

14th Steering Committee Meeting of the
CGIAR Eco-Regional Collaborative Research Program
for Central Asia and the Caucasus

Promoting sustainable renewable energy production on marginal lands of Central Asia



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The rationale...

Irrigated land's areas per capita have been
fallen from 0.22 to 0.13 ha for last 25 years...



Uzbekistan loses about 20.000 hectares of agricultural lands by end of
every year by reason of high salinization...

2

That's why...

There are few important concerns:

To maintain soil productivity...

To recover soil productivity...

To use marginal lands effectively...

To use marginal water
a. Alternative resources of water
Drainage water
Thermal/Artesian water
Saline and alkaline/Sodic water
b. Waste-Water
Oil polluted water
Non-Food chain agriculture

...as a great potential source for biomass production /non-traditional agriculture use



3

Adoption of Biosaline Technologies in CAR :

- **the direct sowing of mixed crops** using zero-tillage techniques and green manure mulches;
- **biosaline agroforestry trials**
- **alley-cropping systems** (dual-purpose crops + multipurpose trees characterized with positive benefits on increased water-use efficiency, reduced transpiration rates and accumulation of toxic salts at the root zone) that result in water savings through the use of marginal quality drainage water; and
- **crop rotations** that alternate with indigenous halophytes to increase biosaline forage production for livestock feeding.



Halophytes can be used for **desalination** and **phytoremediation**...

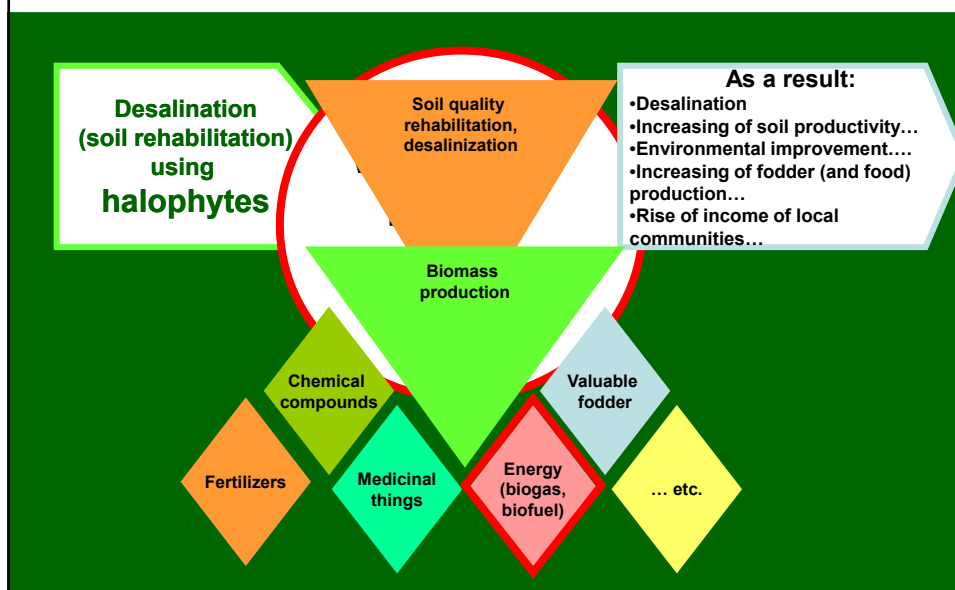


because many of them are able to accumulate some salts, extract salts from soil and irrigated water.

- The time for desalination is about 3-5 years, and 6-7 years at very high salinization level.
- As estimated, 18-20 tons/ha halophyte biomass can accumulate 8 – 10 tons of salts from 1 ha in a year.



Strategy for adoption of Biosaline technologies



Anaerobic digestion for halophyte biomass utilization as renewable energy production is suggested.



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International Center for
Biosaline Agriculture sub-office for
Central Asia and Caucasus

In joint investigations possibility of biogas production from halophyte biomass was proved scientifically...

7



Wild halophytes on saline abandoned land...



Mixed planting of triticale,
legumes and *Atriplex* sp.



Halophyte pasture
(*Kochia* sp.)



Mixed planting of *Climacoptera* sp.
and maize

8

Research objectives :

- To study anaerobic digestion (AD) of some halophyte biomass for methane-gas production;
- To compare AD of halophytes in mesophilic and thermophilic conditions in lab-scale experiments at batch-test and continuous-test modes;
- To design computer simulations (GPS-X program) for AD of various biomass for biogas production.

9

Objects of the investigation:



Kalidium caspicum



Climacoptera lanata



Salicornia europaea

A lab-scale experiments on anaerobic degradation of three wild halophytes (*Kalidium caspicum*, *Salicornia europaea* and *Climacoptera lanata*) from highly saline biotopes of Kyzylkum desert (Uzbekistan) and conventional glycophyte *Panicum coloratum* were conducted.



Panicum coloratum

10

Total mineral content



It was revealed that halophytes contain very high concentrations of mineral compounds

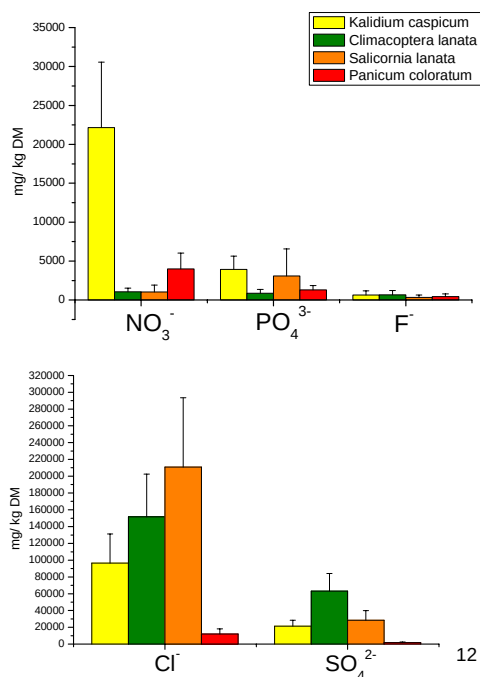
40-50% of DM

Plant species	Water content %	DM, % Dry matter content	Total mineral content, % from fresh weight	Total mineral content, % from dry weight
<i>Kalidium caspicum</i>	76,96	23,04	9,47	42.84 ± 2.48
<i>Climacoptera lanata</i>	78,52	21,48	10,09	51.62 ± 6.6
<i>Salicornia europaea</i>	83,02	16,98	6,75	38,64 ± 1.64
<i>Panicum coloratum</i>	-	-	-	8.01 ± 0.18
			Ash, % on FM ^[1] basis	Ash, % on DM ^[2] basis

[1] FM – fresh matter
[2] DM – dry matter

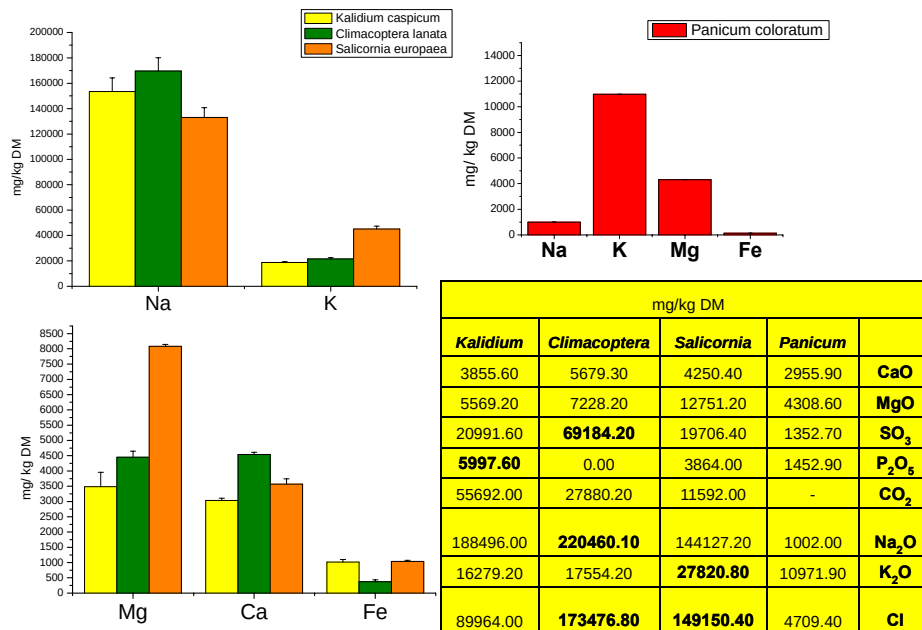
11

Anion content



12

Element composition



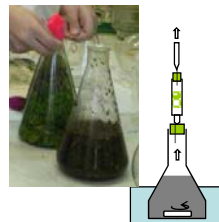
Soluble carbon

	mg/kg DM		
	Total carbon	Non-Purgeable Organic Carbon	Inorganic carbon
<i>Kalidium caspicum</i>	151200	165668.4	1032
<i>Climacoptera lanata</i>	79160	81672.43	980
<i>Salicornia europaea</i>	78200	77333.03	969
<i>Panicum coloratum</i>	82020	81180	1133

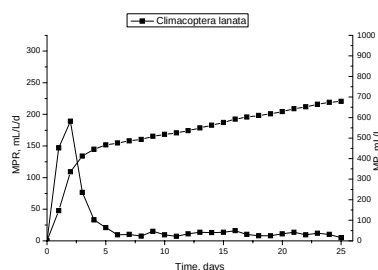


Batch-tests on anaerobic digestion of halophytes biomass

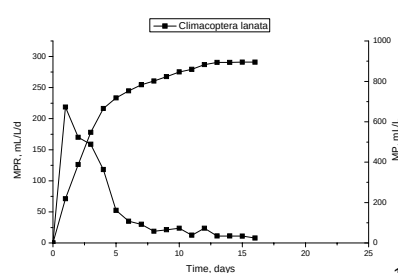
Organic fractions (%)	Easy convertible to CH ₄		Slowly convertible to CH ₄		Inert	
	Meso	Thermo	Meso	Thermo	Meso	Thermo
<i>Kalidium capsicum</i>	55	39	>17	32	<28	29
<i>Climacoptera lanata</i>	21	35	>29	27,5	<50	37,5
<i>Salicornia europaea</i>	19	24	>39	43	<42	33
<i>Panicum coloratum</i>	35	41,5	>21	20	<44	36



Mesophilic conditions (35°C)



Thermophilic conditions (55°C)



15

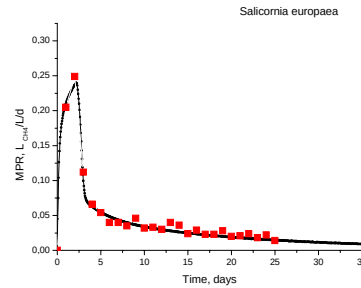
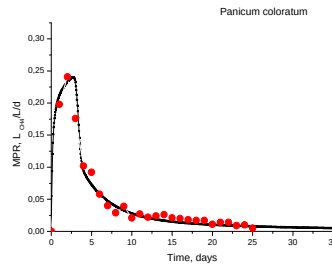
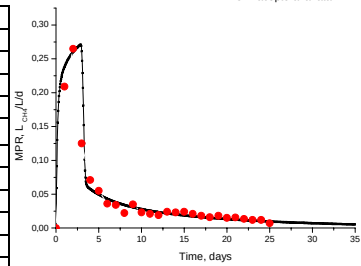
1. Gas yield in M and T conditions was similar
2. Rates of biomass degradation were higher at thermophilic conditions. At T-conditions about 80% of cumulative gas was produced during 5-10 days, at M – it took 25-30 days
3. Maximal amount of methane-gas was produced in result of anaerobic degradation of *Kalidium* (1000 mL/L at T; 1100 mL/L at M), *Salicornia* had produced 950/900 mL/L, *Panicum* - about 900/800 mL/L; and *Climacoptera* – 880/700 mL CH₄ from L of sludge.



16

Obtained and predicted results of AD of plant biomass at M-conditions

Kinetic Constants (plant)	<i>Climacoptera</i>	<i>Panicum</i>	<i>Salicornia</i>	
plant maximum specific hydrolysis rate	0.86	0.88	0.75	[1/d]
plant hydrolysis half saturation coefficient	0.001	0.001	0.001	[-]
half-delay time of hydrolysis	0.01	0.01	0.01	[d]
plant very slowly hydrolys.comp. sp.reaction rate	0.095	0.3	0.06	[1/d]
Kinetic constants (microorganisms)				
sp.decay rate of heterotrophic aerobes in ad sludge	0.35	0.1	0.37	[1/d]
specific decay rate of methanogens in ad sludge	0.001	0.001	0.001	[1/d]
specific decay rate of acidogens in ad sludge	0.05	0.035	0.01	[1/d]
maximum specific growth rate of acidogens	0.098	0.09	0.09	[1/d]
half-saturation coefficient on growth of acidogens	3	8.94	3	[gCOD/m3]
maximum specific growth rate of methanogens	0.028	0.025	0.025	[1/d]



17



Continuous tests on AD of halophyte biomass for biogas production (35°C, 55°C)

Lab-scale experiments in continuous mode during 30, 40 and 110 days had showed possibility for a stable producing of

300-500 mL of CH₄ per day from 1 L of ADL.



To avoid an inhibiting effect of salts on anaerobic bacteria it is need to adjust OLR and HRT, and to add microelements (Ni, Co, Fe) into anaerobic reactor fed halophyte biomass.

18

Conclusions:

- Biomass of halophytes (inedible biomass!) can be used as a **valuable source of methane-gas** and it may become an important source of secure and sustainable energy in arid lands



- **The 1st International Conference on Arid Land (ICAL1)**, Narita-Tokyo, Japan, May 24-28, 2011.
- **EXPO-4**, Tashkent, Uzbekistan, May, 2011.
- **17th International Energy and Environment Fair and Conference**. Istanbul, Turkey, 15-17 June, 2011.

Future prospects...

- Appropriate technologies of cultivation of halophytes in single or mixed planting are developing now in Uzbekistan **to produce sufficient amount of plant biomass for biogas production and for desalination and improvement of lands.**
- **Incentives for farmers and agropastoralists** to invest in increasing productivity of marginal lands and to establish small alliance (cooperatives) and investments in market outlets are very important.
- **Creating institutional arrangements and policy interventions** to increase community participation in arid biosaline conservation agriculture on marginal lands is critical.

Thank you for attention!

20