



## Nature Based Circular Economy of Agro-industrial Wastewater

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**15<sup>th</sup> Specialized Conference on Small Water & Wastewater Systems**

**7<sup>th</sup> Specialized Conference on Resources Oriented Sanitation**

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The screenshot shows the MIGAL website interface. At the top, there is a navigation menu with links: About, Business Unit, Research Authority, Research, Northern R&D, and Community. A search bar and social media icons (LinkedIn, YouTube, Facebook) are also present. The main content area features a large image of a building and a section titled "About MIGAL".

**About MIGAL**

MIGAL is an independent research organization whose mission is to promote and conduct applied research to benefit private and public enterprise. Our team of qualified researchers includes 80 PhDs and a total of 260 researchers distributed into 53 labs that are managed by seasoned senior group leaders. Located in a unique countryside area in Northern Israel, MIGAL is internationally recognized as a hub of agro-innovation. Our scientists hold unique expertise in plant-based platforms to produce therapeutic molecules, metabolic engineering, chemical extractions, vaccines technologies and computational chemistry.

Research in MIGAL is highly interdisciplinary combining expertise in plant sciences, chemistry, computational chemistry, biochemistry and microbiology. We also have an in-house R&D unit of about 50 agro-researchers and technicians working in several experimental farms nearby. This agro R&D unit known as "Northern R&D" enables us to execute research programs that go all the way from the bench to the field. Our research groups often work together to produce new and innovative approaches to specific scientific questions.

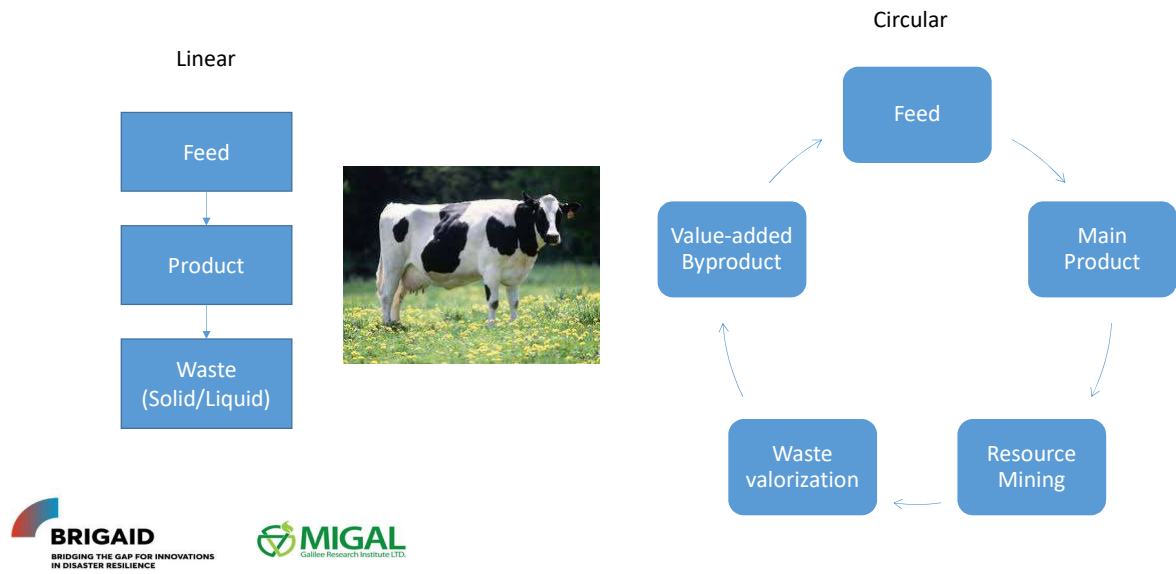
MIGAL forms the basis for a large number of agro-innovation and BioMed projects, some of which ended up as successful, publically traded, biotech companies.

**Researcher – Entrepreneur Program: MIGAL translational research seed incubator**

In view of the recognition that researchers are a key ingredient to the successful commercialization of technology developed through their research programs, MIGAL offers a unique opportunity for leading researchers who wish to become involved in translational research and later on in R&D efforts based on their

On the right side of the screenshot, there are two logos: "Northern R&D" (Northern Research & Development) and "Migal" (מִיגָל) with a drone icon. Below these is the text: "החברה למחקר ופיתוח קיבוצי ואיסום פירות בע"מ" and the website URL: <http://www.migal.org.il/>

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



### About the research

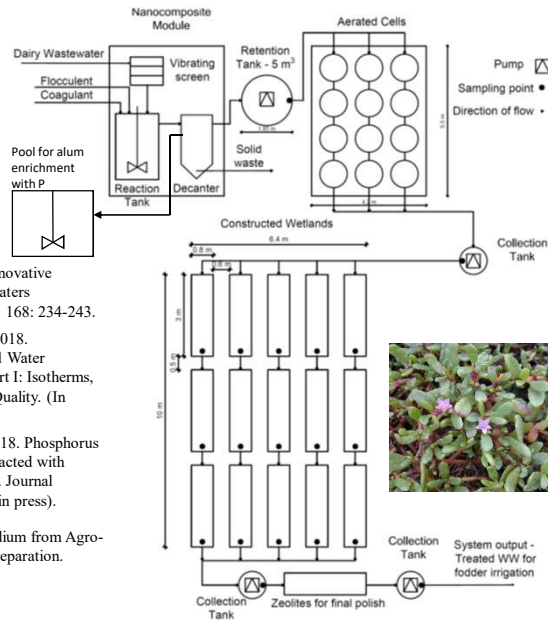


- **BRIGAIID** is a 4-year project (2016-2020) under EU Horizon-2020 aimed to effectively bridge the gap between innovators and end-users in resilience to floods, droughts and extreme weather
- **Specific goal:** circularize agro-industrial wastewater onsite to reuse standards- dairy farm as case study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

Parameter	Typical Value in Dairy Sewage mg/L <sup>1</sup>	Regulation for release to sewage (mg/L) <sup>2</sup>	Regulation For irrigation <sup>3</sup>
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
<b>Na</b>	<b>200-1000</b>	<b>150</b>	<b>150</b>

1. [http://shaham.moag.gov.il/TrainingActivities/Cowshedwastewater/cowshed\\_wastewater.pdf](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). *Chemosphere*, 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



**Before**



After



### Step 1: Rapid settling with Nanocomposite Clay and Polymers

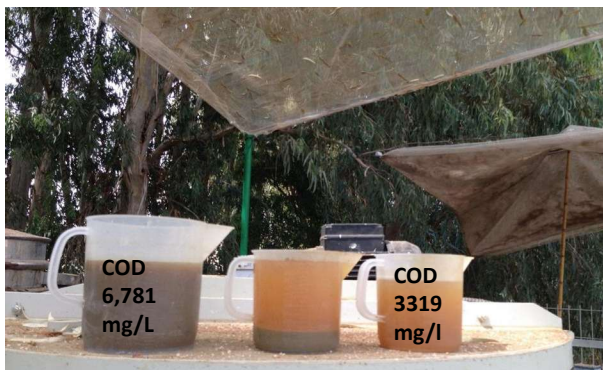
(19) **United States**  
 (12) **Patent Application Publication**  
 RYTWO

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(54) METHOD FOR PRE-TREATMENT OF WASTEWATER AND RECREATIONAL WATER WITH NANOCOMPOSITES (60)

(71) Applicant: Gavish-Galilee Bio Applications, Ltd., Kiryat Shmona (IL.) (51)

(72) Inventor: Giora RYTWO, Kiryat Shmona (IL.) (52)

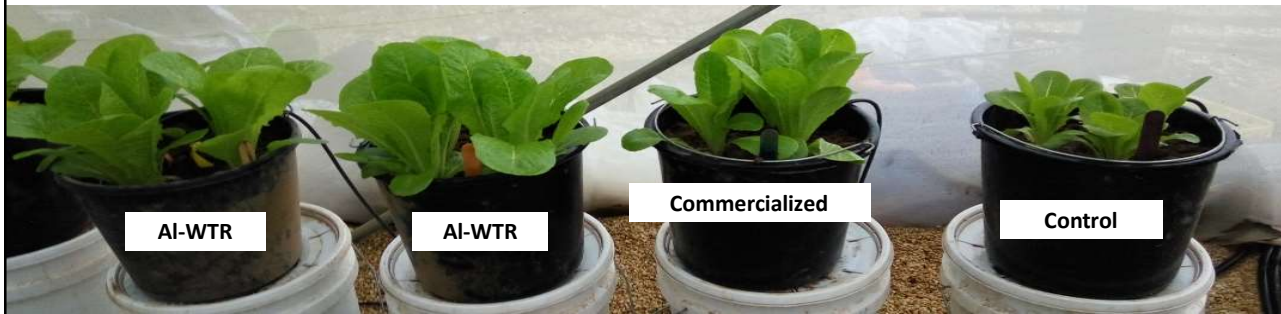


15 min. 90% reduction in TSS, 50% reduction of COD



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

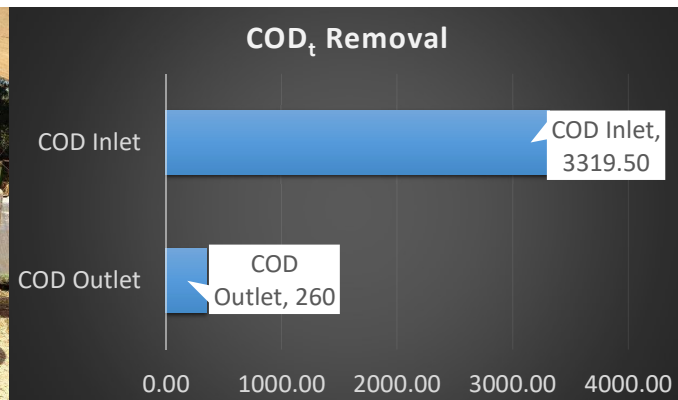
- Phosphorous is an essential plant nutrient, that has no substitute (USGS, 2007) and worldwide resources will be depleted in 100-200 yrs [median estimate] (Reijnders, 2014).



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 AI Water Treatment Residuals. *Soil Science Society of America Journal*

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



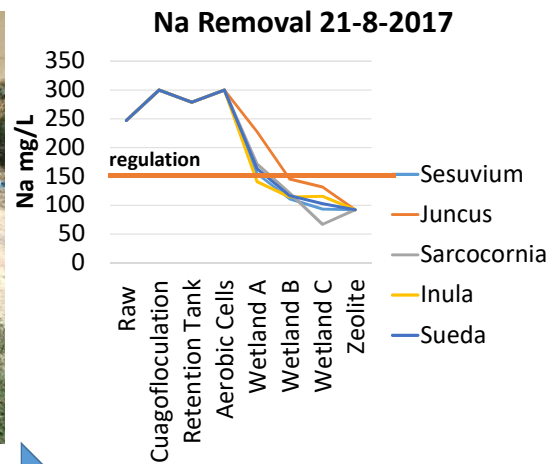
89% reduction in COD<sub>t</sub> (HRT <2 d)

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

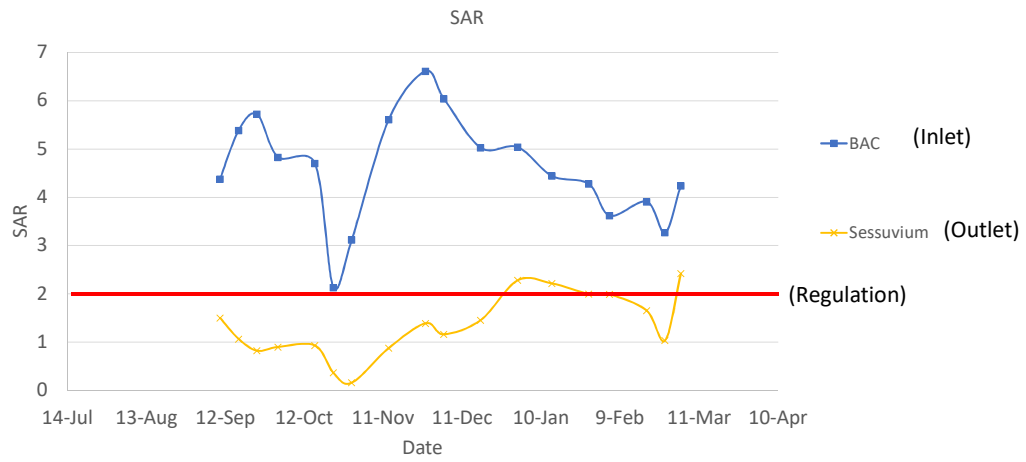


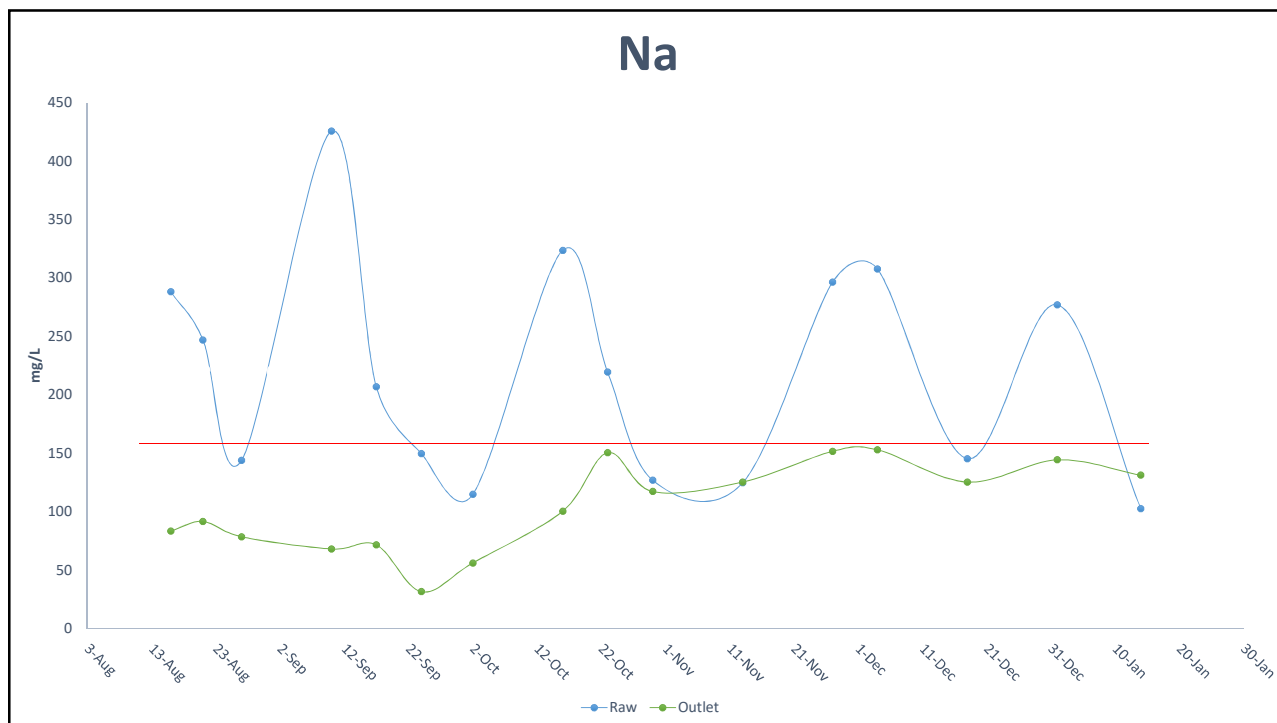
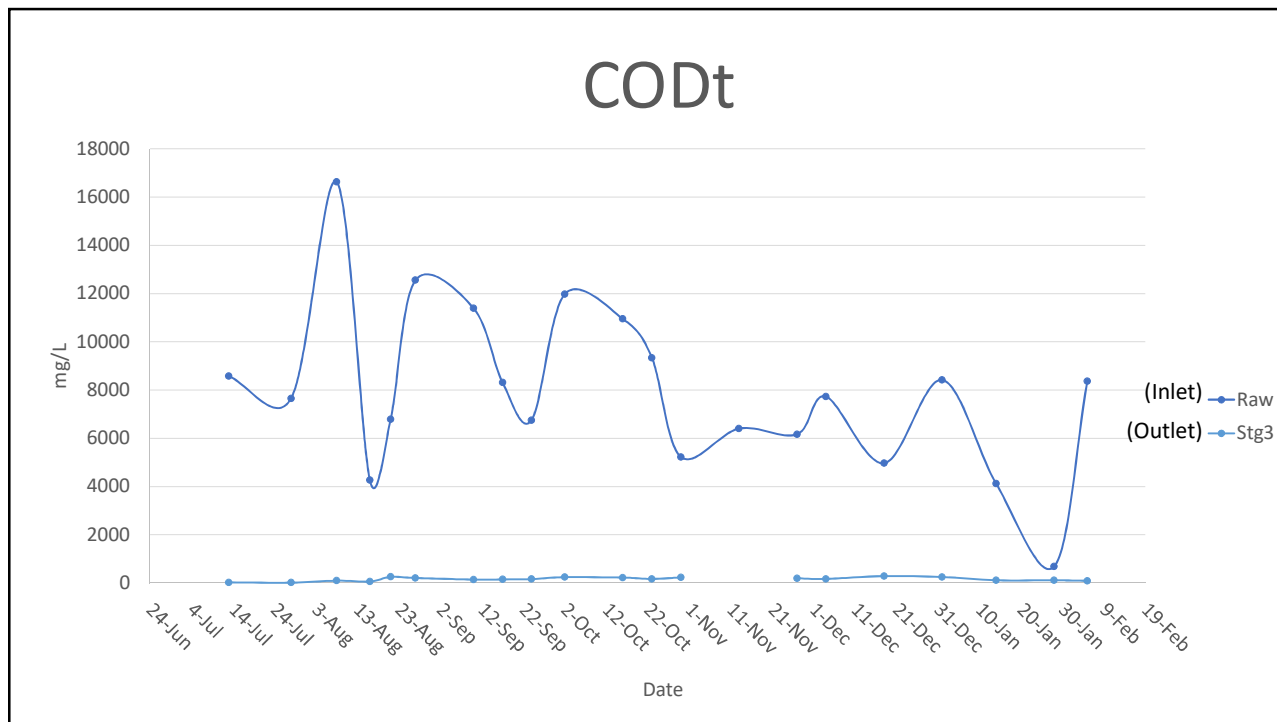
Options

Direct Reuse (Onsite irrigation)- almost there!

To sewage system (regional irrigation)

## Sodium Adsorption Ratio



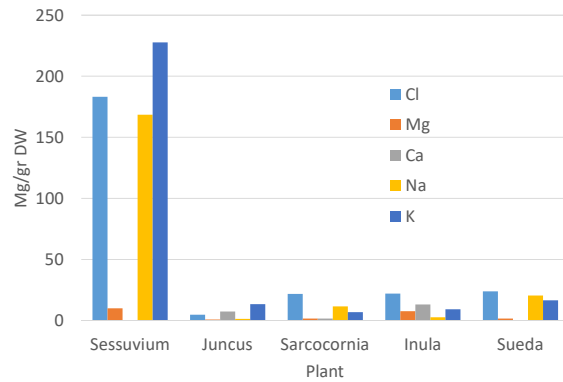




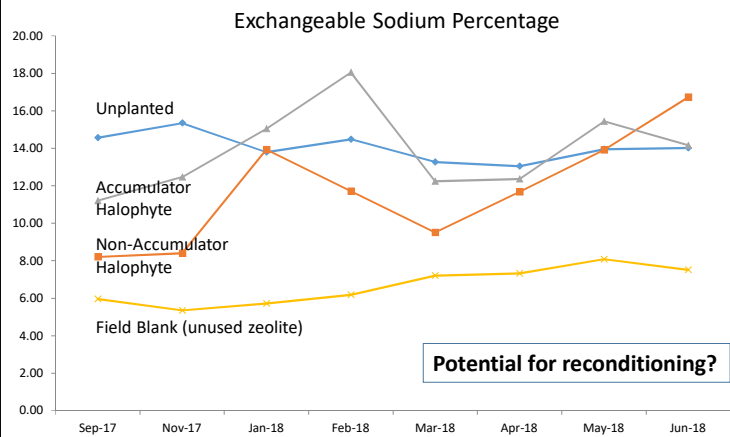
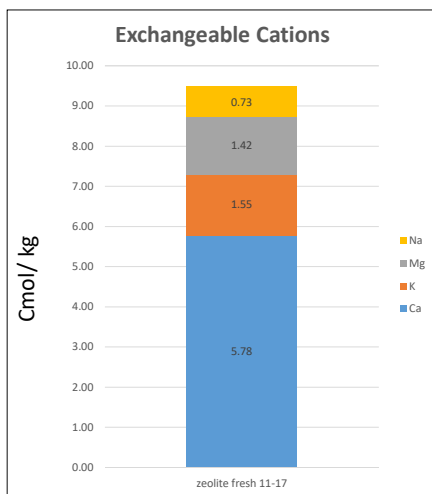
## Do the Plants remove Sodium?

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

### Monthly Removed Elements by plants (October)



## What about the rhizosphere?



Potential for reconditioning?

## How Plants desalinate the rhizosphere



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T.J. Purakayastha et al.

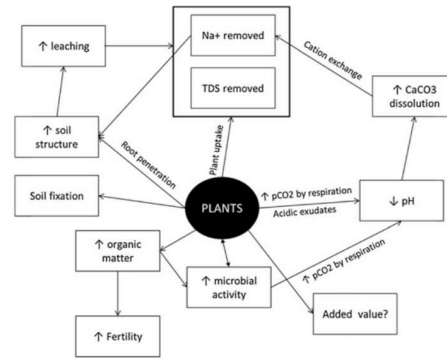


Fig. 5 Role of plants in salt-affected soil remediation and possible variations in soil properties as a result of this process (from Qadir et al. 2000, 2006; Rabhi et al. 2010)

## 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<sup>1</sup>, Rebeca Mata<sup>2</sup>



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.

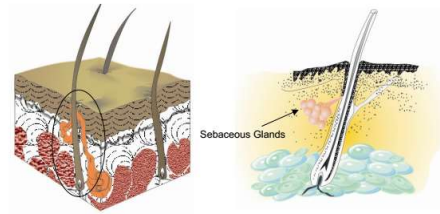


Table 1. Composition of sebum in humans.

Substance	Composition (%)
Wax esters	25
Squalene	13

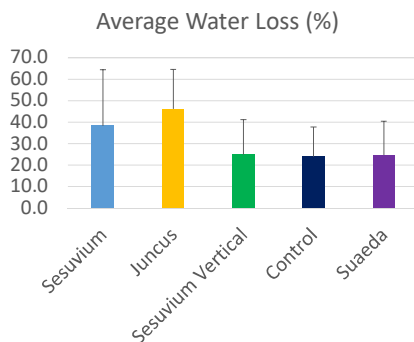
Zhi-Rou Huang<sup>1</sup>, Yin-Ku Lin<sup>2,3</sup> and Jia-You Fang<sup>1,\*</sup>

## Current Issue: excess chloride

- PolyDADMAC (150 mg/l)



- Evapotranspiration (150 mg/l, high variability)

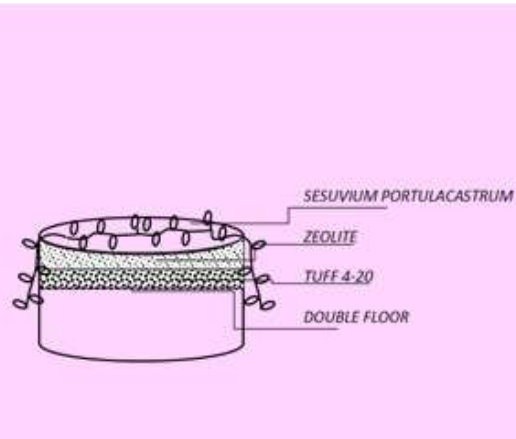


### What can we do?

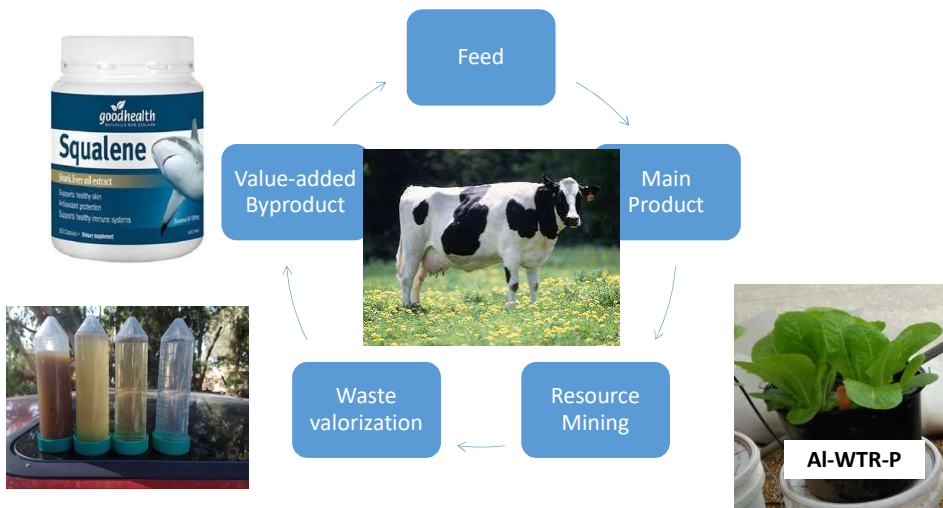
- Change the settling procedure
- Remove the chloride
- Reduce Water Loss

## AND... Turn the limitation into an advantage

### Towards Zero Liquid Discharge of Inland Brine from Slaughterhouse



## Summary



# Thank You

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



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