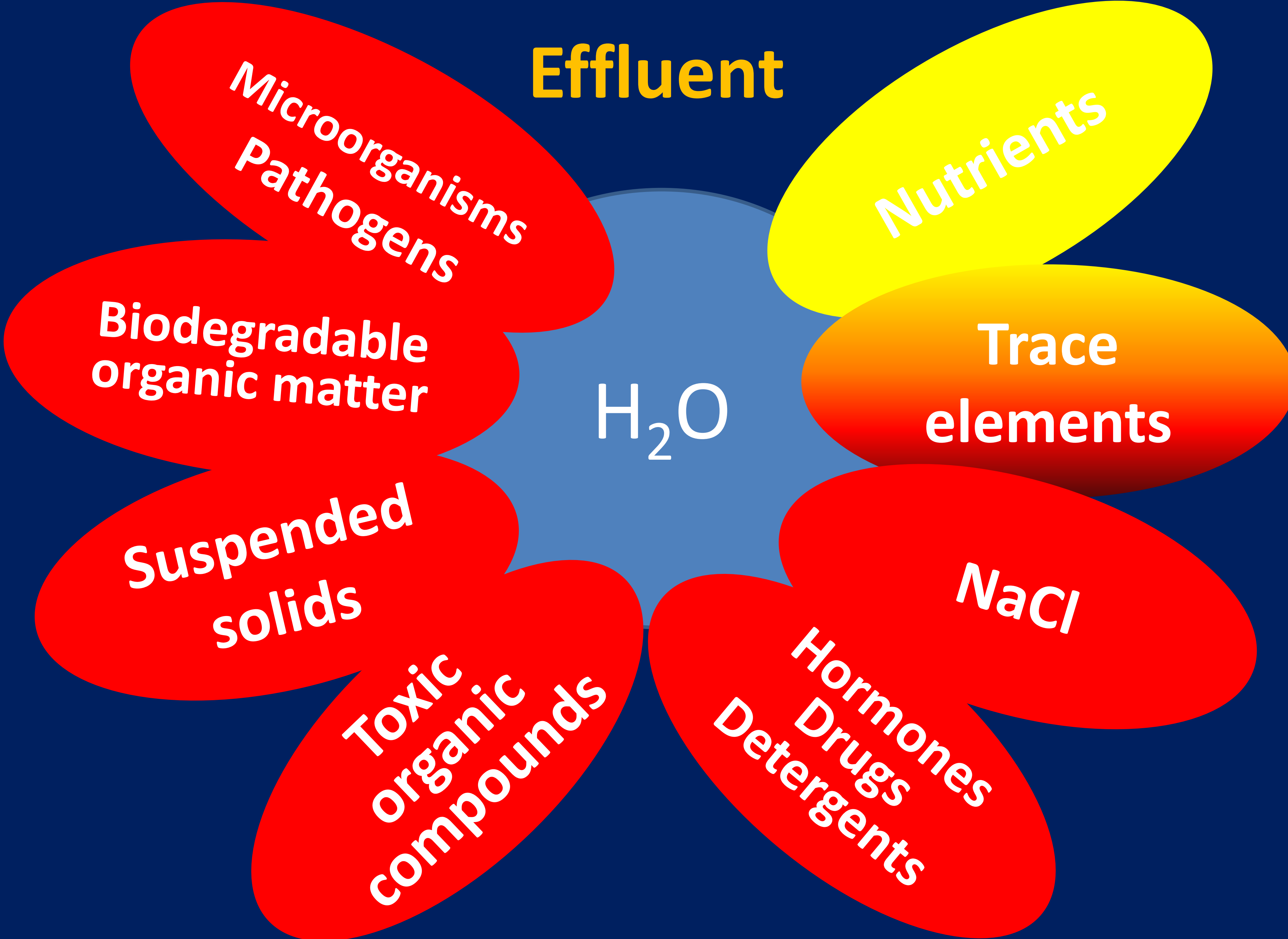
Recycled water

Effluent



Effluent
Microorganisms
Pathogens
Nutrients
Biodegradable organic matter
Trace elements
H_2O
Suspended solids
NaCl
Toxic organic compounds
Hormones
Drugs
Detergents

Effluent


Microorganisms
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MERC project- ‘Utilization o wastewater for olive irriga

Jordan:
- Rainfed
- Recycled water
- Fresh water

Palestinian Authority:
- Rainfed
- Recycled water

Israel:
- Fresh water
- Recycled water standard fertigation
- Recycled water reduced fertigation

Objectives

- To investigate the long term effects of irrigation with RWW on soil properties.

- To investigate the impact of fertilization practice and water source on olive tree performance.

- To investigate the impact of fertilization practice and water source on olive oil quality.

Experimental orchard

- 20 hectare, super high-density
- Trees were four years old
- Eight consecutive years
- Soil: 22-24% sand, silt 22-25, 50-55% clay
- Mediterranean climate
- Two water sources: fresh water and effluent

Cultivars

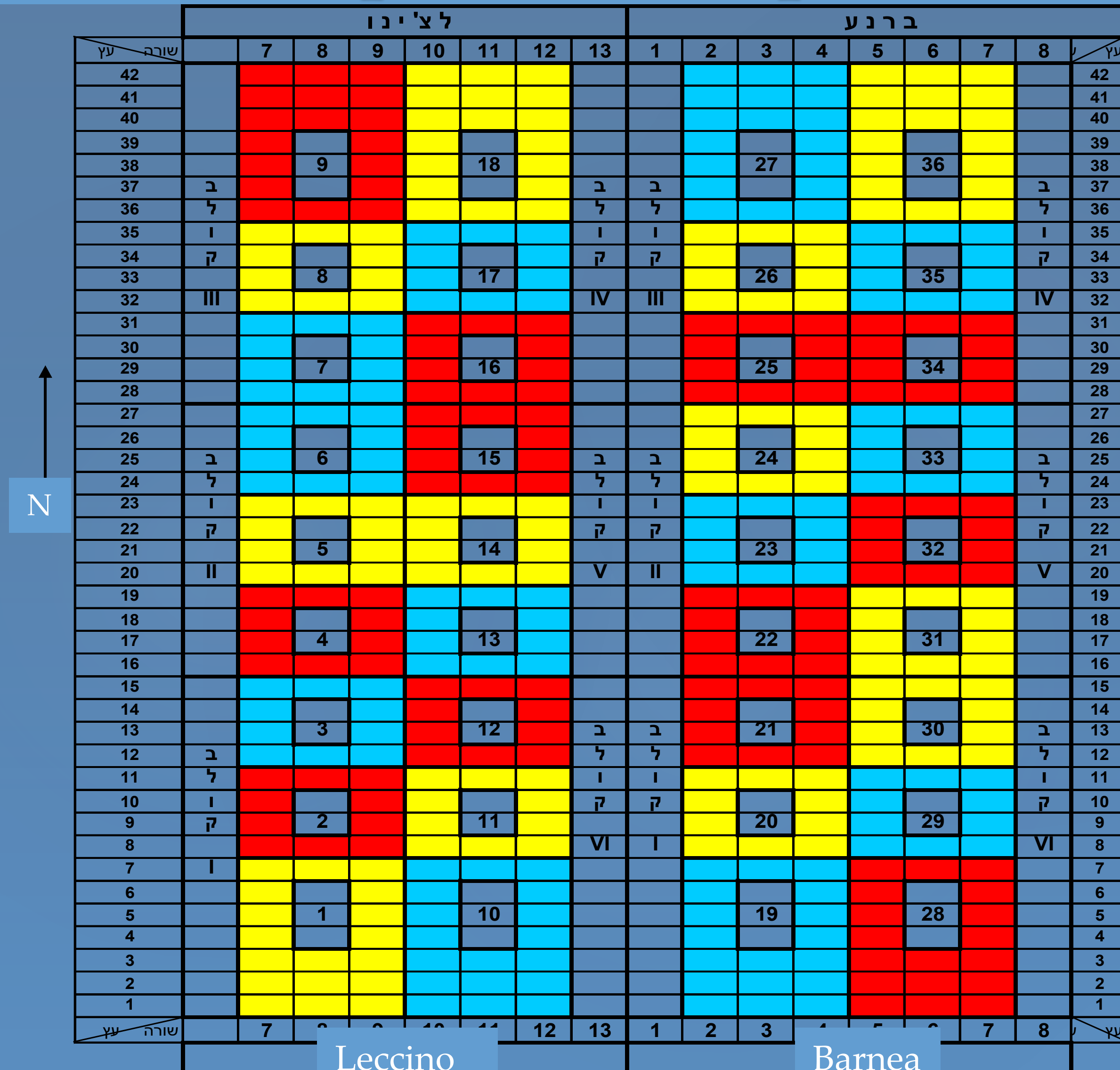
-Barnea

-Leccino

Replicates

6 X 2 measured trees per each cultivar per each treatment

Schematic map of the experimental plot



Fresh water

Recycled Water- Full Fertilization

Recycled Water- Reduced Fertilization

1 FW

2 Re +

3 Re -

“The trip of a drip”

מי שפלת יהודה
אגודה שיתופית חקלאית בע״מ

25 million m^3 TWW

Experimental set up

Year	Fresh water	Effluent+ *(Re+)*	Effluent – *(Re-)*
2006-2009	Standard fertilization	Standard fertilization	Reduced fertilization
2010-2013	Standard fertilization	Reduced fertilization	No fertilization

Standard fertilization; 180 kg/ h N, 290 kg / ha K

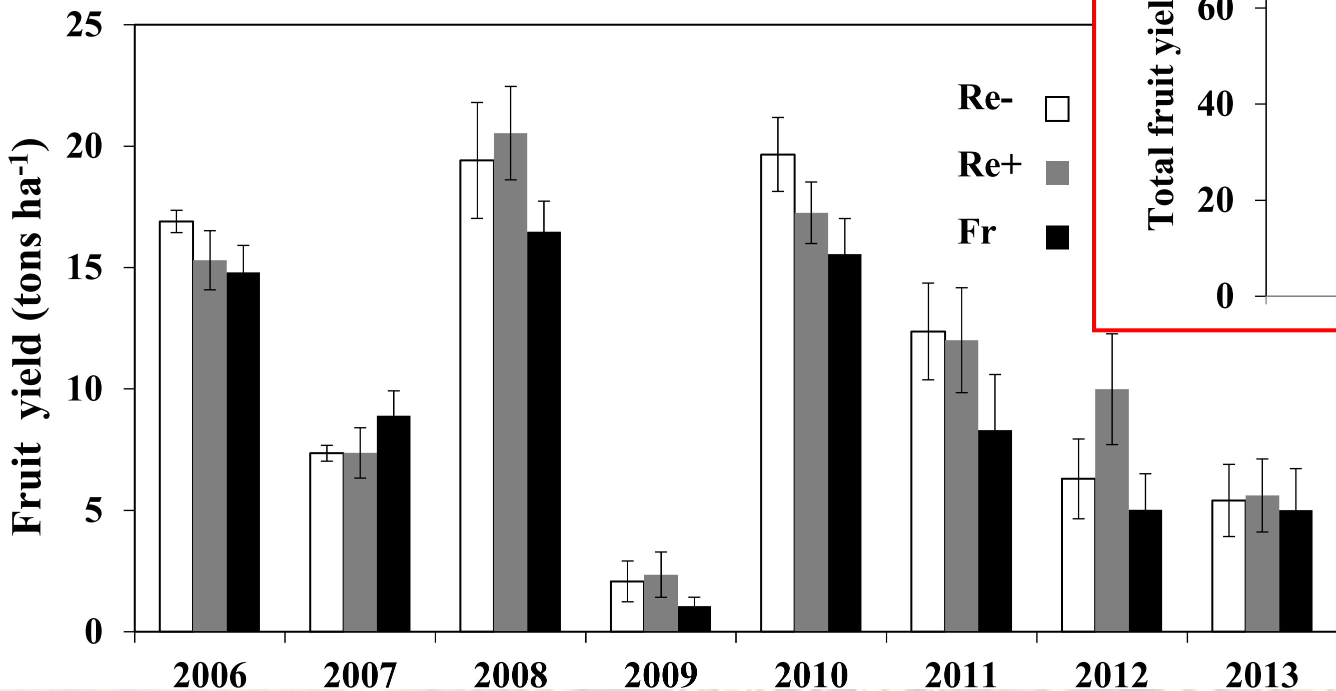
Average NPK received annually with the irrigation water (kg/ha)

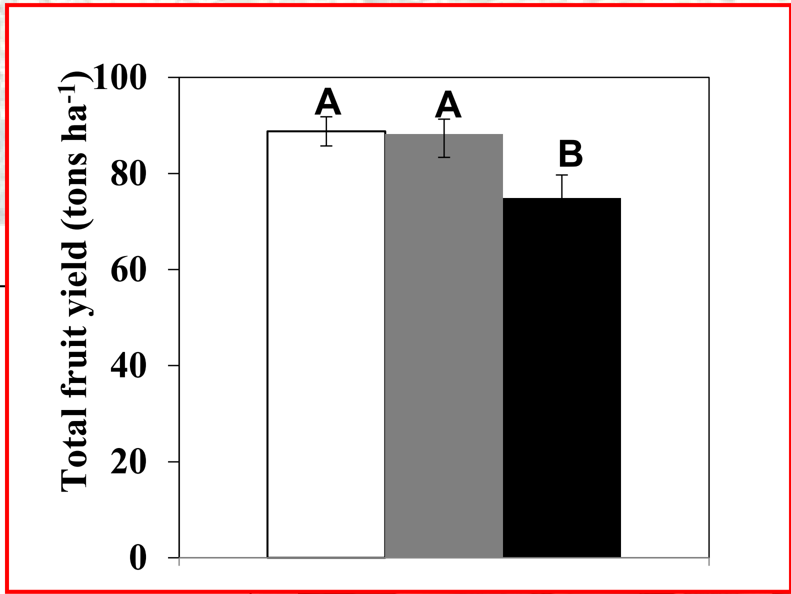
Year	Fresh water	Effluent
2006-2009	N = 9, P = 0, K = 16	N = 94, P = 26, K = 146
2010-2013	N = 12, P = 0, K = 22	N = 124, P = 34, K = 193

Water characteristics (n=40)

Constituent	Units	Effluent	Fresh water
pH		7.7 (0.3)	7.5 (0.2)
EC	dS/m	1.71 (0.22)	0.8 (0.2)
Cl	mg/L	326 (38)	138 (56)
Na	mg/L	202 (27)	69 (28)
Total N	mg/L	20.3(6.7)	2.5 (2.2)
K	mg/L	31.2 (6.8)	3.5 (2.8)
P	mg/L	5.6 (2.8)	0.0 (0.0)
Ca	mg/L	66.9 (8.8)	48.0 (12.9)
Mg	mg/L	35.6 (6.5)	22.1 (11.8)
SAR		5.1 (0.9)	2.1 (0.6)

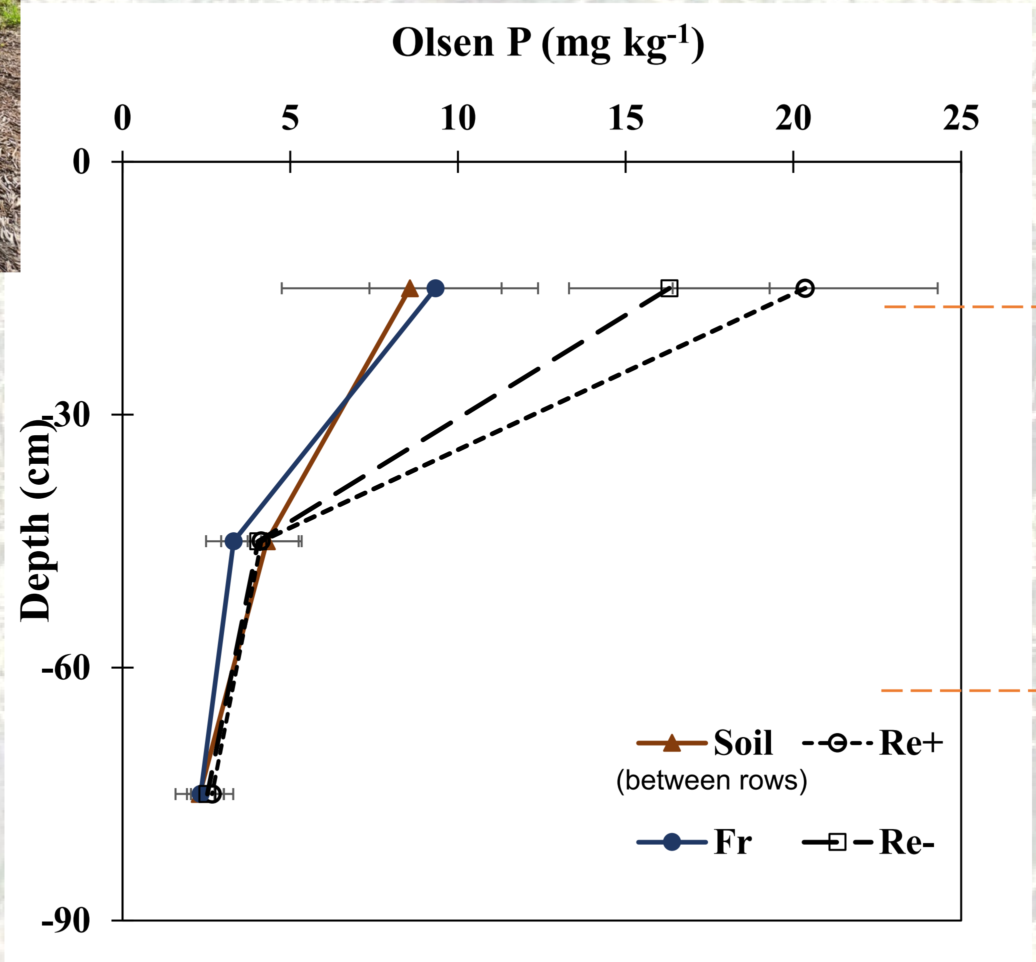
Fruit yield- ‘Barnea’





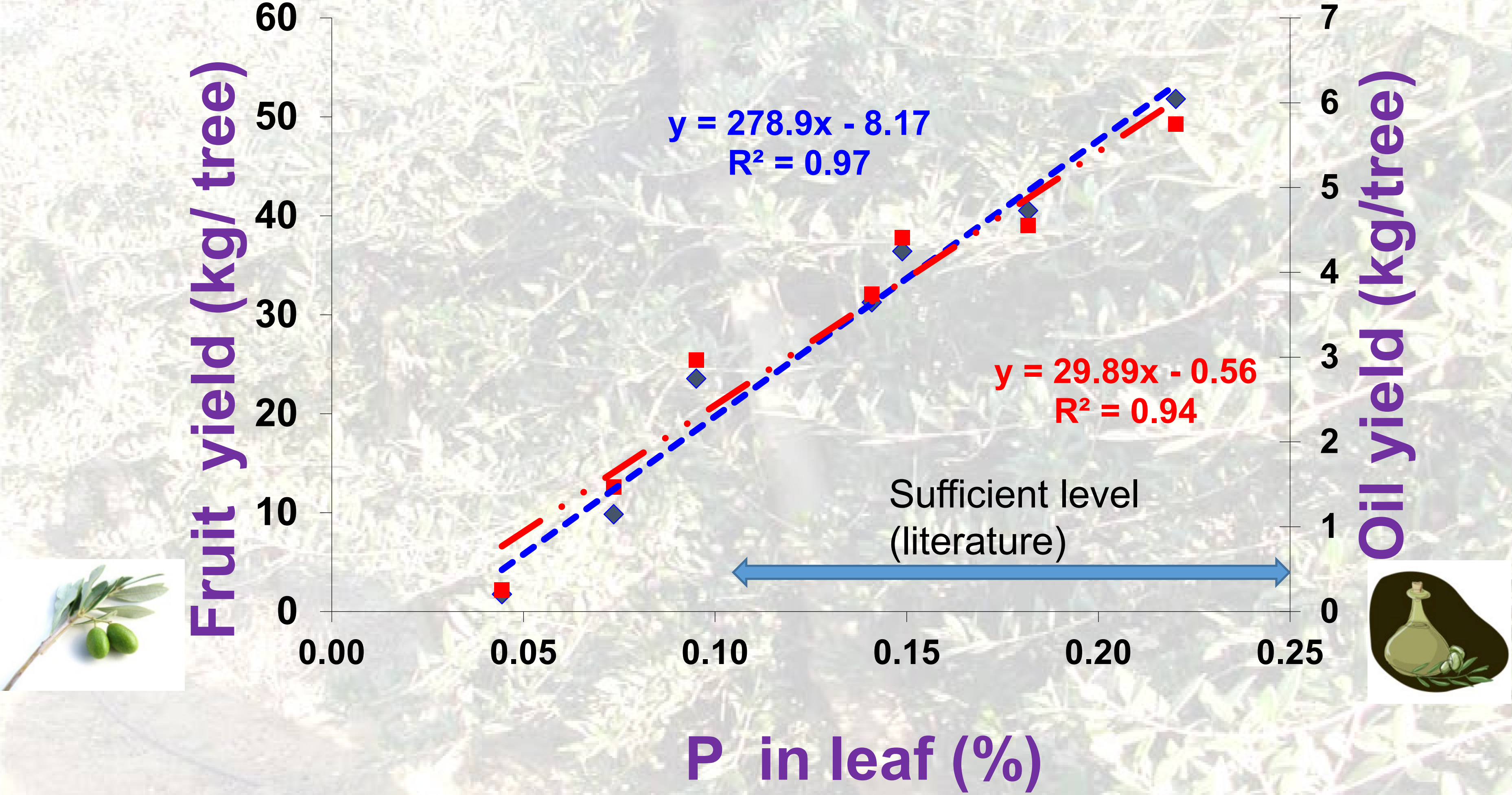
Erel et al., (2019). *Agric. Water Manag*. 213: 324-335.

Phosphorus in soil



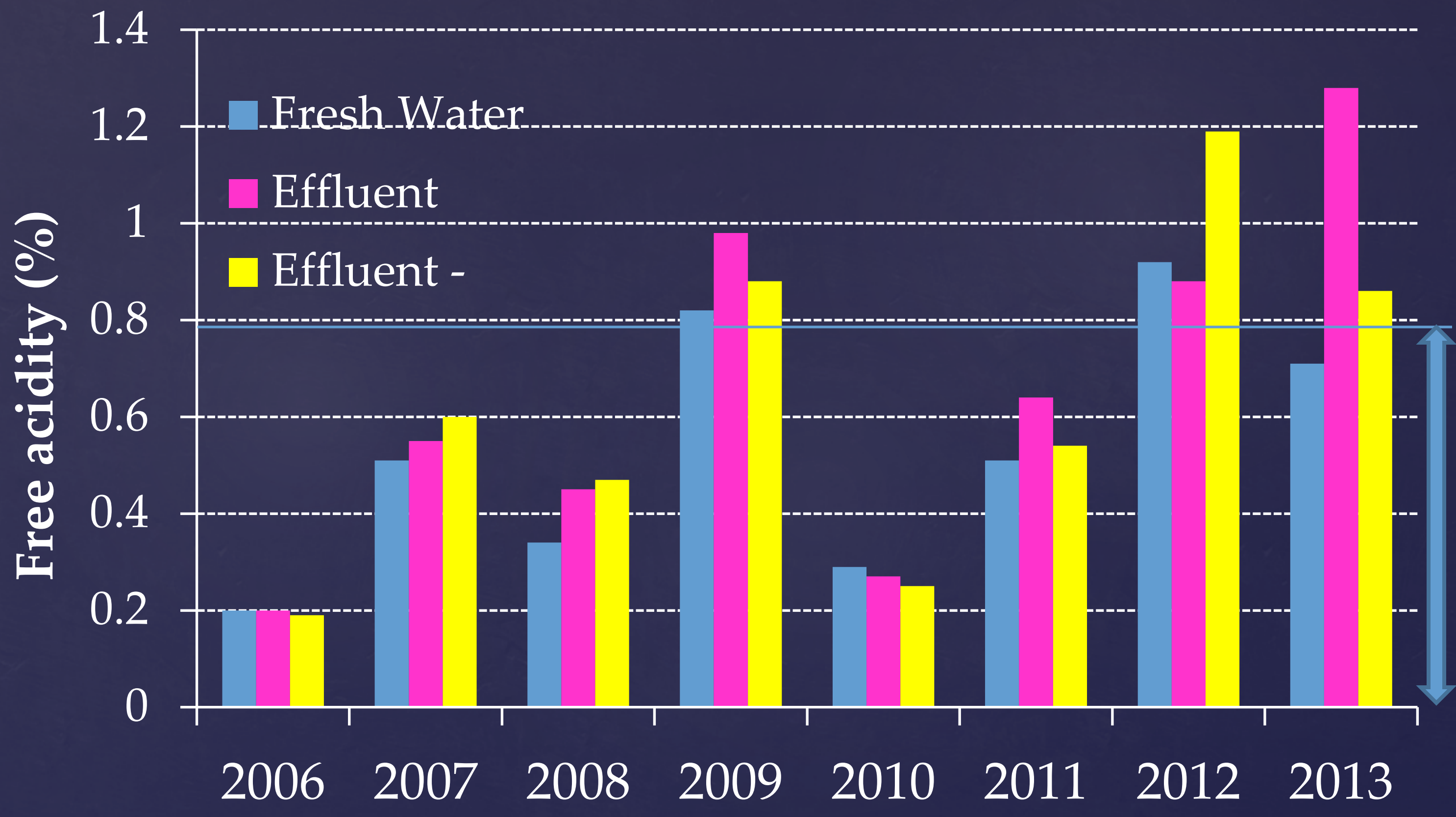
Erel et al., (2019). *Agric. Water Manag*. 213: 324-335.

The correlation between phosphorous level in diagnostic leaves and fruit and oil yield



Erel et al. (2013) *Scientia Hort*. 159: 8-18.

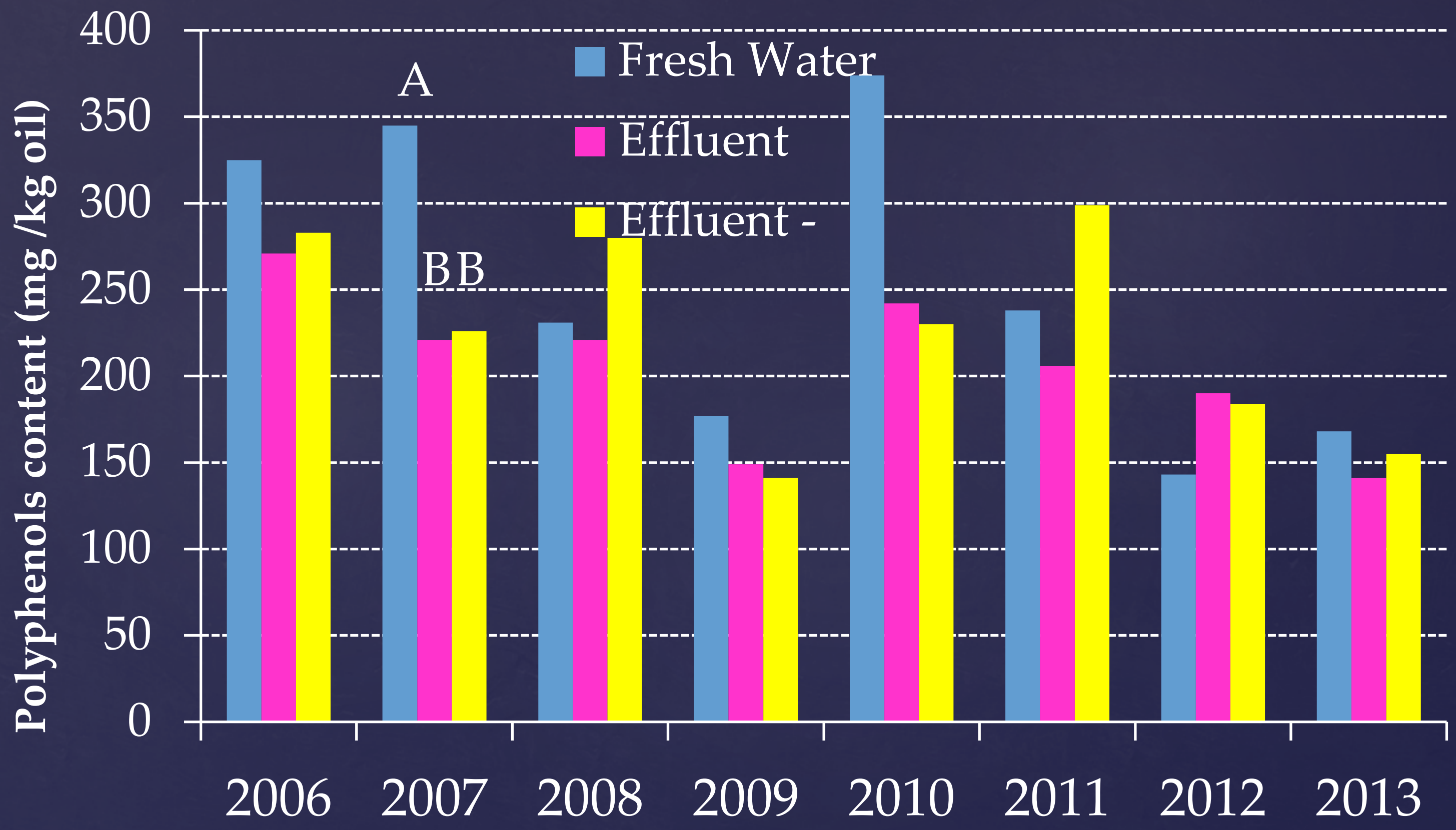
Oil quality- FFA content, 'Barnea'



No significant difference (P<0.05) was found between irrigation treatment in any of the seasons

Basheer et al. (2019). *J. Sci. Food Agric.* 99: 6342-6349

Oil quality- polyphenol content, 'Barnea'



Different letters indicates on significant difference (P<0.05) between irrigation treatment in any of the same season

Basheer et al. (2019). *J. Sci. Food Agric.* 99: 6342-6349

Sensorial evaluation

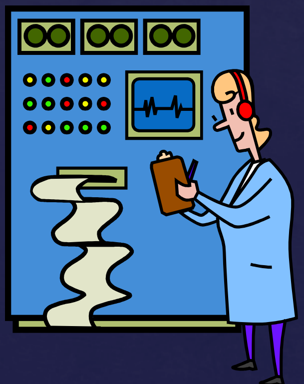
Attribute	Fresh water	Effluent+	Effluent -
'Barnea' (average of 7 seasons)			
Fruitiness	3.8	4.0	3.5
Bitterness	2.8	2.0	2.0
Pungency	4.0	3.6	3.3
'Leccino' (average of 4 seasons)			
Fruitiness	3.1	3.2	3.4
Bitterness	0.2	0.6	0.2
Pungency	0.6	1.8	1.3

No sensory defects were detected in any of the oil samples.

Basheer et al. (2019). *J. Sci. Food Agric.* 99: 6342-6349

Health risks

- Bacteriological
- Heavy metal contamination
- Residues of pharmaceuticals and hormones



Bacteriological tests- Water and Oil

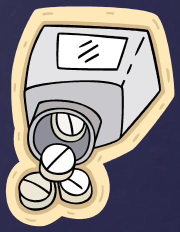
Water	fresh water	effluent
Coliform bacteria (per 100 ml water)	<1	17,000
Salmonella bacteria (per 100 ml water)	Negative	Negative

Oil	Irrigated with	
	fresh water	effluent
Total bacteria count (per 1 gr. oil)	80	40
Coliform bacteria (per 1 gr. oil)	< 3	< 3
Salmonella bacteria (per 20 gr. oil)	Negative	Negative

Residues of pharmaceuticals and hormones

Using mass spectroscopy we measure (detection level):

- Carbamazepine (0.08 ppm)
- Sulfadimethoxine (0.01 ppm)
- Ciprofloxacine (0.08 ppm)
- Tetracycline (0.1 ppm)
- Estrone (0.1 ppm)
- 17b Estradiol (0.01 ppm)

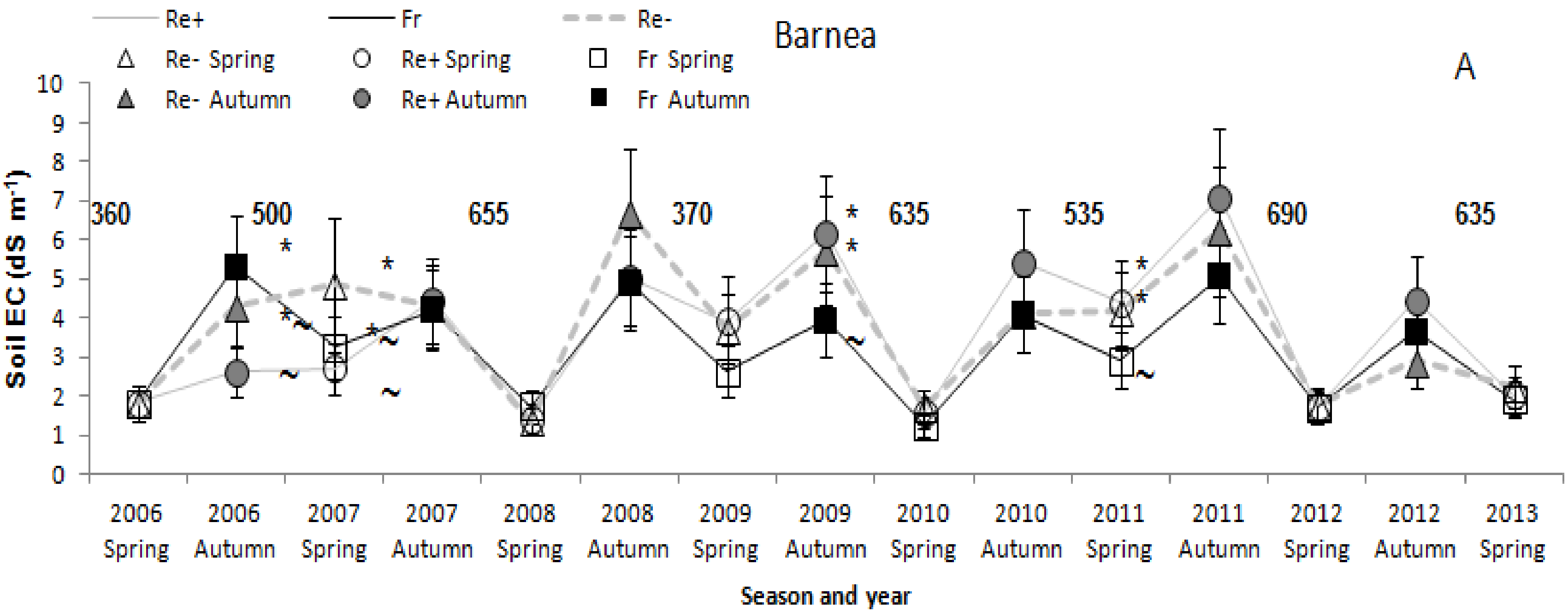


None of these compounds or their metabolites were detected in oils from trees irrigated with effluent.

Residues of heavy metals

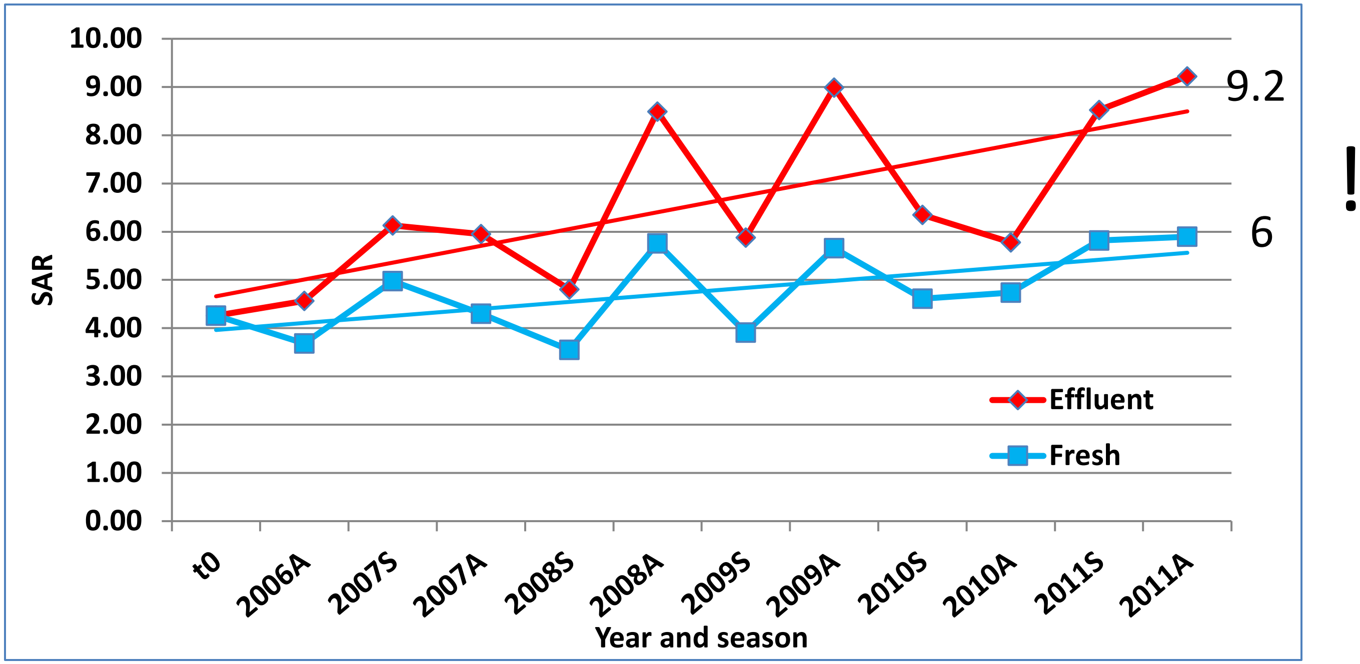
Cd **was the only heavy metal found in oil, in very low concentration (< 0.05 mg /kg oil) while oil obtained from trees irrigated with effluent having lower levels than trees irrigated with fresh water.**

Soil Ec



Erel et al. (2019). *Agric. Water Manag*. 213: 324-335.

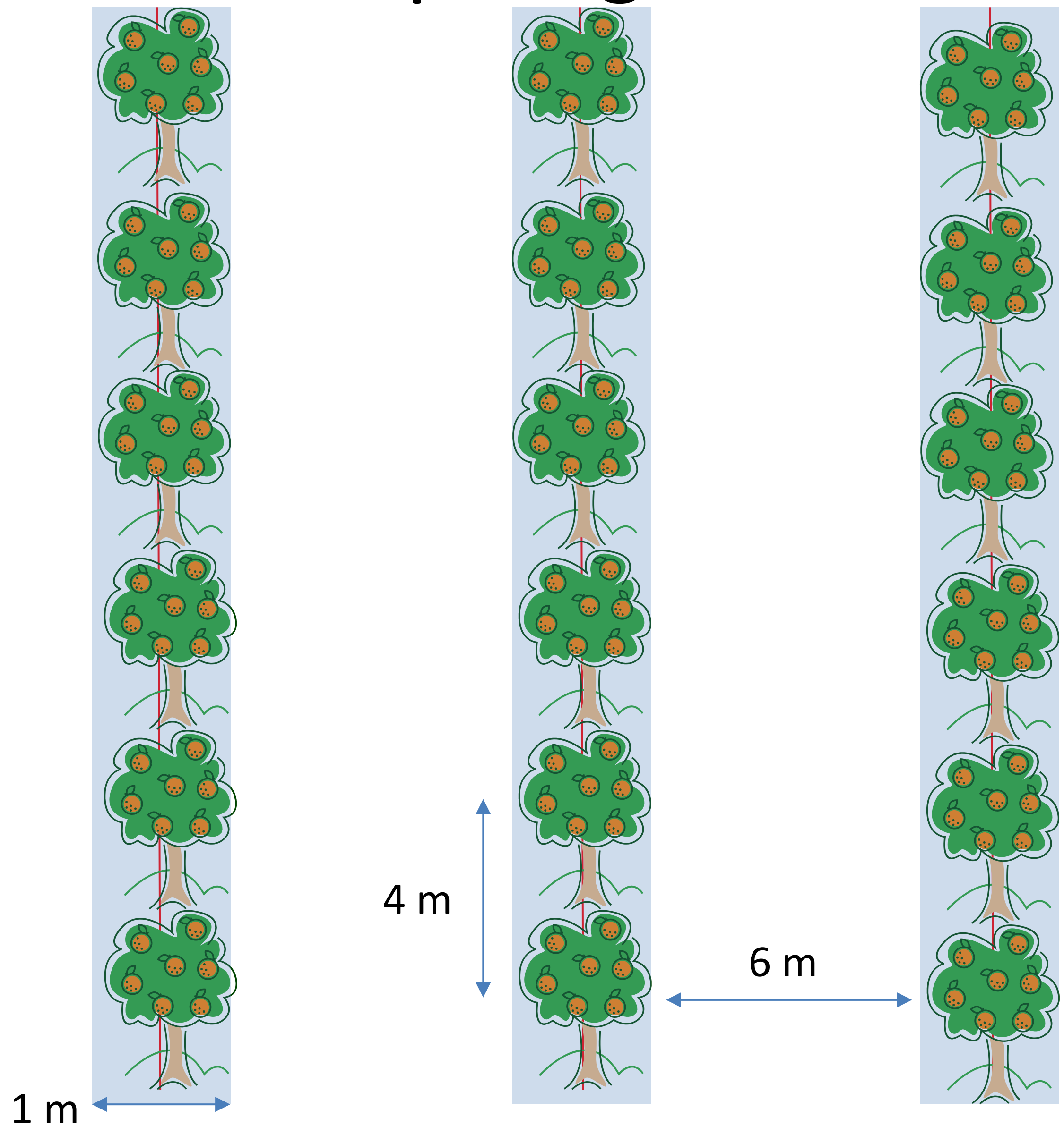
Soil SAR



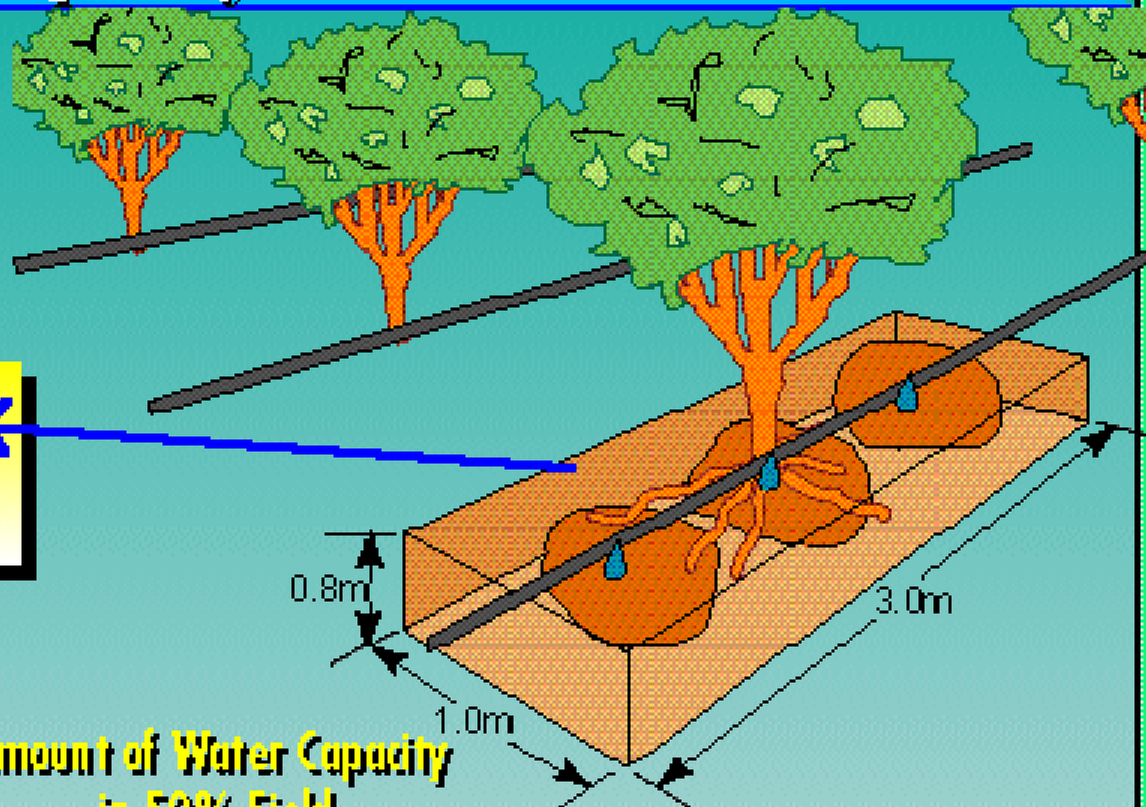
- SAR values of the soil extract increase steadily with time.
- SAR increase is faster in the plots irrigated with recycled water.

Erel et al. (2019). *Agric. Water Manag*. 213: 324-335.

Irrigated soil in orchard irrigated with drip irrigation



Amount of Water Capacity



Total Net Volume=

$3.0m \times 1.0m \times 0.8m = 2.4m^3$

Type of Soil	% of Water Field Capacity	Amount of Water Capacity in 50% Field
Heavy Soil	30%=720 liter	360 liter
Medium Soil	20%=480 liter	240 liter
Light Soil	10%=240 liter	120 liter

Large volume of low quality irrigation water applied to a limited soil volume

Enhance changes in soil chemical and physical properties

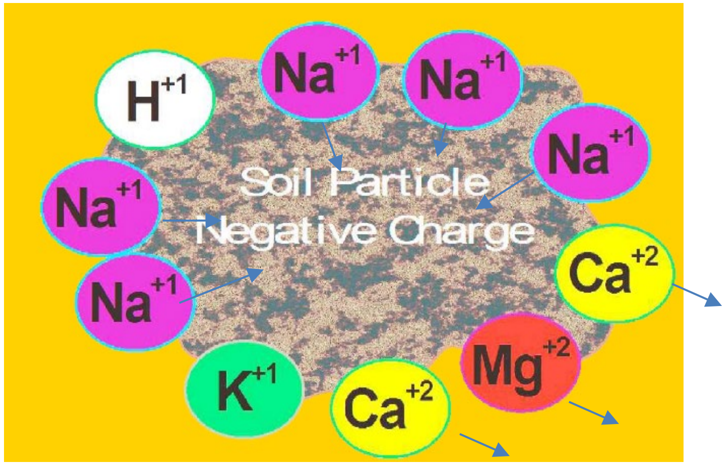
Conclusions

- Recycled water did not reduce fruit and oil yield.
- Recycled water did not affect olive oil quality parameters.
- Recycled water irrigation did not cause bacterial, heavy metal, pharmaceutical, or hormone contamination of oil
- Nutrients arriving with recycled water need to be taken into account while considering fertilizers to be given:
  - Reduce fertilizer cost
  - Improve oil quality
  - Reduce environmental contamination risks
- A constant increase in SAR values suggest possible soil degradation following RWW use.

Experimental orchard

An olive orchard in Timorim following long term irrigation with saline-sodic water

EC = 2.5 dS/m   SAR = 14.6-> Soil SAR ~ 30

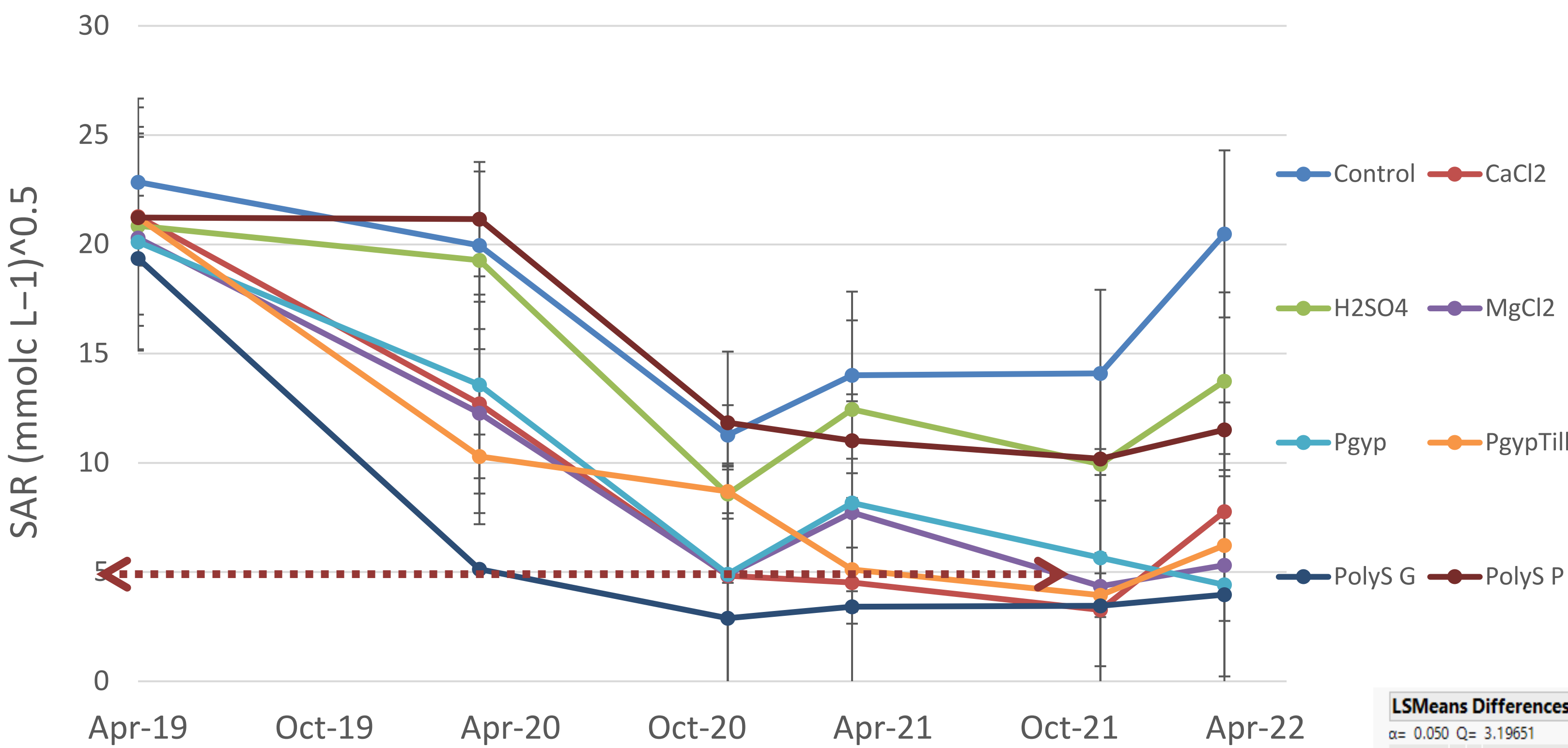


Treatments studied

Prior to the rainy season	During the irrigation season
Polysulphate granular $K_2Ca_2Mg(SO_4)_4$	$CaCl_2$
Polysulphate powder $K_2Ca_2Mg(SO_4)_4$	$MgCl_2$
Gypsum	H_2SO_4

$$SAR = \frac{[Na]}{([Ca + Mg]/2)^{0.5}}$$

Soil SAR at 0-30 cm depth



LSMeans Differences Tukey HSD

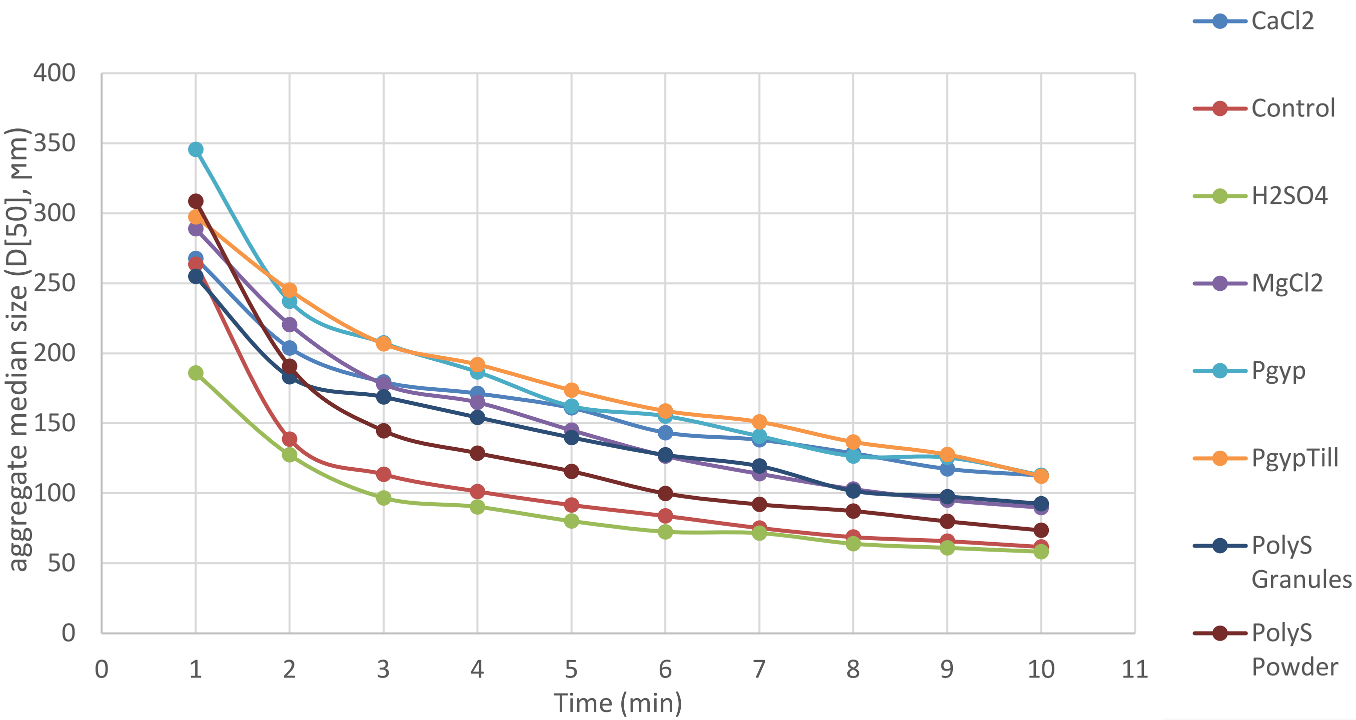
α= 0.050 Q= 3.19651

Level			Least Sq Mean
C	A		20.477946
H2SO4	A	B	13.736351
PolyS P	A	B	11.512100
CaCl2		B	7.763288
PgypTill		B	6.228273
MgCl2		B	5.313120
Pgyp		B	4.415012
PolyS G		B	3.965321

Levels not connected by same letter are significantly different.

Ziskin et al. (2024). *Agric. Water Manag*. 299: 108837.

Aggregate stability – soil sampling of 11/2021



LSMeans Differences Student's t

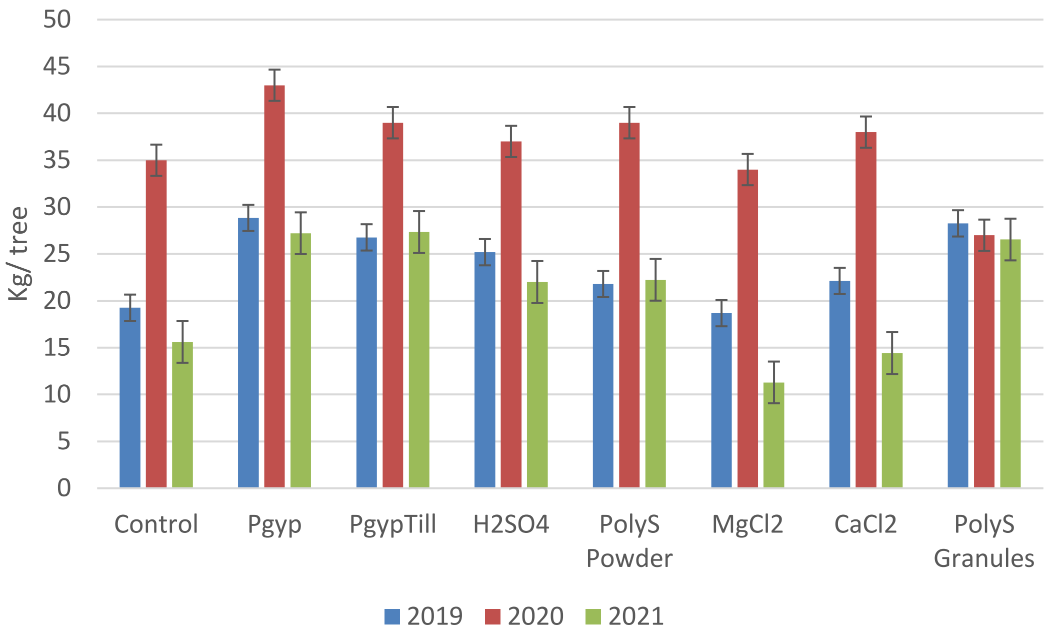
α= 0.050 t= 1.96594

Level						Least Sq Mean
PgypTill	A					180.12167
Pgyp	A					179.99167
CaCl2		B				162.36000
MgCl2		B	C			152.57000
PolyS Granules			C	D		143.96667
PolyS Powder				D		132.09833
Control					E	106.41233
H2SO4					E	90.80667

Levels not connected by same letter are significantly different.

Fruit Yield, 2019-2021

Error bars SE **



2019

Mean		Level
28.850000	A	Pgyp
28.266667	A	PolyS Granules
26.775000	A	PgypTill
25.191667	A	H2SO4
22.125000	A	CaCl2
21.800000	A	PolyS Powder
19.283333	A	Control
18.691667	A	MgCl2

2020

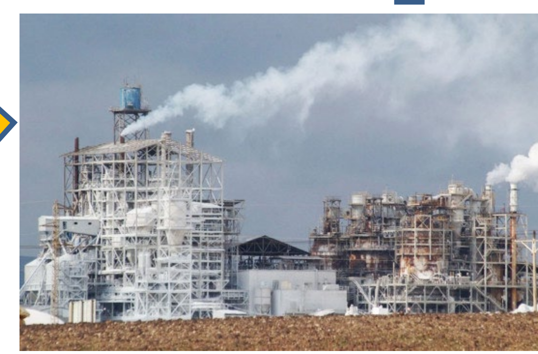
Mean		Level
43.250000	A	Pgyp
39.291667	A	PgypTill
38.666667	A	PolyS Powder
37.625000	A	CaCl2
37.250000	A	H2SO4
34.875000	A	Control
34.375000	A	MgCl2
26.833333	A	PolyS Granules

2021

Mean			Level
27.333333		A	PgypTill
27.208333		A	Pgyp
26.541667	B	A	PolyS Granules
22.250000	B	A	PolyS Powder
22.000000	B	A	H2SO4
15.625000	B	A	Control
14.416667	B	A	CaCl2
11.291667	B		MgCl2

Sustainable agriculture-

PG – from waste to resource






SAFTY EXP

Objective : The ensure the safety of using FG for soil application

- The results indicate that there is no significant increase in radioactive and chemical contaminants in soil and plant following PG application.

Collaborators;

Ran Erel, Alon Ben-Gal, Issac Zipori, Guy Levy
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Ministry of Agriculture, Israel

Zohar Kerem, Loai Basheer
Faculty of Agriculture, The Hebrew University of Jerusalem, Israel

Thank you !

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Chief Scientist, Ministry of Agriculture, Israel

CFPN (ICL)

Publications;

-Segal, E., Dag, A., Ben-Gal, A., Zipori, I., Suryano, S. and Yermiyahu, U. (2011).Olive irrigation with reclaimed wastewater: agronomic and environmental considerations. *Agric. Ecosyst. Environ*. 140: 454-461.

-Frank, S., Dag, A., Yermiyahu, U., Zipori, I., Hadar, Y. and Minz, D. (2015). Seasonal effect and anthropogenic impact on the composition of the active bacterial community in Mediterranean orchard soil. *FEMS Microbiol. Ecol*. 91: fiv096.

-Erel, R., Eppel, A., Yermiyahu, U., Ben-Gal, A., Levy, G., Zipori, I., Schaumann, G.E., Mayer, O. and Dag, A. (2019). Long-term irrigation with reclaimed wastewater: Implications on nutrients management, soil chemistry and olive (*Olea europaea* L.) performance. *Agric. Water Manage*. 213: 324-335.

-Basher, L., Dag, A., Yermiyahu, U., Ben-Gal, A., Zipori, I. and Kerem, Z. (2019). Effect of reclaimed wastewater irrigation and fertigation level on olive oil composition and quality. *J. Sci. Food. Agric*. 99: 6342-6349.

-Ziskin, R., Dag, A., Yermiyahu, U., & Levy, G. J. (2024). Different amendments for combating soil sodicity in an olive orchard. *Agric. Water Manage*, 299, 108837.

Training course on Using low quality water for irrigation, Tel Aviv, 2016