Nature Based Circular Economy of Agro-industrial Wastewater

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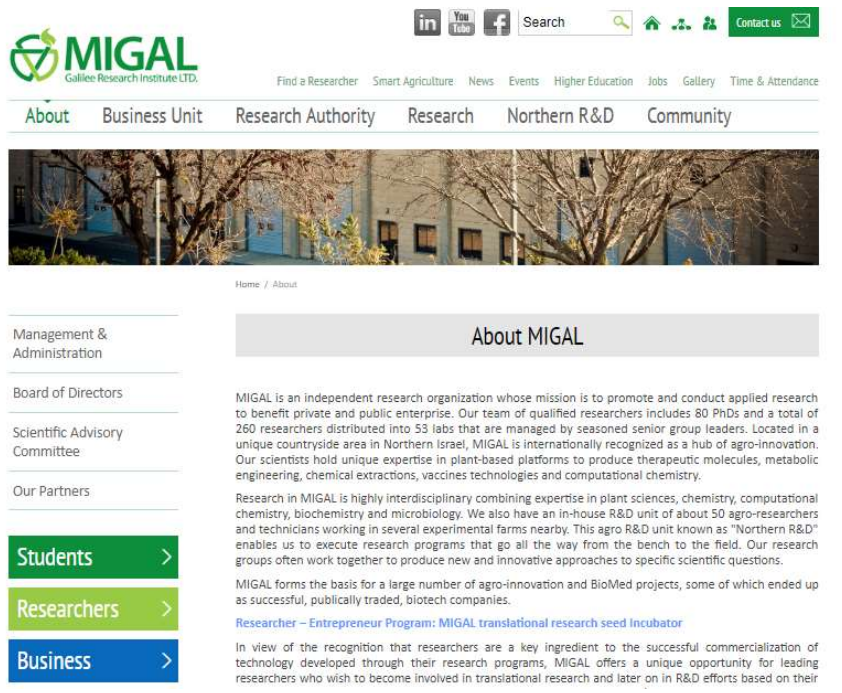
International Water Association

15th Specialized Conference on Small Water & Wastewater Systems

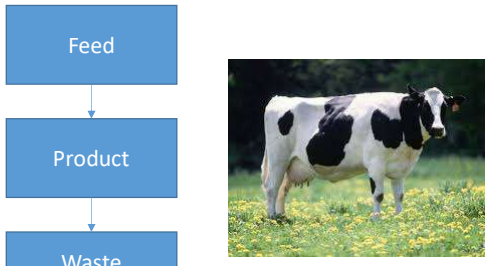
7th Specialized Conference on Resources Oriented Sanitation

14-18/10/2018 | Technion, Haifa, Israel

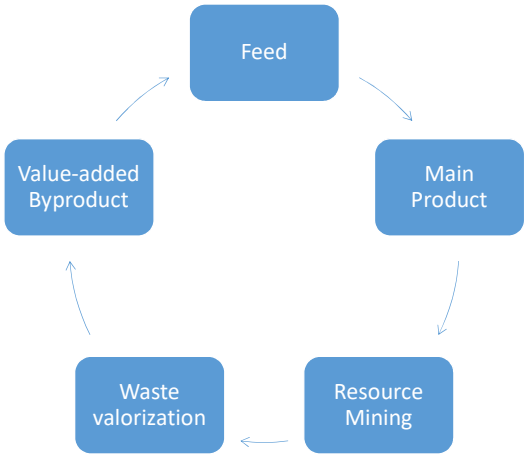


Change in Concept: From Linear to Circular Agro-Industrial Economy

Linear



Circular



BRIGAID
BRIDGING THE GAP FOR INNOVATIONS IN DISASTER RESILIENCE

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About the research

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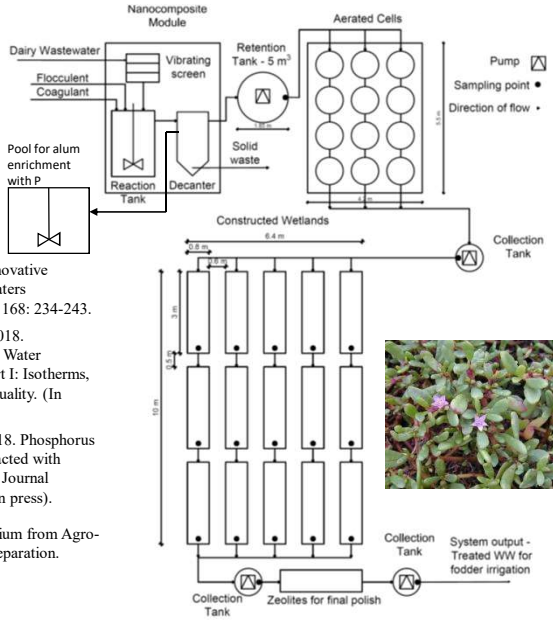
climateinnovationwindow.eu

- **BRIGAID** is a 4-year project (2016-2020) under EU Horizon-2020 aimed to effectively bridge the gap between innovators and end-users in resilience to floods, droughts and extreme weather
- **Specific goal**: circularize agro-industrial wastewater onsite to reuse standards- dairy farm as case study with focus on Sodium removal

Parameter	Typical Value in Dairy Sewage mg/L[1]	Regulation for release to sewage (mg/L)[2]	Regulation For irrigation[3]
COD mg/L	3,000-12,000	800	100
TSS mg/L	1,500-4,000	400	10
Total-N	200-600	50	25
Total-P	60-150	15	5
Na	***200-1000***	***150***	***150***

1. http://shaham.moag.gov.il/TrainingActivities/Cowshedwastewater/cowshed_wastewater.pdf
2. http://www.sviva.gov.il/InfoServices/ReservoirInfo/doclib/water-and-streams/maim51.pdf
3. https://www.health.gov.il/LegislationLibrary/Briut01.pdf

Schematic Diagram of Dairy Wastewater Treatment Facility



Zohar, I. J. Ippolito, M. S. Massey, M.I. Litaor. 2017. Innovative approach for Recycling Phosphorous from Agro-Wastewaters Using Water Treatment Residuals (WTR). Chemoshpere, 168: 234-243.

Zohar, I., M. S. Massey, J.A. Ippolito, and M. I. Litaor. 2018. Phosphorus Sorption Characteristics in Aluminum-Based Water Treatment Residuals Reacted with Dairy Wastewater, Part I: Isotherms, XRD, and SEM-EDS Analysis Journal Environmental Quality. (In press) doi:10.2134/jeq2017.10.0405

Massey, M.S., I. Zohar, J.A. Ippolito, and M.I. Litaor. 2018. Phosphorus sorption to aluminum-based water treatment residuals reacted with dairy wastewater, Part II: X-ray adsorption spectroscopy. Journal Environmental. Quality. doi:10.2134/ jeq2017.10.0407 (in press).

Orlofsky E. Chernovianov S. Litaor MI. Removal of Sodium from Agro-Industrial Waster with Halophyte-Zeolite wetlands. In preparation.

Sesuvium portulacastrum
Aizoaceae
- Halophyte, Edible, Cosmetic and Medicinal Uses

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Before

After

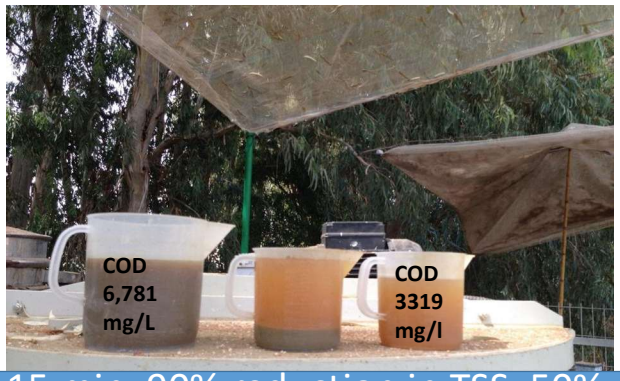
Step 1: Rapid settling with Nanocomposite Clay and Polymers

(19) United States
(12) Patent Application Publication
RYTWO

(54) METHOD FOR PRETREATMENT OF WASTEWATER AND RECREATIONAL WATER WITH NANOCOMPOSITES (60)

(71) Applicant: **Gavish-Galilee Bio Applications, Ltd.**, Kiryat Shmona (IL)
(72) Inventor: **Giora RYTWO**, Kiryat Shmona (IL)

(51)
(52)



15 min. 90% reduction in TSS, 50% reduction of COD

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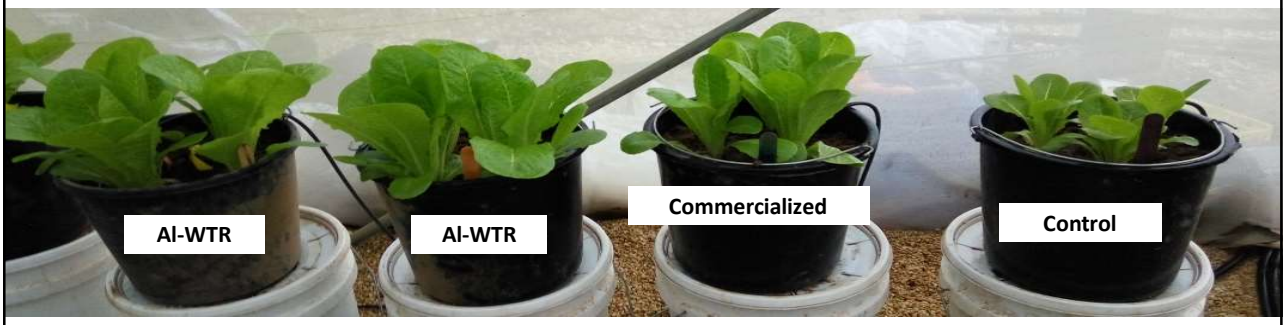
P-Mining from Dairy Wastewaters Using Al-WTR (Water Treatment Residuals)

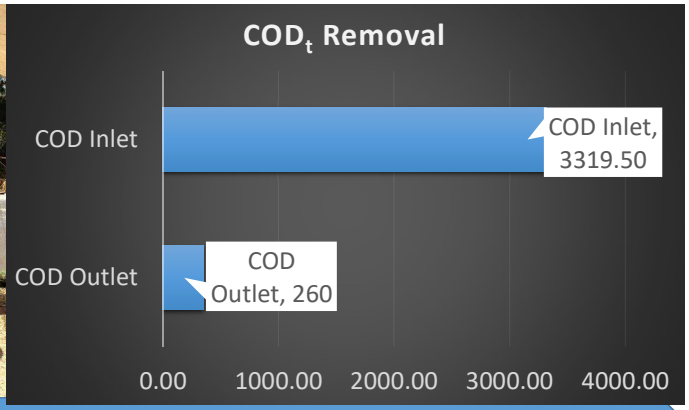
- Phosphorous is an essential plant nutrient, that has no substitute (USGS, 2007) and worldwide resources will be depleted in 100-200 yrs [median estimate] (Reijnders, 2014).



Zohar, I. J. Ippolito, M. S. Massey, M.I. Litaor. 2017. Innovative approach for Recycling Phosphorous from Agro-Wastewaters Using Water Treatment Residuals (WTR). Chemosphere, 168: 234-243

M. Iggy Litaor Schechter, S., I. Zohar, M. S. Massey, J. A. Ippolito, (in review). Making Phosphorus Fertilizer from Dairy Wastewater with Al Water Treatment Residuals. **Soil Science Society of America Journal**

Step 2: Organic Load, Nitrogen, Phosphorous Reduction in Aerated Bioreactor Cells

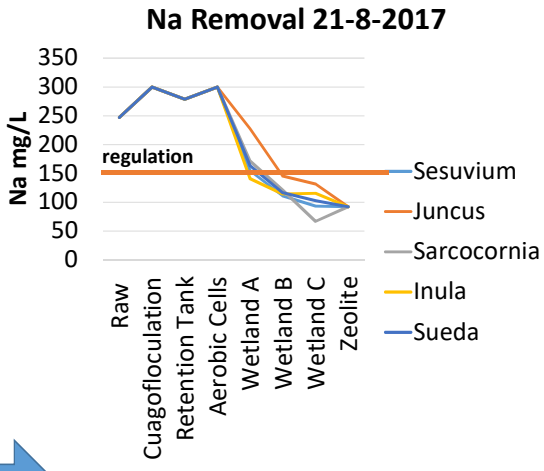


89% reduction in COD$_t$ (HRT <2 d)

Litaor, M. I. *et al. Environmental Nanotechnology, Monitoring & Management* **4,** 17–26 (2015).

Example of Full Scale System for Dalton Winery Onsite Treatment (NC + BAC)

Step 3- Natural Na removal with Halophyte Wetlands and Zeolite Mineral Ion Exchanger



2.3 d retention time to achieve <150 mg/L Na.

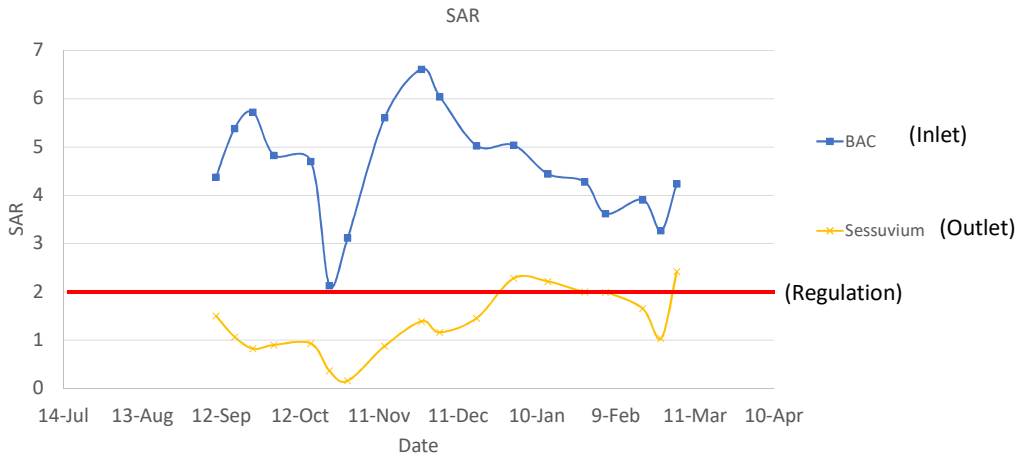
Water Through the Stages

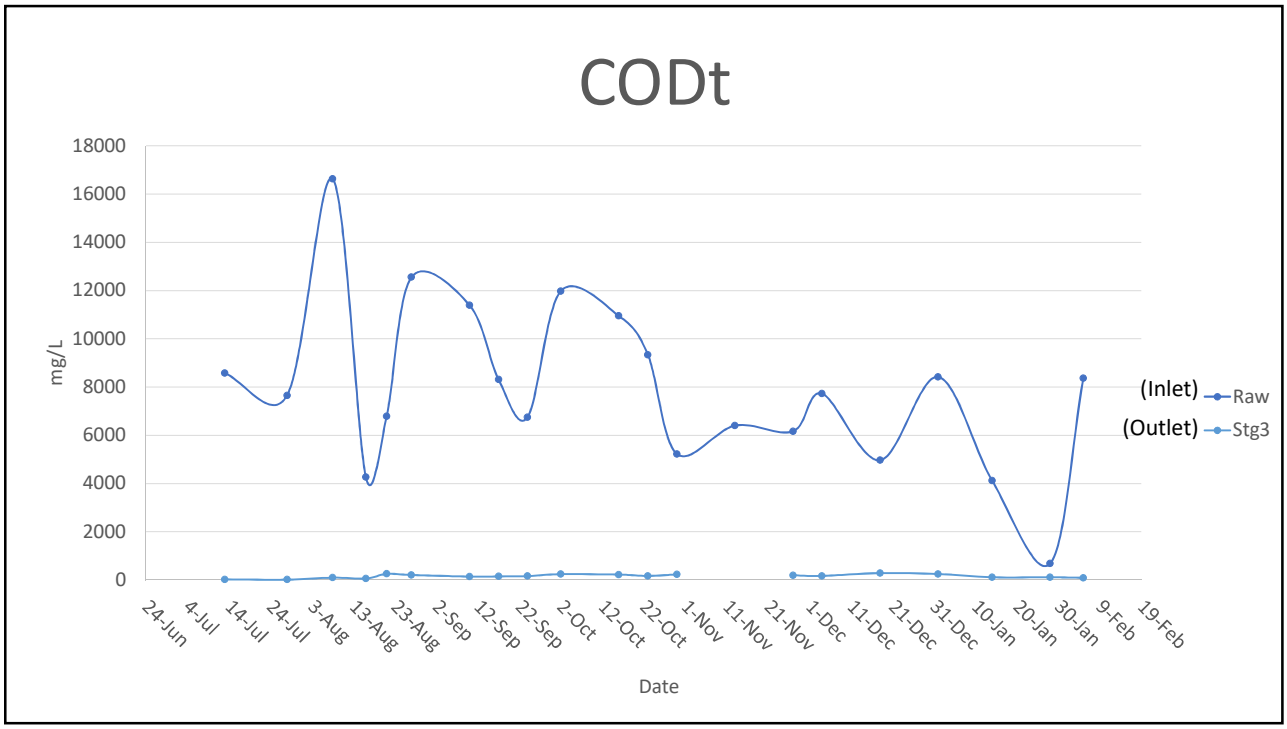
Options

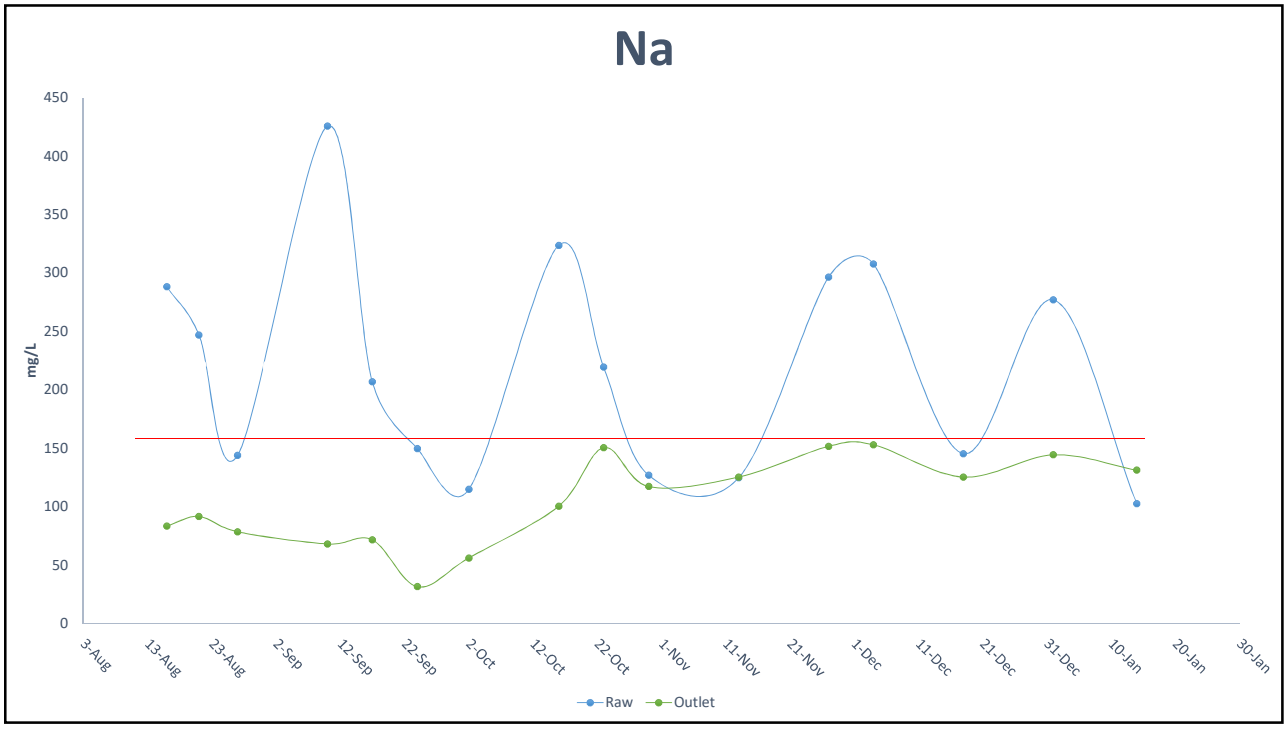
Direct Reuse (Onsite irrigation)- almost there!

To sewage system (regional irrigation)

Sodium Adsorption Ratio

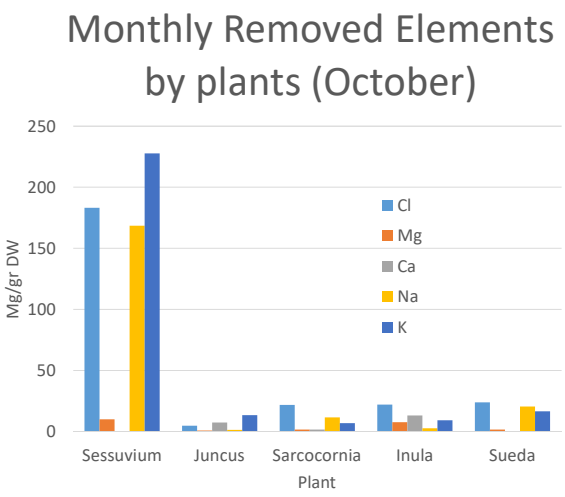



CODt
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
mg/L
24-Jun
4-Jul
14-Jul
24-Jul
3-Aug
13-Aug
23-Aug
2-Sep
12-Sep
22-Sep
2-Oct
12-Oct
22-Oct
1-Nov
11-Nov
21-Nov
1-Dec
11-Dec
21-Dec
31-Dec
10-Jan
20-Jan
30-Jan
9-Feb
19-Feb
Date
(Inlet) Raw
(Outlet) Stg3

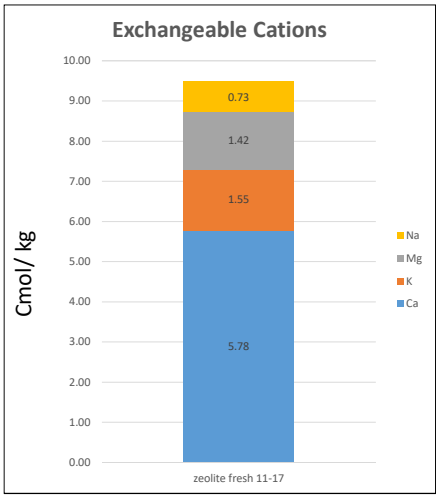

Na
450
400
350
300
250
200
150
100
50
0
mg/L
3-Aug
13-Aug
23-Aug
2-Sep
12-Sep
22-Sep
2-Oct
12-Oct
22-Oct
1-Nov
11-Nov
21-Nov
1-Dec
11-Dec
21-Dec
31-Dec
10-Jan
20-Jan
30-Jan
Raw
Outlet

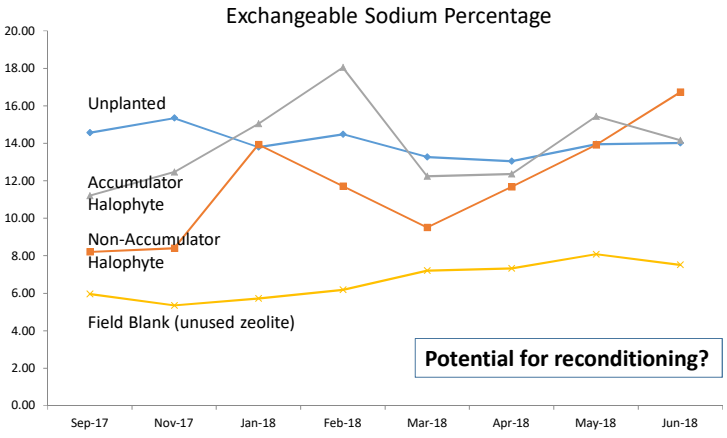
Do the Plants remove Sodium?

Plant Species	Weight	Na content (mg/g plant)	Removed Na (g)
Sesuvium portulacastrum	47.5 kg	50 – experimental 20- control	98.66
Juncus maritimus	9.5 kg	0- exp 0-control	-
Sarcoconia fruticosa	3	39.7- experimental 38.2- control	10.7
Inula crithmoides	4.5 (only one/three wetlands)	3.6- experimental 5.3- control	1.65
Suaeda monoica	9.75	41.0 experimental 16.6- control	32.7



What about the rhizosphere?





How Plants desalinate the rhizosphere

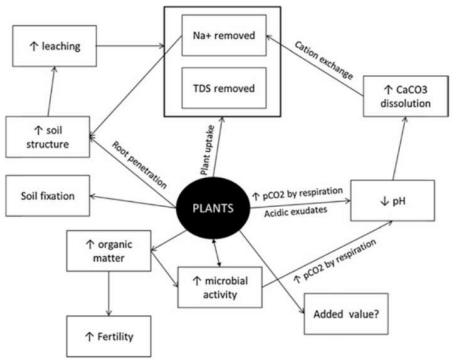


Fig. 5 Role of plants in salt-affected soil remediation and possible variations in soil properties as a result of this process (from Qadir et al. 2000, 2006; Rabhi et al. 2010)

Closing the Loop: Halophyte Agriculture

Certain plants can be grown at sea or in saline water with no signs of salt stress

Growing halophytes floating at sea

Ricardo Radulovich*, María José Rodríguez[1], Rebeca Mata[2]

Halophyte crop cultivation: The case for *Salicornia* and *Sarcocornia*

Yvonne Ventura, Moshe Sagi*

The Jacob Blaustein Institutes for Desert Research, The Albert Katz Department of Dryland Biotechnologies, Ben-Gurion University, PO Box 653, Beer Sheva 84105, Israel

Surface-flow constructed wetland fed with marine effluent.

Value-added byproduct: Antioxidant and emollient metabolites

Shella and Uthayakumari (2013) identified* 17 bioactive compounds in *S. portulacastrum,* including:

- **Squalene** (emollient)
- **Vitamin E** (emollient)
- Phytol (biocide)
- Benzoic acid (preservative)
- Hexadecanoic acid (antioxidant, nematicide)

*The sample workup was not targeted to individual compound characteristics and are found as relative, not absolute concentrations.

"**Truly one of nature's great emollients**, squalene is quickly and efficiently absorbed deep into the skin, restoring healthy suppleness and flexibility without leaving an oily residue"

Figure 2. Sectional view of the skin with sebaceous glands.

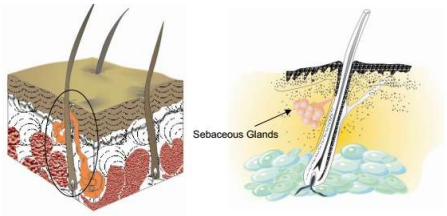


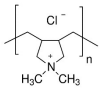
Table 1. Composition of sebum in humans.

Substance	Composition (%)
Wax esters	25
Squalene	13

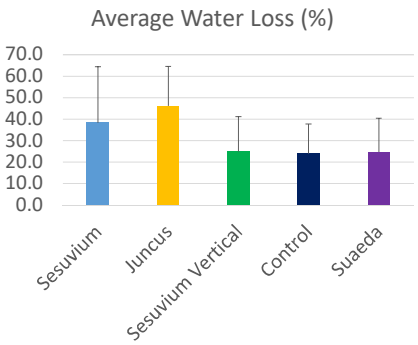
Zih-Rou Huang [1], Yin-Ku Lin [2,3] and Jia-You Fang [1,*]

Current Issue: excess chloride

- PolyDADMAC (150 mg/l)



- Evapotranspiration (150 mg/l, high variability)

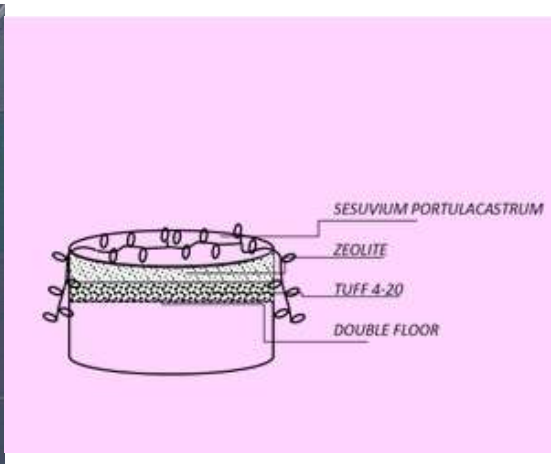


What can we do?

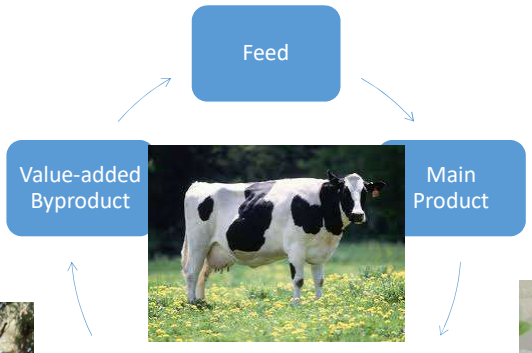
- Change the settling procedure
- Remove the chloride
- Reduce Water Loss

AND… Turn the limitation into an advantage

Towards Zero Liquid Discharge of Inland Brine from Slaughterhouse

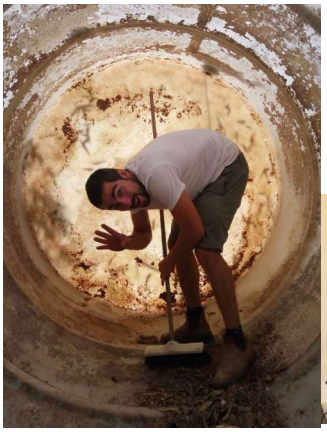


Summary



Thank You

Prof. Iggy Litaor
Simon Chernoivanov
Menashe and Nimrod Levy
MIGAL and The Hydrogeochemistry Lab
BRIGAID



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