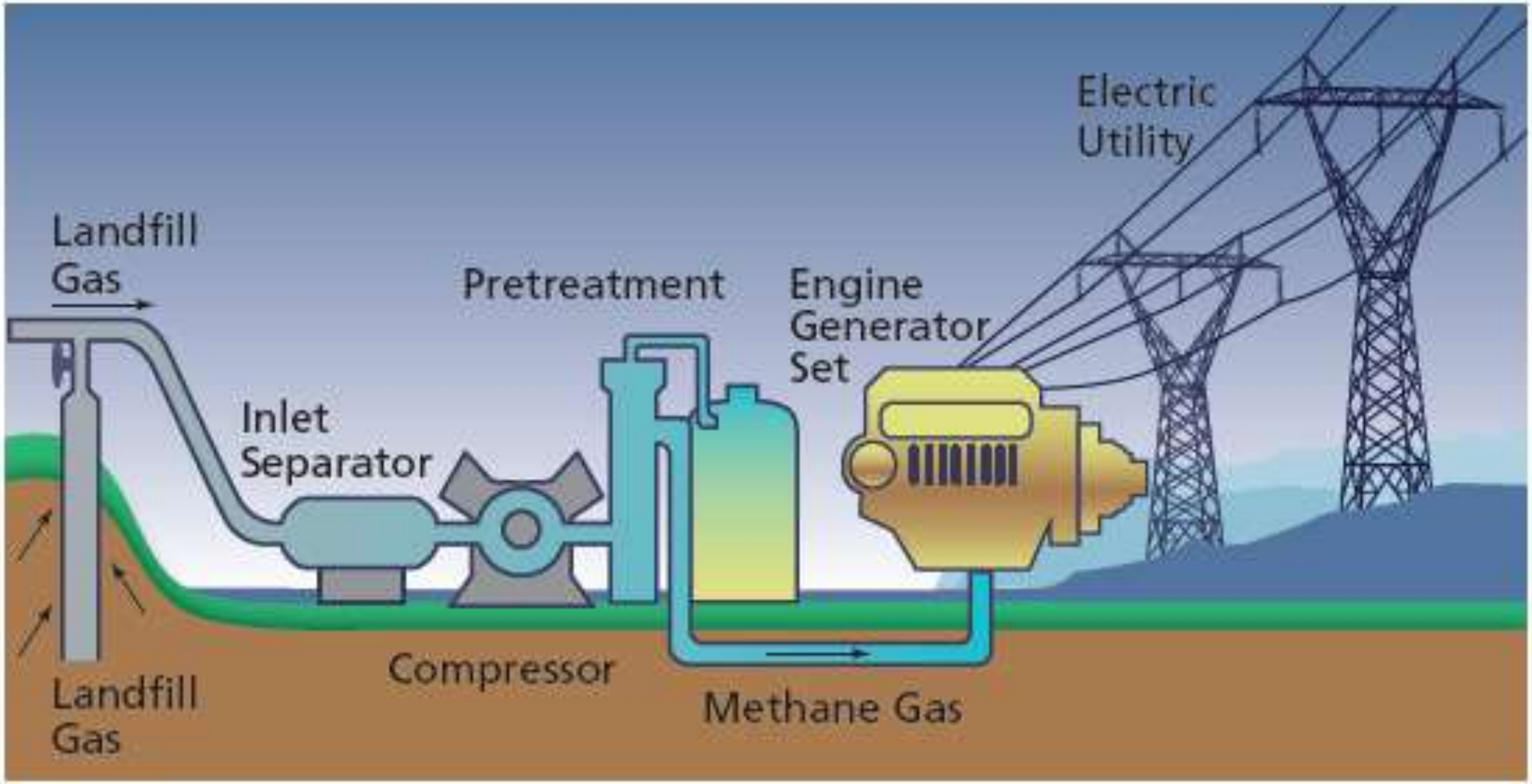
ENERGIA ALTERNATIVA DESDE LOS RELLENOS

Raffaello Cossu, Maria Cristina Lavagnolo, Mario Malagoli

University of Padova

GRAL , Junio 2015 Antigua, Guatemala

Traditional energy generation from landfilling



RESIDUAL DERELICT AREAS

- Closed landfill are often marginal lands with very low value, located far from city centres and residential areas.
- Landfill site can also occupy large areas

El relleno de Bordo Poniente, Mexico

374 hectáreas de superficie!

ALTERNATIVE RENEWABLE ENERGY SOLUTIONS

The use of these large landfill spaces to locate renewable energy plants could represent a possibility to avoid competition with farmlands for food production and to improve socio-economical conditions of local communities providing new jobs and benefits into abandoned or potentially contaminated sites. Whether national legislations provide incentives for renewable energy production, the income from renewable energy production can represent a benefit for landfill owners and managers to support costs for landfill monitoring and post-closure management.

SOLAR ENERGY

- Landfill location in intensive solar radiation
- Physical characteristics of landfill top cover Surface slopes
- Panel placement angles
- Foundation needs for panels

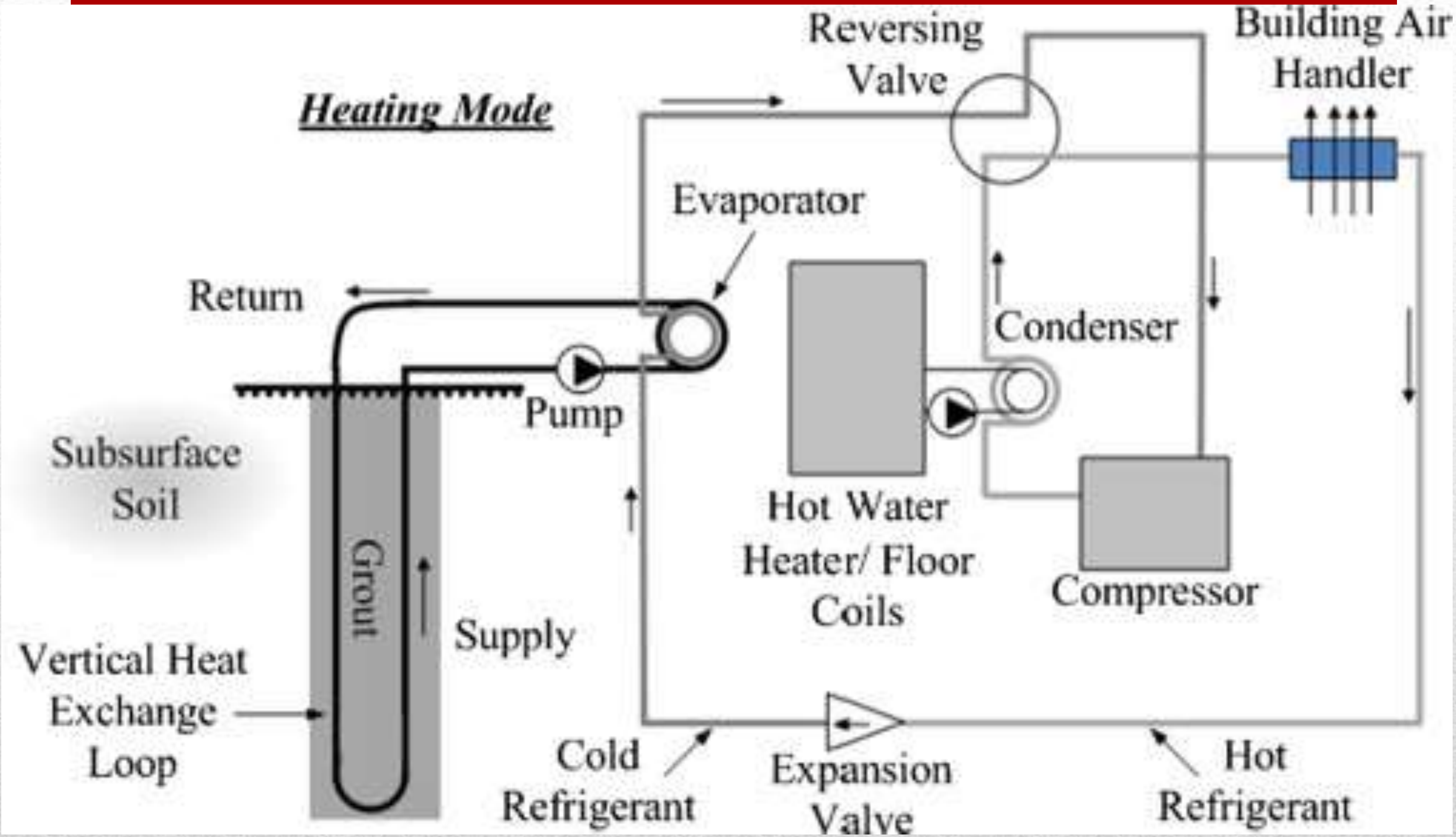
WIND ENERGY

- Windmill can represent a potential utilisation of landfill sites
- Meteo conditions (whether, wind)
- Foundations for high windmill towers

GEOTHERMAL ENERGY

- Aerobic landfill may represent a source of energy if the Heat generated by the exothermal aerobic degradation is recovered.
- Aerobic degradation can lead to temperature of up to 70-80° C and the insulation capacity of landfill bodies can retain this heat and avoid its dispersion in atmosphere.

GEOTHERMAL ENERGY



Ground-source heat pumps can use the heat source of landfill bodies to supplement heating and cooling systems for houses and buildings *(Coccia et al., 2013).*

ENERGY CROPS

- Closed landfill sites may also provide possibilities to combine renewable energy production and leachate treatment.
- Phytotreatment units on landfill top cover surfaces to treat the leachate still generated by the landfill, planted with crops or oil-rich plants can represent a solution for the production of bio-fuels (biodiesel or bioethanol).

Research aim

- Treatment and recycle of wastewater (*sewage fractions, leachate*) by using phytoremediation
- Cultivation of oleaginous plants suitable for biodiesel production
- Use of delerelict areas (*landfill surface*)
- Solution to the “Tank or table?” dilemma

Possible wastewater-plants-soil combinations

Wastewater
A. Grey water
B. Yellow water
C. Landfill Leachate

Culture
α. Sunflower (*Helianthus annuus)*
β. Soybean (*Glycine max*)
γ. Rapeseed (*Brassica napus*)

Substrate
I. Landfill surface (Sand)
II. Landfill surface(Agricultural soil)
III. Contaminated soil

Three combinations have been tested at a lab scale:

First run:

A+B in different proportion; three cultures (α, β, γ); substrate I

Second run:

C in decreasing dilution; crops (α, β, γ); substrates I and II

Thirsd run:

A+C; energy crops:(α, β) ; substrate II

Materials and methods: the pots

level check, sampling device

Lab scale experiment
20 L pot

30 cm
GROWING LAYER

I experiment: *sand*
II experiment: *sand or agricultural soil*
III experiment: *agricultural soil*

10 cm
WATER DRAINAGE LAYER
gravel

Materials and methods: the greenhouse

Duration: 3/4 months (april-july)

Climate condition: controlled

Temperature: 21 – 26° C

4 pots per each species
+ control

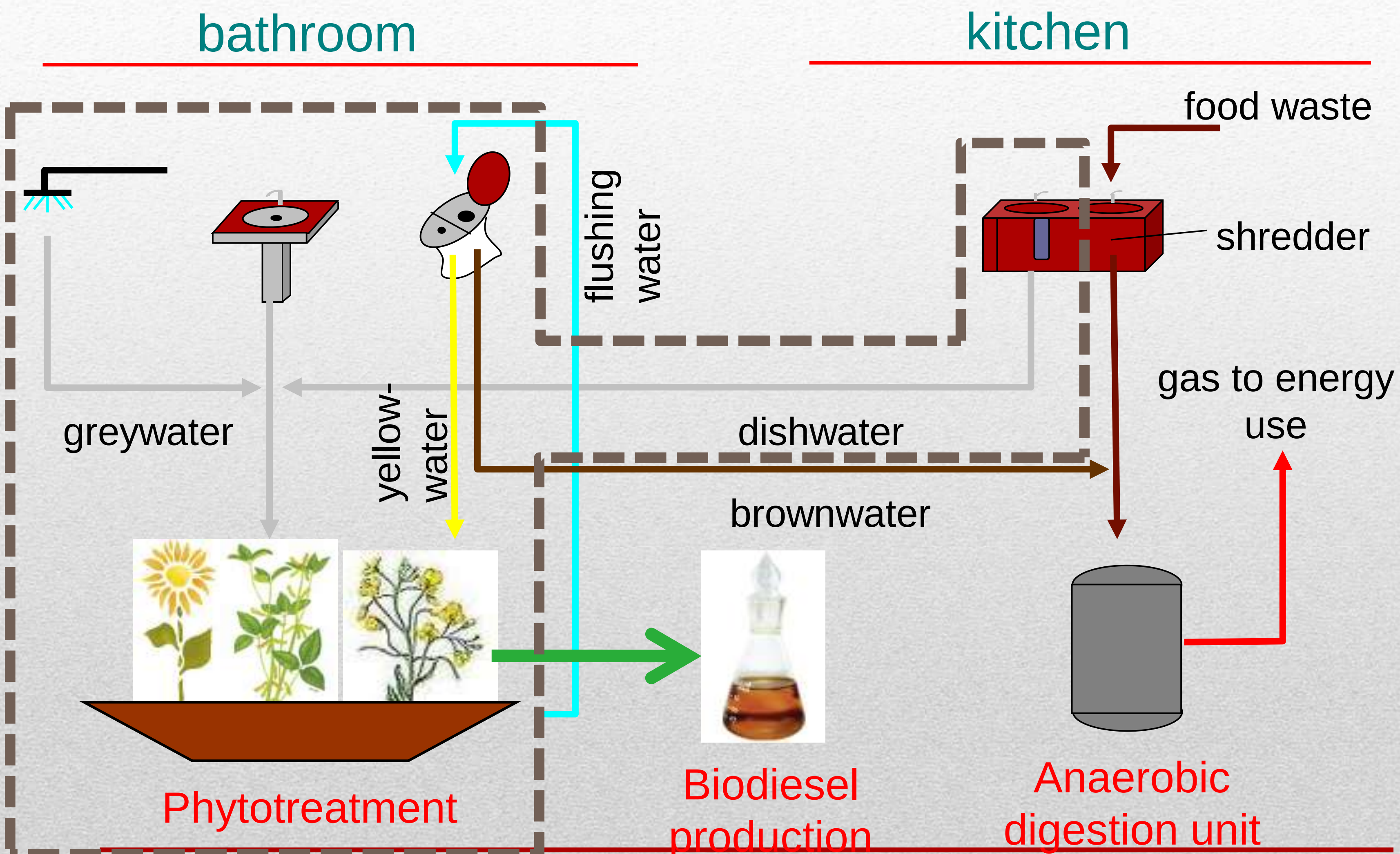
The setting

The plants

Sunflowers Soybean Rapeseed

I Run: Waste waster

The *AQUANOVA* Concept

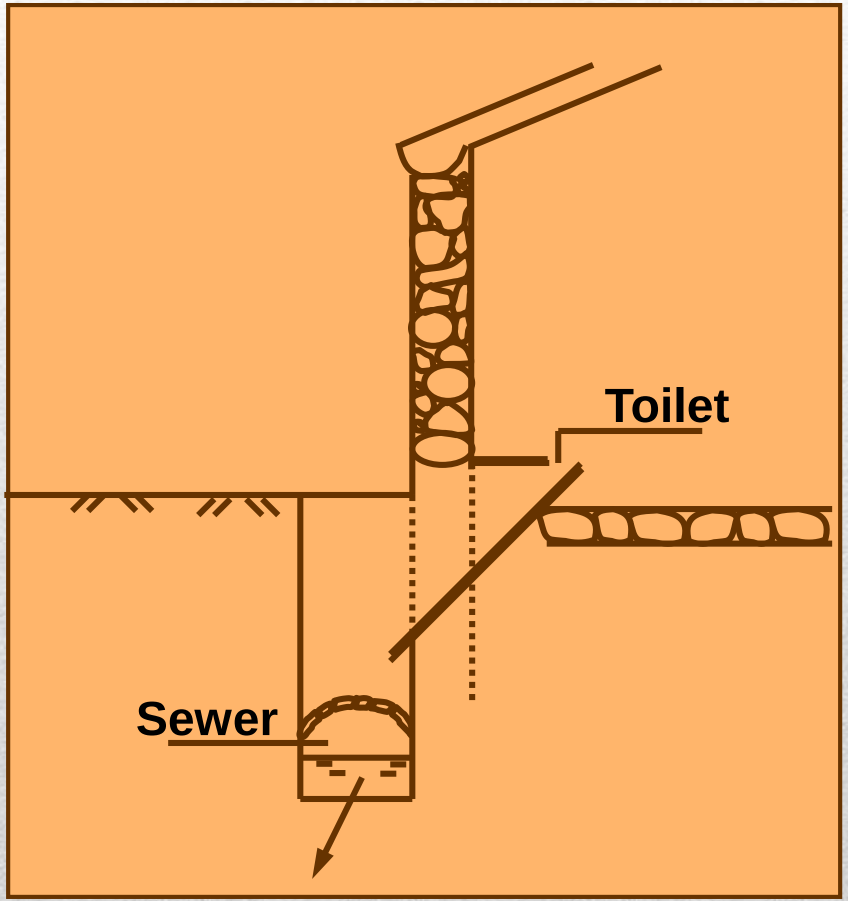


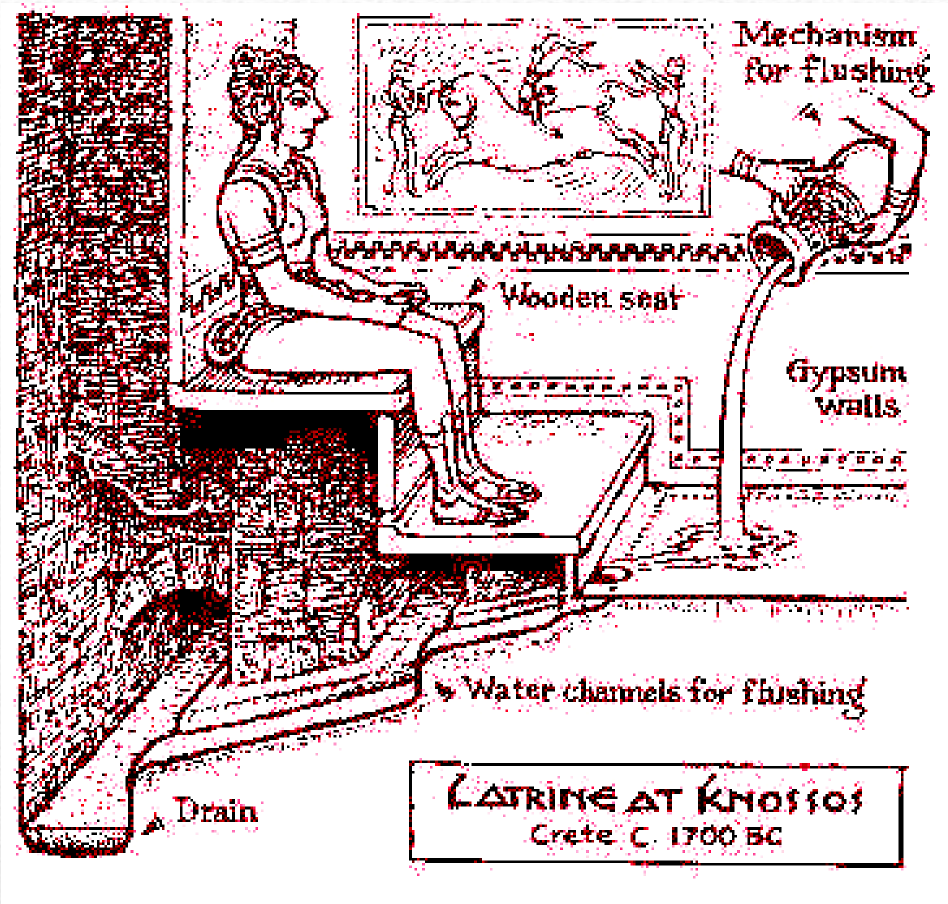
SCHEME INVOLVED IN THE INVESTIGA

Our life friend: the toilet

Toilet systems

3500 – 2500 BC – Mesopotâmic Empire





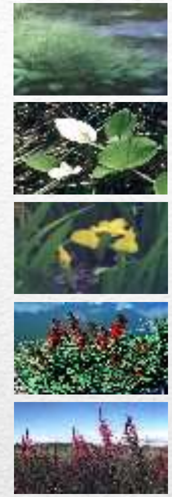
1700 BC – Crete (King Minos Palace)

AQUANOVA System

CAMPUS OF THE UNIVERSITY OF PADOVA, ITALY

AQUANOVA System

Tested plants – small scale



Alisma
Calla
Iris
Lobelia
Lytrum

Mentha
Thalia
Typha
Acorus
Canna
Lysimachia
Eichornia
Lemna

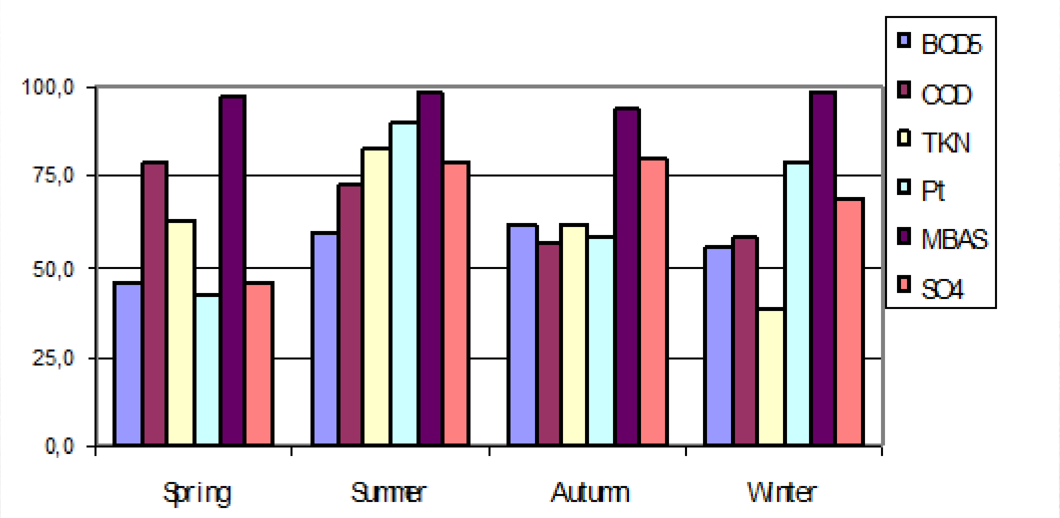
Selected plants

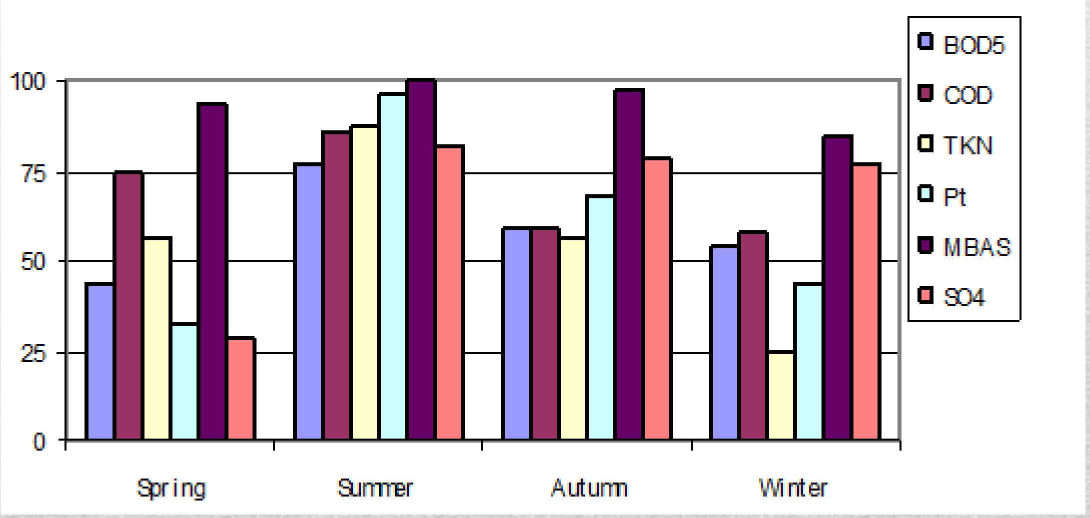
Canna Lisimachia Litrum Alisma Thalia

Canna Preselia Pontederia Iris Menta

AQUANOVA System

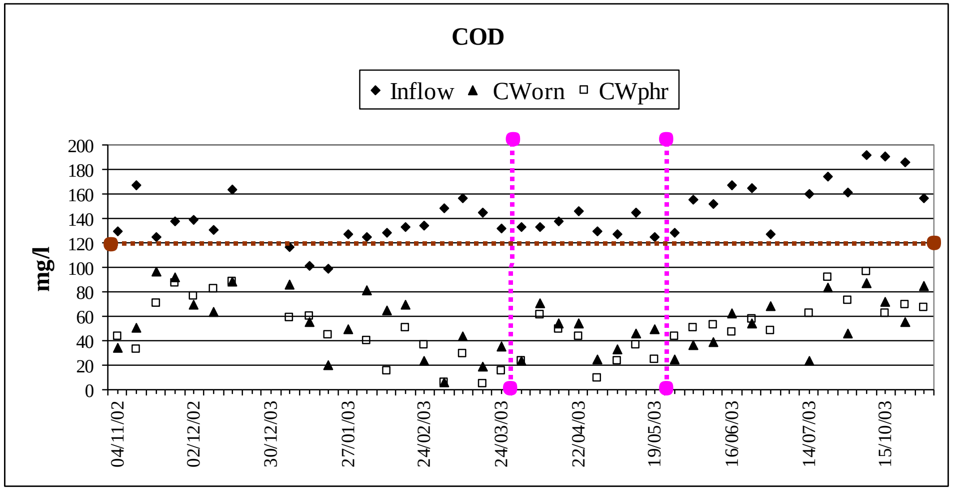
Phytotreatment – Removal rate

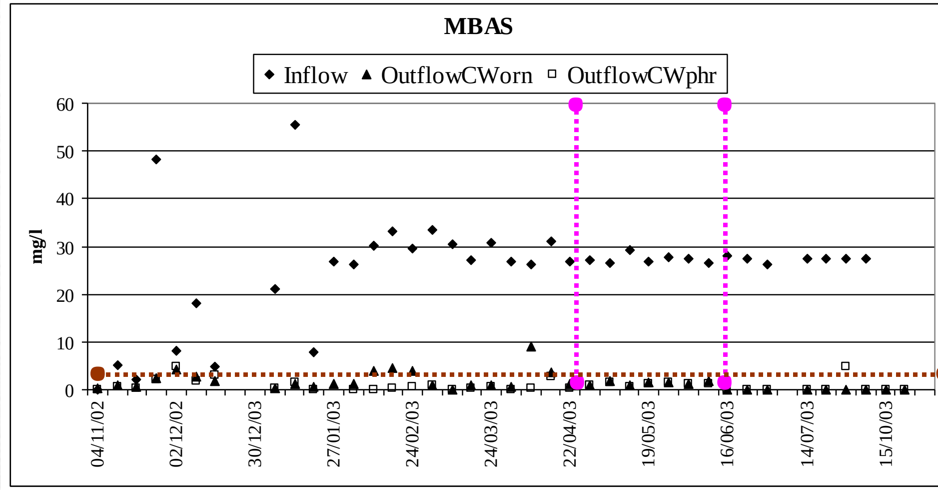


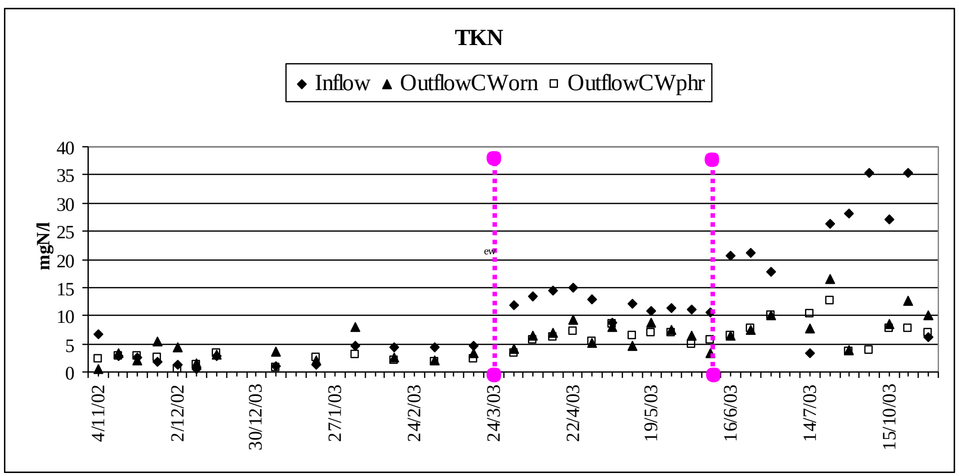


AQUANOVA System

Phytotreatment – Removal rate





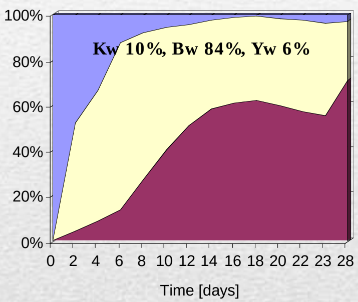


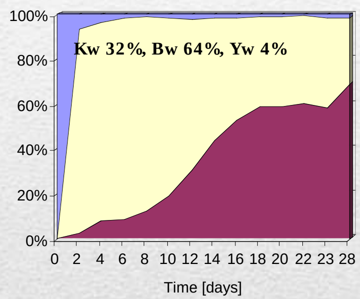
Concentration of different parameters (COD, BOD, MBAS) in the inflow and the outflow of both units (CWonr and CWphr)

AQUANOVA System

Anaerobic digestion – Gas production

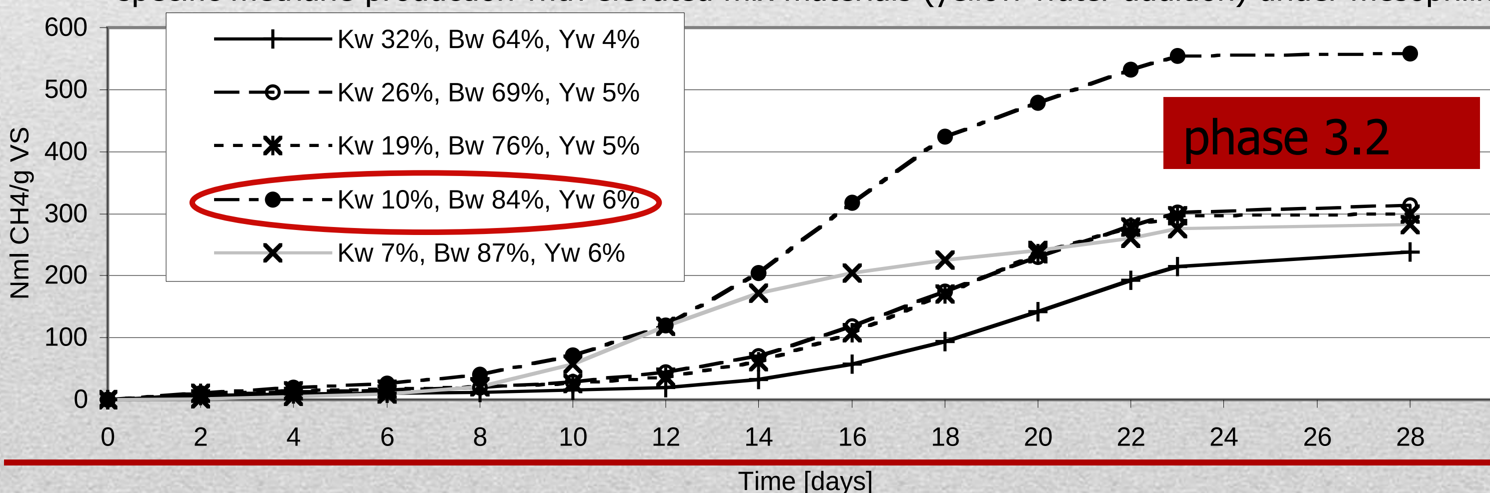
	Temperature Condition*	Seeded bacterial type	Substance
Phase 1	Mesophilic	Mesophilic	KW, BW, YW (Single factor)
Phase 2	Thermophilic	Thermophilic	KW, BW, YW (Single factor)
Phase 3-1	Mesophilic	Mesophilic	KW, BW (Mixed)
Phase 3-2	Mesophilic	Mesophilic	KW, BW, YW (Mixed)





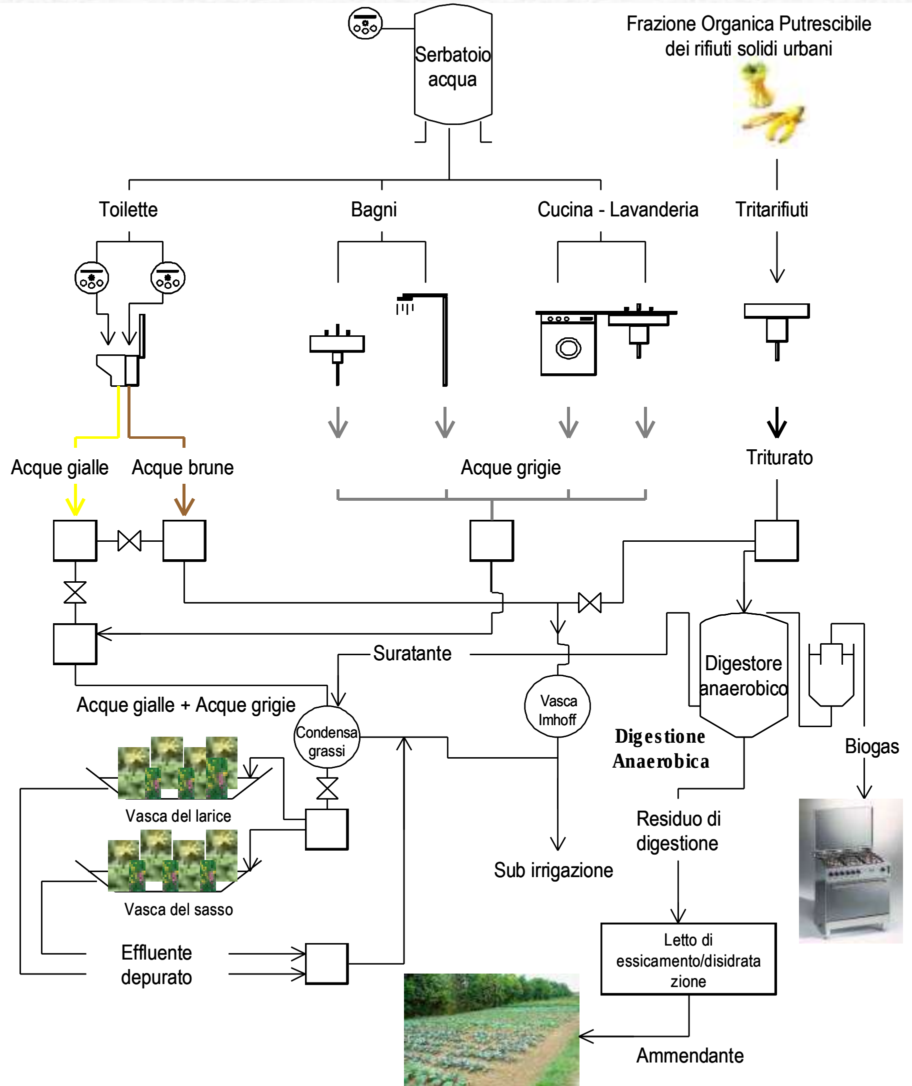
ırameter	KW32%	KW26%	KW19%	KW10%	KW7%
P CH_4/g-VS]	274.4	359.3	332.1	606.9	283.5
Rm CH_4/g-VS d]	22.43	27.4	31.06	51.67	25.99
– [d]	13.32	11.26	12.09	9.62	7.59
R^2	0.98	0.98	0.98	0.99	0.99

specific methane production with elevated mix materials (yellow water addition) under mesophilic condition



AQUANOVA System

ENERGIANOVA Project
BOSCONERO mountain hut, Forno di Zoldo, BL – 1457 m



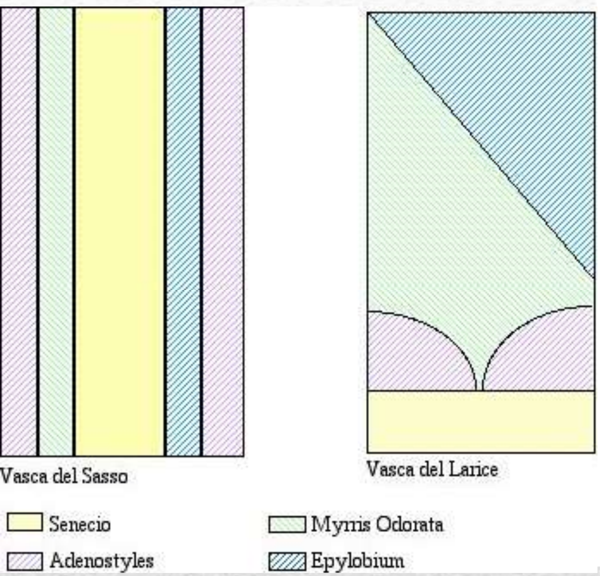
Mesophilic conditions (36° C)
Gasometer Volume 60 L

Anaerobic Digestor Volume of 2 m^3
Pump provides to the internal recirculation

AQUANOVA System

ENERGIANOVA Project

Scheme of the Aquanova system at the BOSCONERO mountain hut



Aconitum Lycoctonum

Mentha

Senecio Cordatus

Urtica

Rumex acetosella

Chenopodium Bonus Enricus

Prunella vulgaris

Leucanthem
s alpina

Adenostyles glabra

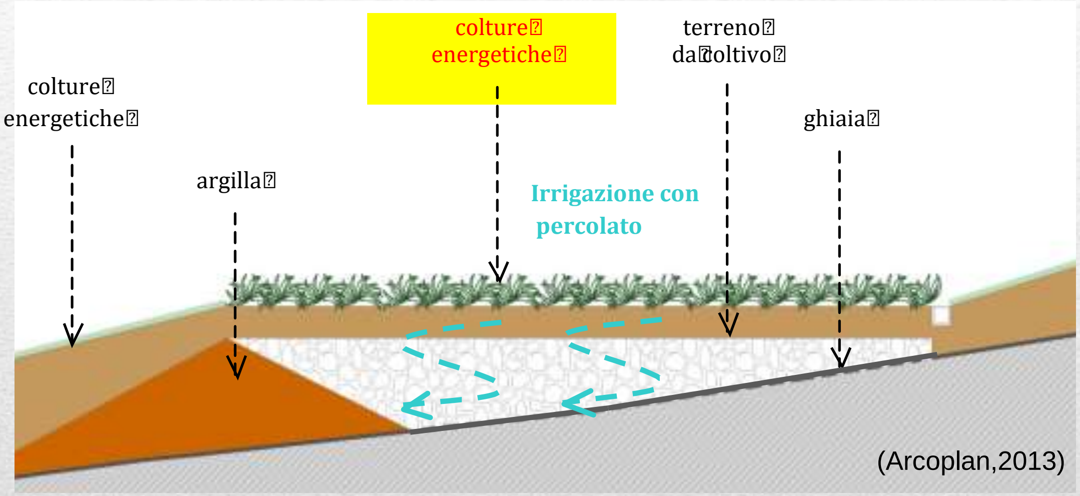
Senecio Cordatus

Leachate treatment by energy crops

Research aims

Phytotreatment to irrigate energy crops on the top of landfill

Energy crops to produce renewable energy



Treatment of wastewater and production of energy at the same time

Reutilisation of derelict area (closed landfill, contaminated soil, etc.)

Save potable water for the irrigation of the crops, reusing leachate

No competition between land for food and for energy

Avoiding CO_2 emission for transport and energy demand treatment

Avoiding the contamination of agricultural soils and groundwater

Leachate treatment by energy crops

Research aims

To identify the best performance conditions for the phytotreatment units in terms of pollutants removal and plant growth for

Different wastewater streams
- Yellow water
- Grey water
- Leachate

to test the mixture and phytotreatment efficiency

Different types of energy crops
- *Helianthus annus* (H)
- *Glycine max* (G)
- *Brassica napus* (B)

to test the best plant performance (phytotreatment & seeds production)

Different soil substrate
- Sand
- Soil

to test the best sinergy with plants and soil

Helianthus annus (H)

Glycine max (G)

Brassica napus (B)

Research facilities: plants

The selection of the species were based in particular for:
- a widely present especially in the local region (North of Italy).
- their capability for the remediation of wastewaters, have the potential of increase the biomass by consuming nutrients that are included in this particular waters.
- they are mostly used for high performance and quantity of oil seeds for biodiesel production.

Research facilities: the greenhouse

Leachate treatment by energy crops

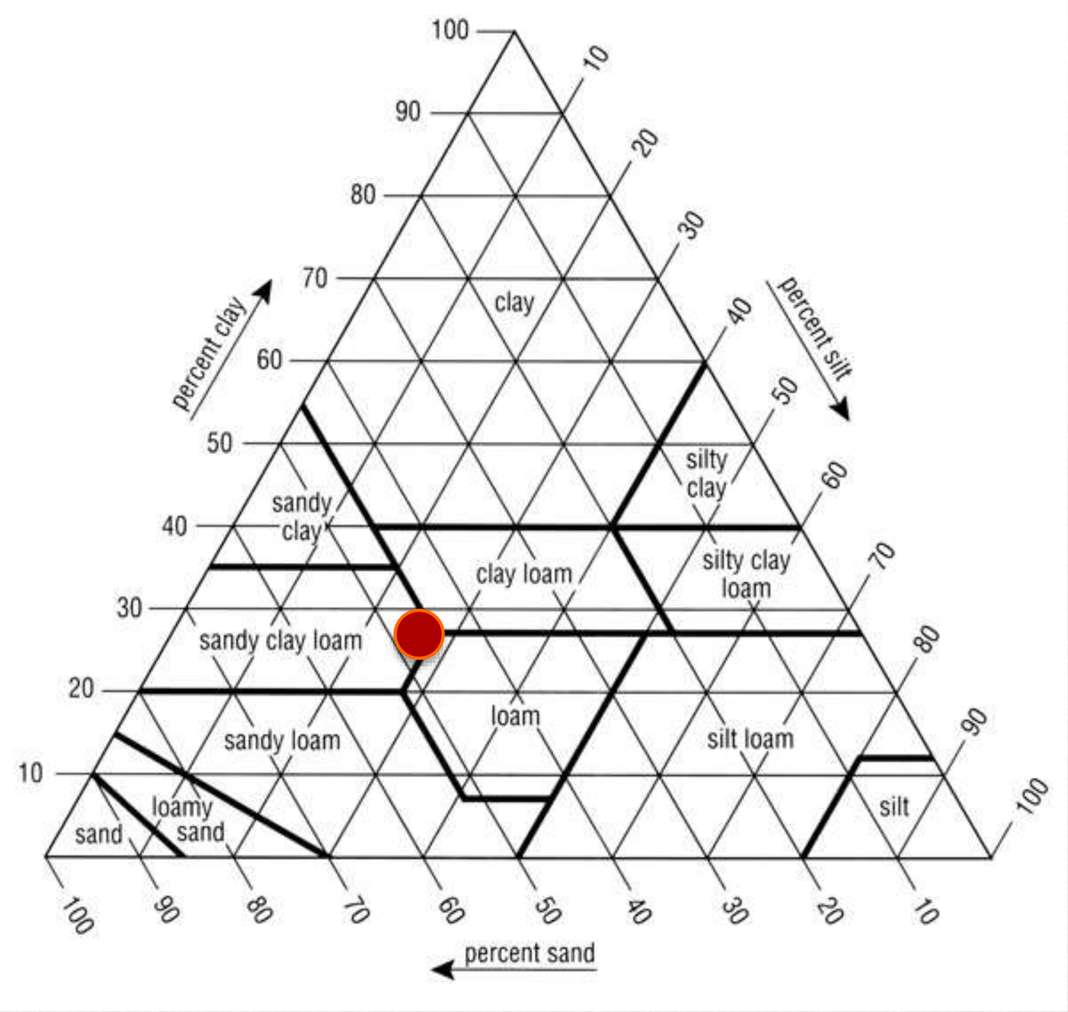
Different trial runs

Phase	Waste waters	Seasonal Period	Species	Reactors	Feeding water composition (%)	Substrate
0	Domestic wastewater (Aquanova)	June to September 2010	- Helianthus annus - Glycine max - Brassica napus	Pots (20L)	YW 0,1-3,5% GW(a) 99,9 -96,5%	Sand
1	Domestic wastewater (Aquanova)	June to August 2011	- Helianthus annus - Glycine max - Brassica napus	Tanks (300L)	YW 0,1-3,5% GW(a) 99,9 -96,5%	Soil
2	Leachate A	November of 2011 to January 2012	- Helianthus annus - Glycine max - Brassica napus	Pots (20L)	2-30 % leachate 90 – 70% tap water	Sand Soil
3	Leachate B	May to August 2012	- Helianthus annus - Glycine max	Pots (20L)	20% leachate 80% GW(b)	Soil
4	Leachate C (a,b)	May to June 2013	- Helianthus annus - Glycine max	Tanks (300L)	10-60% leachate 90 - 40% tap water	Soil

YW = yellow water; GW = grey water.

Leachate treatment by energy crops

Soil substrate composition



Parameters	Soil Phase 1	Sand Phase 2	Soil Phase 2	Soil Phase 3	Soil Phase 4
			%		
TS	88.5%	98.0%	92.3%	98.5%	
VS	1.8%	1.2%	2.1%		
TOC	<1%	<1%	<1%	<1%	<1%
			mg/KgDRY		
N	279.2	77.6	455.3	1900	320
P	368.3	111	313	704	256
S	-	128	84.9		49.1
			g/kgDRY		
Ca	78.1	161	97.33	37.2	11.8
K	1.15	0.83	2.39	1.82	0.42
Mg	18.6	52.7	38.1	22.6	1.36
Na	0.49	0.37	0.39	0.72	2.25
			g/kgDRY		
Cd	<10	<10	<10	<10	<10
Cr	10.5	-	20	20.8	19.5
Cu	21.3	-	24.1	25.9	27.1
Fe	140.2	-	155.0	186.6	177.5
Zn	31.2	-	63.2	70.1	77.6

Leachate treatment by energy crops

Results

phytotreatment efficiencies

plants growth (total biomass and lenght of the roots)

mass balance of N&P

quantity & quality of seeds for biodiesel production

Leachate treatment by energy crops

Wastewater composition

Parameters	Yellow water	Grey water (a)	Grey water (b)	Leachate A	Leachate B	Leachate C(a)	Leachate C(b)
pH	6.40	7.90	7.96	8.02	8.09	7.85	7.81
TS	16475	449	405	6315	7215	2605	3738
VS	9946	260	213	1548	2613	1010	1158
COD	6363	68.0	127	2255	3270	607	1005
BOD	–	–	29.4	75.0	203		
TOC	–	–	15.4	1953	885	1002	1471
TKN	9765	4.30	5.60	1204	1285	627	1015
NH_4^+–N	1095	2.90	<0.5	1117	1176	588	1005
NO_3^-–N	5.60	1.30	1.89	0.57	5.90	2.50	2.03
TP	3.00	0.30	0.50	22.0	23.0	7.60	2.90
PO_4^{3-}–P	0.30	0.20	<0.10	20.0	13.5	<10	<10
Cl^-	2208	43.7	46.1	1622	2057	594	886
SO_4^{2-}	1261	42.2	29.4	<10	<10	<10	<10

All the values are expressed in mg/L except pH.

Leachate treatment by energy crops

RESULTS: Vegetation growth

TOTAL MASS (g_{DRY}/pot)				
Phase 1	*GW+YW*	*Control*		
H	143,8	137,4		
G	55,1	61,4		
B	140,5	29,9		
Phase 2	*L_Sand*	*Sand_control*	*L_Soil*	*Soil_control*
H	21,2	29,5	49,8	25,4
G	20,3	18,7	28,5	23,4
B	31,0	24,7	16,4	8,93
Phase 3	*L+GW*	*Control*		
H	2,8	9,4		
G	10,6	12,6		
Phase 4	*L*	*Control*		
H	461,9	465,9		
G	72,8	70,3		

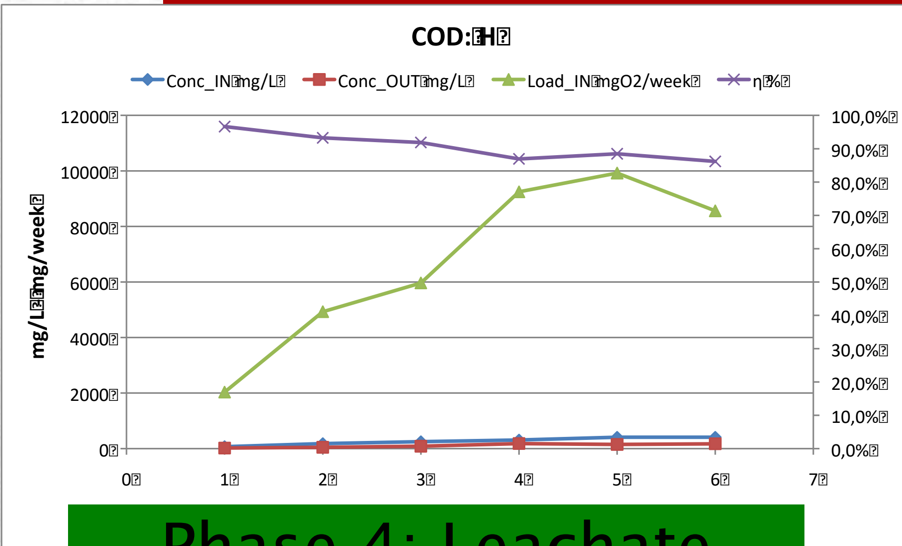
H: *Helianthus annus*
G: *Glycine max*
B: *Brassica napus*

Leachate better or similar to Control

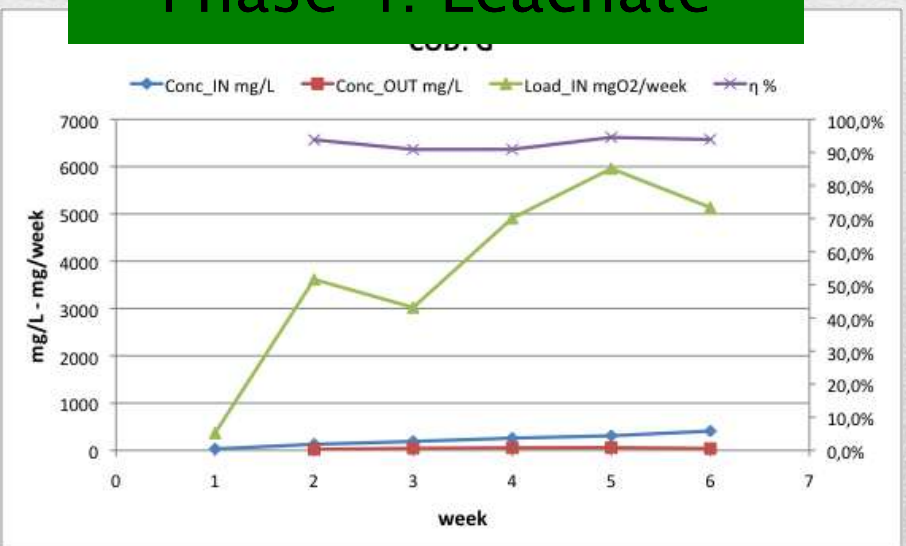
Sunflower, Soybean : better on SOIL

Rapeseed : better on SAND

Leachate treatment by energy crops



Phase 4: Leachate

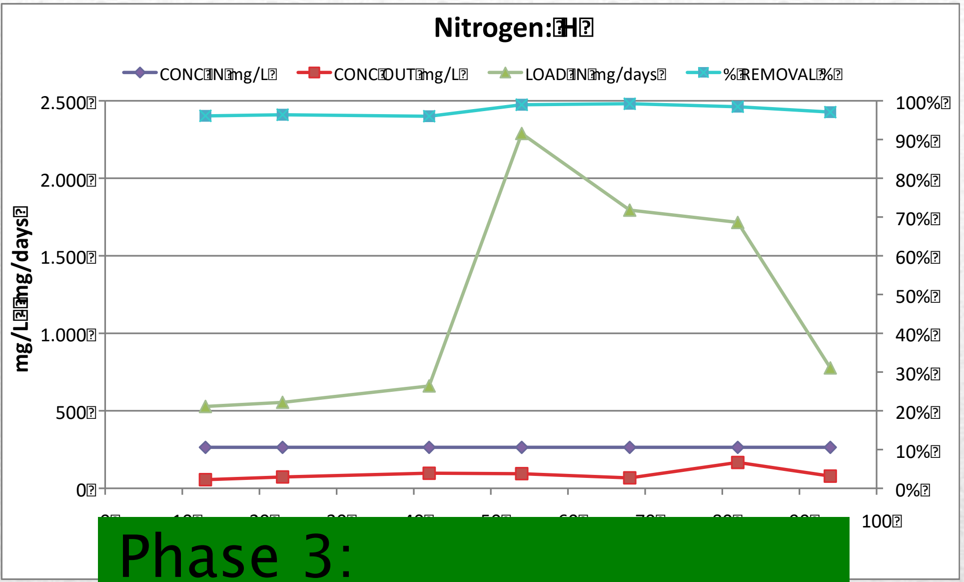


RESULTS: COD removal

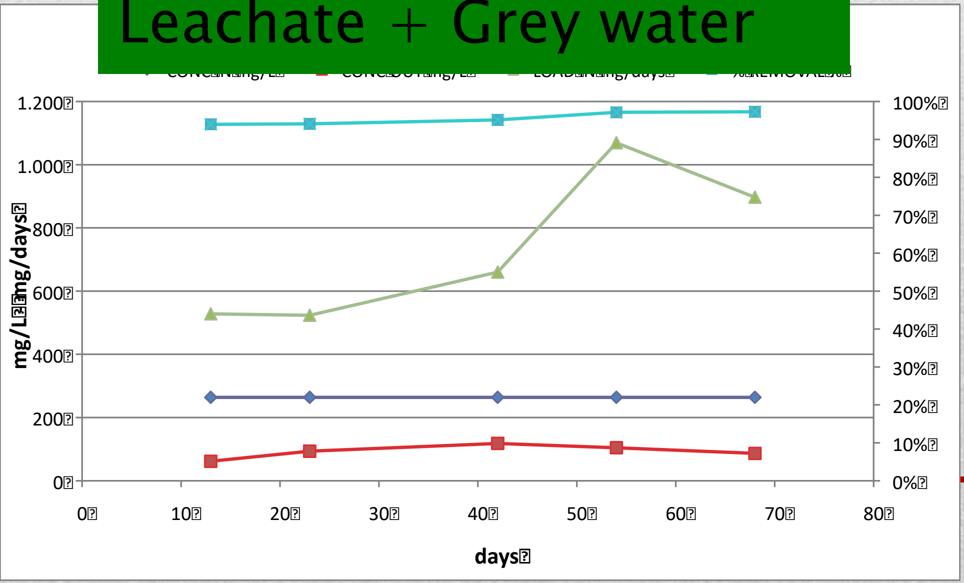
PHASE 1		
COD_IN (mg/L) 169,8 ± 84,9		
CROPS	**OUT (mg/L)**	**η %**
Helianthus annus (H)	56,6 ±34,2	67,7%
Gclycine max (G)	55,2 ± 29,4	66,4%
Brassica napus (B)	49,7 ± 25,2	70,2%
PHASE 2		
COD_IN (mg/L) 353,2 ± 226,2		
CROPS_SOIL	**OUT (mg/L)**	**η %**
H_sand	162,4 ± 164,6	85,7%
H_soil	165,7 ± 105,5	93,4%
G_sand	98,0 ± 84,3	86,3%
G_soil	123,2 ± 81,4	91,2%
B_sand	127,7 ± 146,2	90,2%
B_soil	91,8 ± 78,1	94,1%
PHASE 3		
COD_IN (mg/L) 755,1		
CROPS	**OUT (mg/L)**	**η %**
Helianthus annus (H)	474,6 ± 56,1	91,8%
Gclycine max (G)	574,5 ± 88,0	93,5%
PHASE 4		
COD_IN (mg/L) 264,3 ± 133,6		
CROPS	**OUT (mg/L)**	**η %**
Helianthus annus (H)	109,8 ± 68,6	90,6
Gclycine max (G)	42,4 ± 13,9	92,8

Leachate treatment by energy crops

RESULTS:
N removal



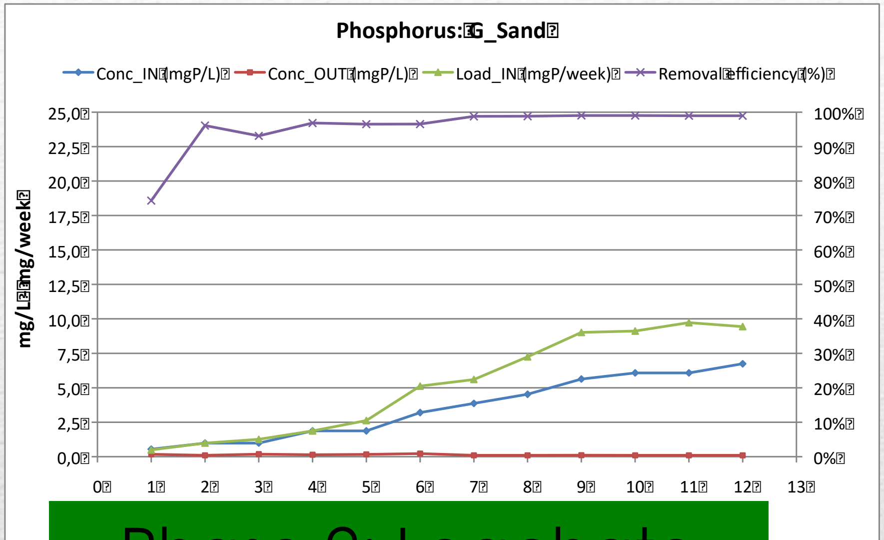
Phase 3:
Leachate + Grey water



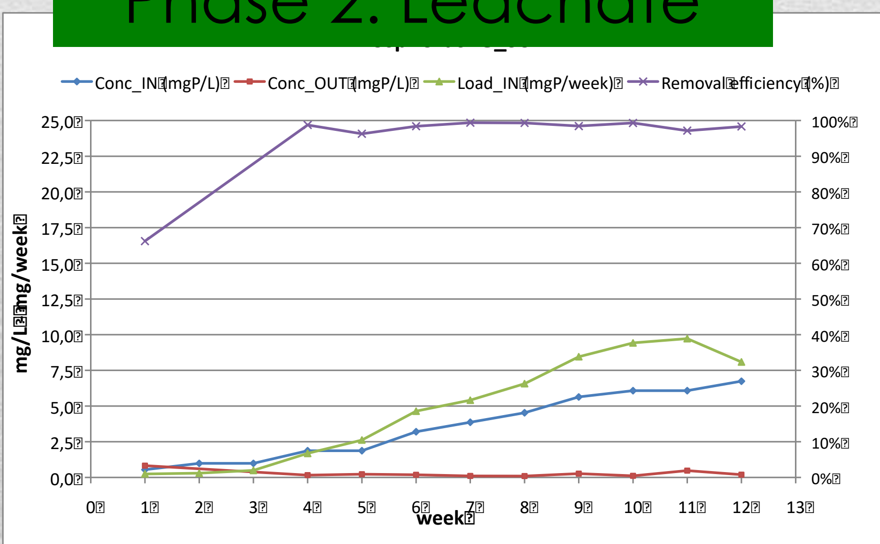
PHASE 1		
TN_IN (mg/L) 164,7 ± 131,7		
CROPS	**Out (mg/L)**	**η %**
Helianthus annus (H)	19,2 ± 14,2	77,5%
Gclycine max (G)	16,1 ± 13,0	78,4%
Brassica napus (B)	17,1 ± 14,2	77,8%
PHASE 2		
TN_IN (mg/L) 189,6 ± 122,8		
CROPS_SOIL	**OUT (mg/L)**	**η %**
H_sand	185,2 ± 238,1	71,8%
H_soil	129,5 ± 145,3	87,1%
G_sand	90,0 ± 123,3	77,1%
G_soil	108,5 ± 81,4	83,5%
B_sand	159,8 ± 176,1	80,1%
B_soil	86,8 ± 82,7	88,8%
PHASE 3		
TN_IN (mg/L) 264,1		
CROPS	**Out (mg/L)**	**η %**
Helianthus annus (H)	82,0 ± 22,6	97,5%
Gclycine max (G)	83,0 ± 15,0	95,5%
PHASE 4		
TN_IN (mg/L) 246,0 ± 133,5		
CROPS	**Out (mg/L)**	**η %**
Helianthus annus (H)	163,8 ± 77,0	94,0%
Gclycine max (G)	113,8 ± 52,3	79,1%

Leachate treatment by energy crops

RESULTS: P removal

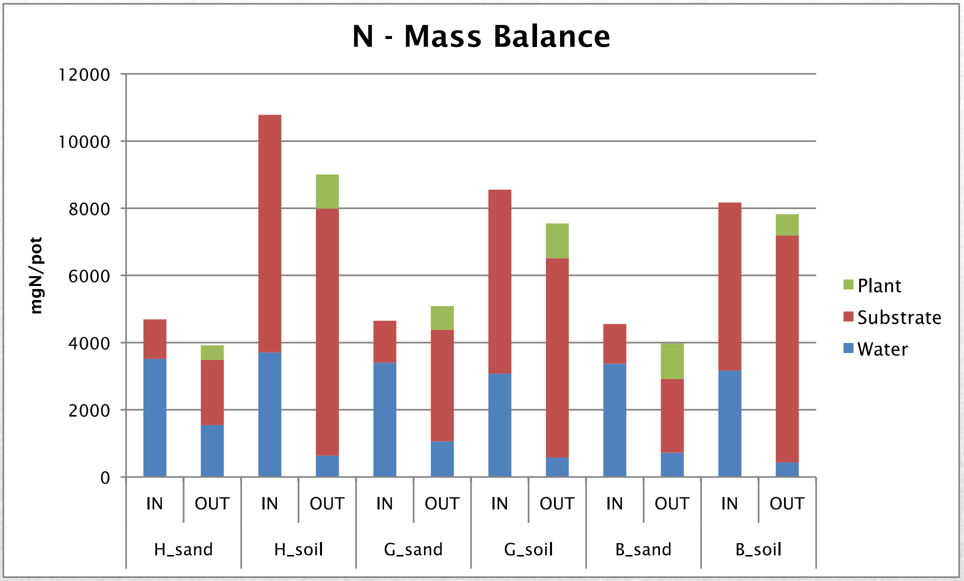


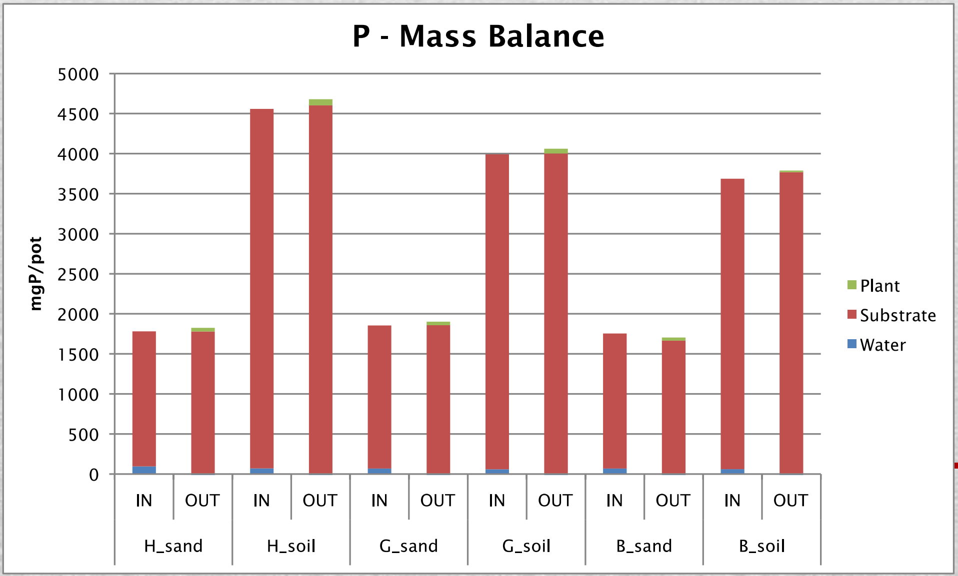
Phase 2: Leachate



PHASE 1		
TP_IN (mg/L) 0,34 ± 0,04		
CROPS	**OUT (mg/L)**	**η %**
Helianthus annus (H)	0,24 ±0,05	30,3%
Gclycine max (G)	0,23 ± 0,04	33,7%
Brassica napus (B)	0,24 ±0,05	31,2%
PHASE 2		
TP_IN (mg/L) 3,75 ± 2,5		
CROPS_SOIL	**OUT (mg/L)**	**η %**
H_sand	0,40 ± 0,46	96,2%
H_soil	0,22 ± 0,13	98,0%
G_sand	0,13 ± 0,04	95,9%
G_soil	0,25 ± 0,22	95,5%
B_sand	0,15 ± 0,10	97,0%
B_soil	0,15 ± 0,07	98,0%
PHASE 3		
TP_IN (mg/L) 5,01		
CROPS	**Out (mg/L)**	**η %**
Helianthus annus (H)	0,60 ± 0,22	96,3%
Gclycine max (G)	0,50 ± 0,00	98,5%
PHASE 4		
TP_IN (mg/L) 1,1 ± 0,33		
CROPS	**Out (mg/L)**	**η %**
Helianthus annus (H)	0,20 ± 0,17	94,3%
Gclycine max (G)	0,10 ± 0,04	95,2%

Leachate treatment by energy crops





Results: Mass balance

Water: suitable pollutant removal

Plant: suitable nutrients uptake

Substrate: biological filter active

Phase 2: Leachate

RESULTS: Quality of seeds

Seed cultivation	Content of Oil	FAME
Phase 1	*(%)*	*(%)*
H	35,9	34,3
G	16,7	18,8
Phase 2	*(%)*	*(%)*
H_sand	43,0	41,1
H_soil	45,1	43,1
G_sand	17,0	16,3
G_soil	16,3	15,5
Phase 3	*(%)*	*(%)*
H	40,0	38,3
G	22,1	21,1

FAME= fatty acid methyl ester

Content of oil *(A. Karmakar, 2010)*
H = 25-35 %
G = 15-20 %

CONCLUSIONES

The phytotreatment capacity of *energy crops* was proved through the depuration efficiencies and the plants growth.

- In general greater growth of plants irrigated with wastewaters and leachate than those with tap water (controls), except for the *Glycine max*

- Good removal performances of the main pollutants (COD, N, P, etc.) from the domestic wastewater were observed. Higher efficiencies when increasing the percentage of YW

- Good efficiency removal of pollutants from leachate, positive influence on the growth of plants and seed production

- N and P mass balance highlight the crucial role of the substrate in the phytotreatment unit performance

- Different substrate were proved as sand and soil to test the best performance of the combination between media and plant:

- Sand was found to be a less suitable substrate for the growth even in the presence of leachate, except for Brassica napus (phase 2)
- Soil is a key element for the removal of pollutants

Previous experiments

1
- vertical phytotreatment - grey water and yellow water from domestic wastewater source separation – soybean, sunflower and rapeseed – 20L pots

2
- vertical phytotreatment - leachate in different proportion up to 30% - soybean, sunflower and rapeseed – sand, agricultural soil – 20L pots

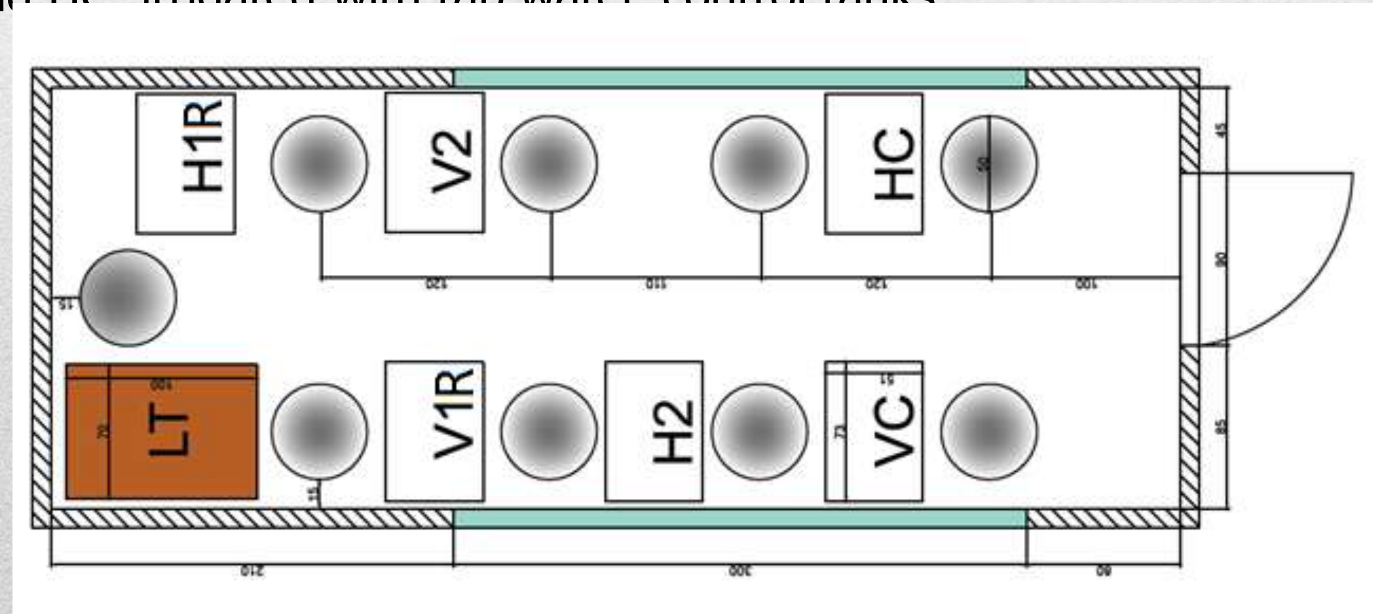
3
- vertical phytotreatment - leachate 20% in greywater - agricultural soil – soybean and rapeseed – 20L pots

4
- horizontal & vertical phytotreatment – with and without ricirculation – leachate up to 30% - agricultural soil & sand - tank scale

Research program: tanks and greenhouse

- 6 tanks: 3 **vertical flow** (**V1R, V2, VC**);

  3 **horizontal subsurface flow** (**H1R, H2, HC**)
- **greenhouse** (14 hours of photoperiod, controlled temperature)
- V1R, V2, H1R, H2 submitted to **increasing leachate dosages**, up to 30% (v/v)
- VC and HC: irrigated with tap water, control tanks

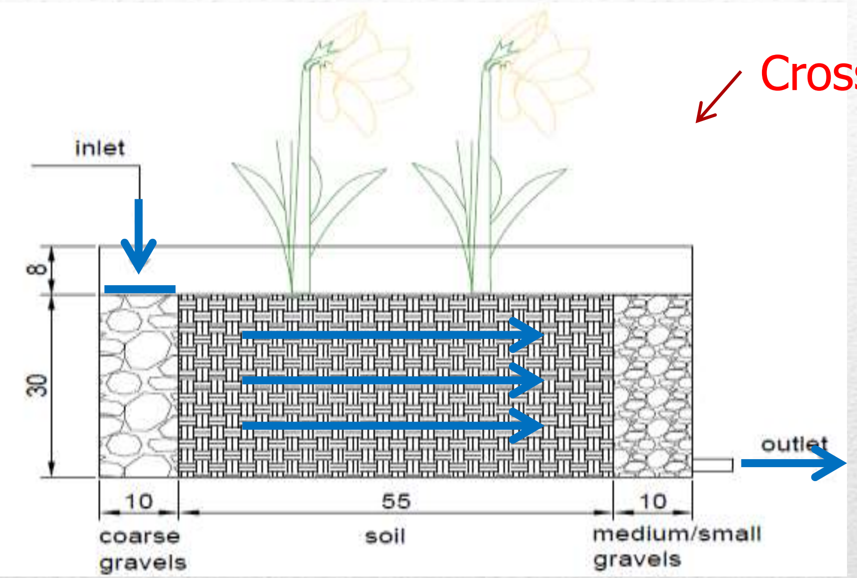


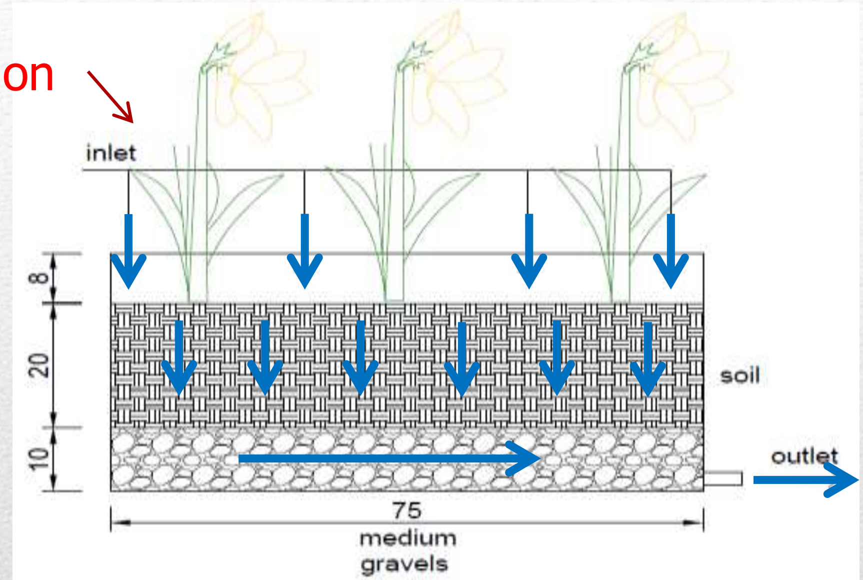
Research program: tanks realization

Horizontal subsurface flow tanks

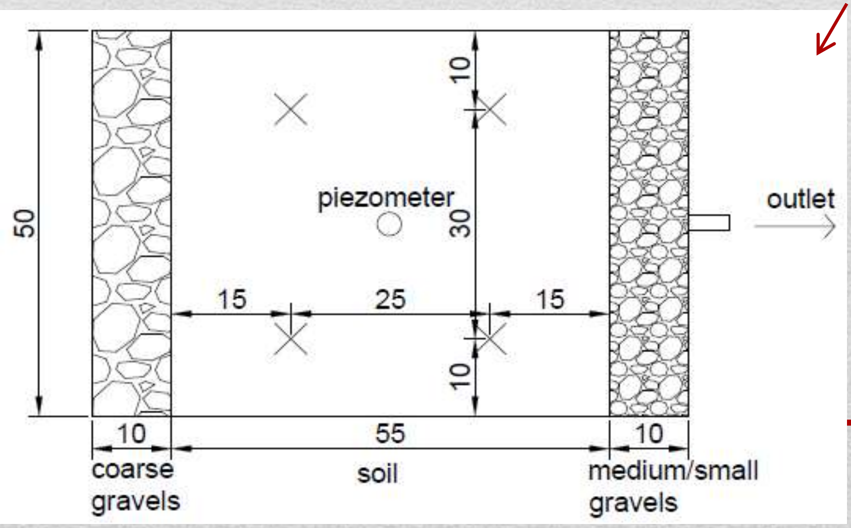
Vertical flow tanks

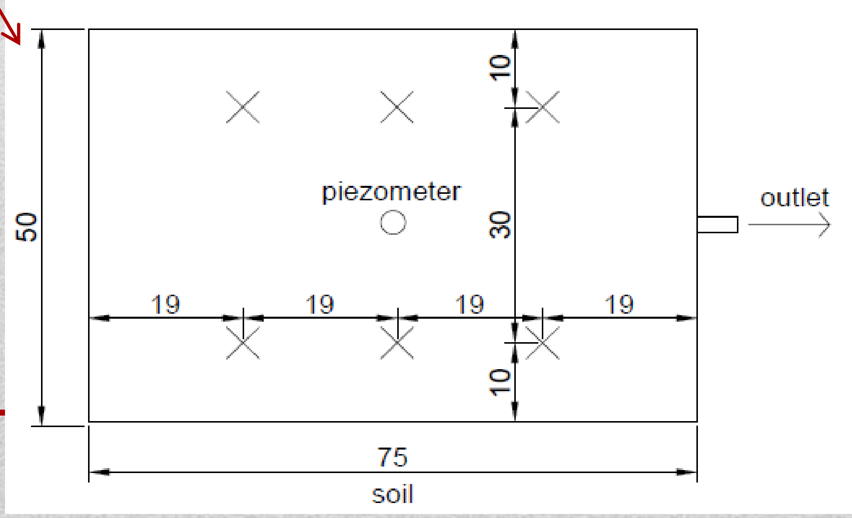
Cross-section





Plan





Research program: landfill leachate

Chemical analysis (CNR-IRSA, 29/2003)		
Parameter	**Value**	*Unit*
pH	**8**	-
TKN	**1240**	*mgN/l*
NH4+	**1221**	*mgN/l*
PTOT	**11**	*mgP/l*
PO43-	**11**	*mgP/l*
TS	**4277**	*mg/l*
VS	**1102**	*mg/l*
COD	**1325**	mgO_2/l
BOD	**50**	mgO_2/l
Cl-	**1138**	*mgCl/l*
NO3	**0**	*mgN/l*
SO4	**0**	$mgSO_4/l$
Na	**2700**	*mgNa/l*
Cr	**199**	*µgCr/l*
Cu	**138**	*µgCu/l*
Fe	**8358**	*µgFe/l*

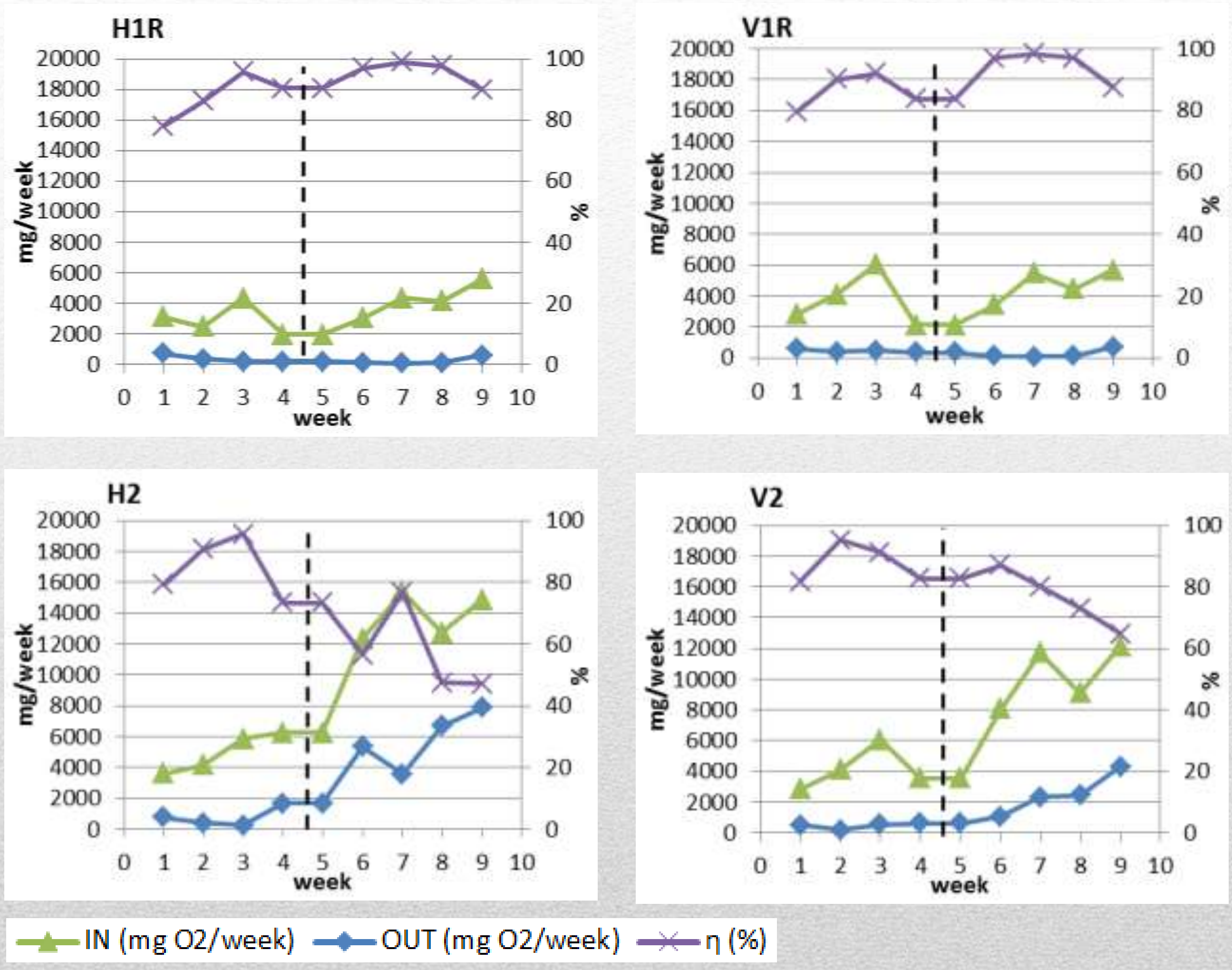
Values of TKN, ammonium nitrogen and the BOD/COD ratio (equal to 0.04) are typical of leachate produced during the **stable methanogenic phase** (Stegmann et al., 2005; Jones et al., 2006)

Research program: irrigation

PHASE	FEEDING QUALITY	LASTING DAYS	COD IN (mgO_2/l)	P_{TOT} IN (mgP/l)	TKN IN (mgN/l)
Acclimation Phase	100 % tap water	7	10	0.04	0.1
Phase 1	10 % leachate	7	142	1.1	124
Phase 2	20 % leachate	7	273	2.2	248
Phase 3A	30 % leachate	14	142	1.1	124
Phase 3B	30 % leachate	35	273	2.2	248

← R

Results: COD loads and removal efficiency

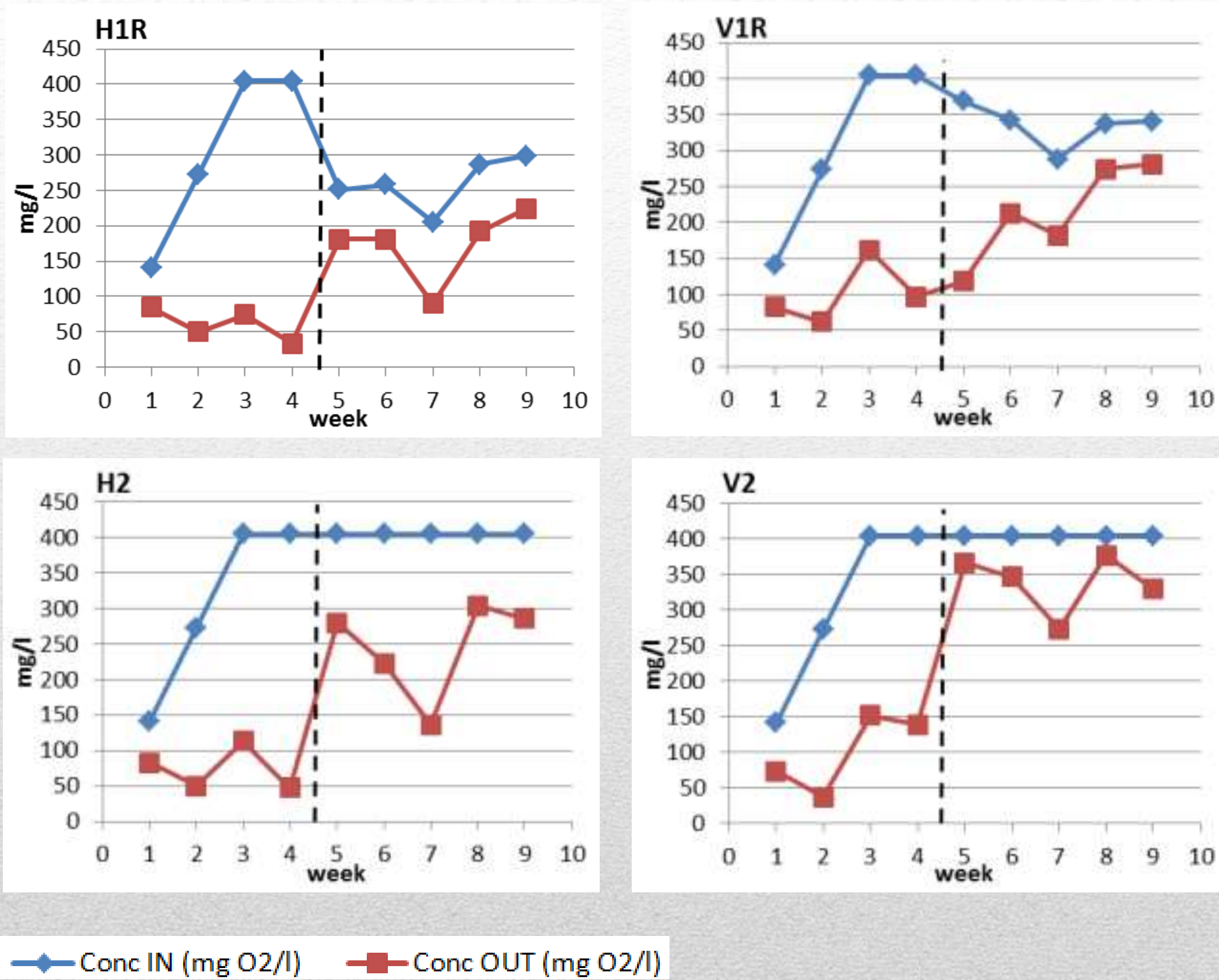


with recirculation

no recirculation

The dotted line indicates the beginning of Phase 3B.

Results: COD inlet and outlet concentration

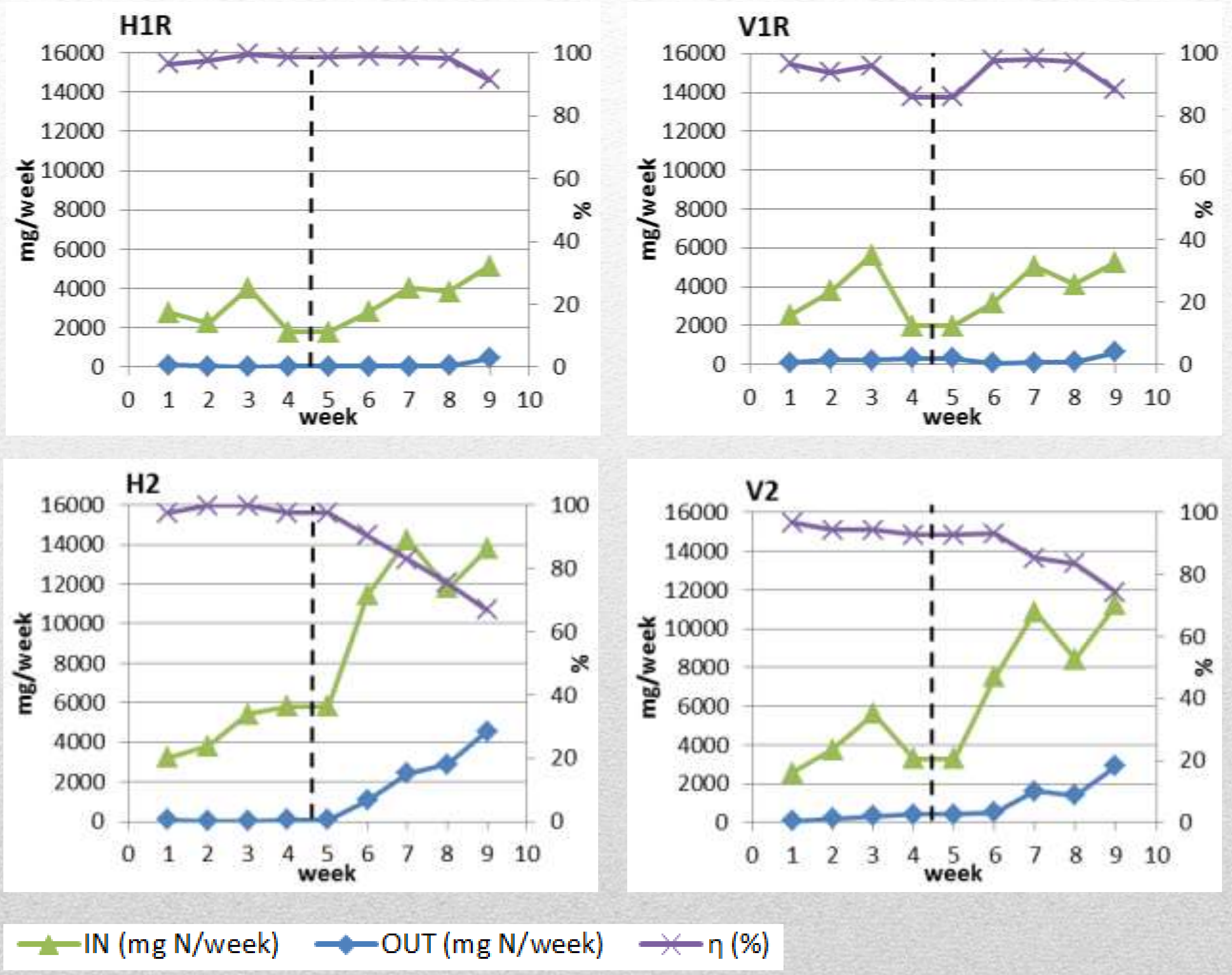


with recirculation

no recirculation

The dotted line indicates the beginning of Phase 3B.

Results: TKN loads and removal efficiency

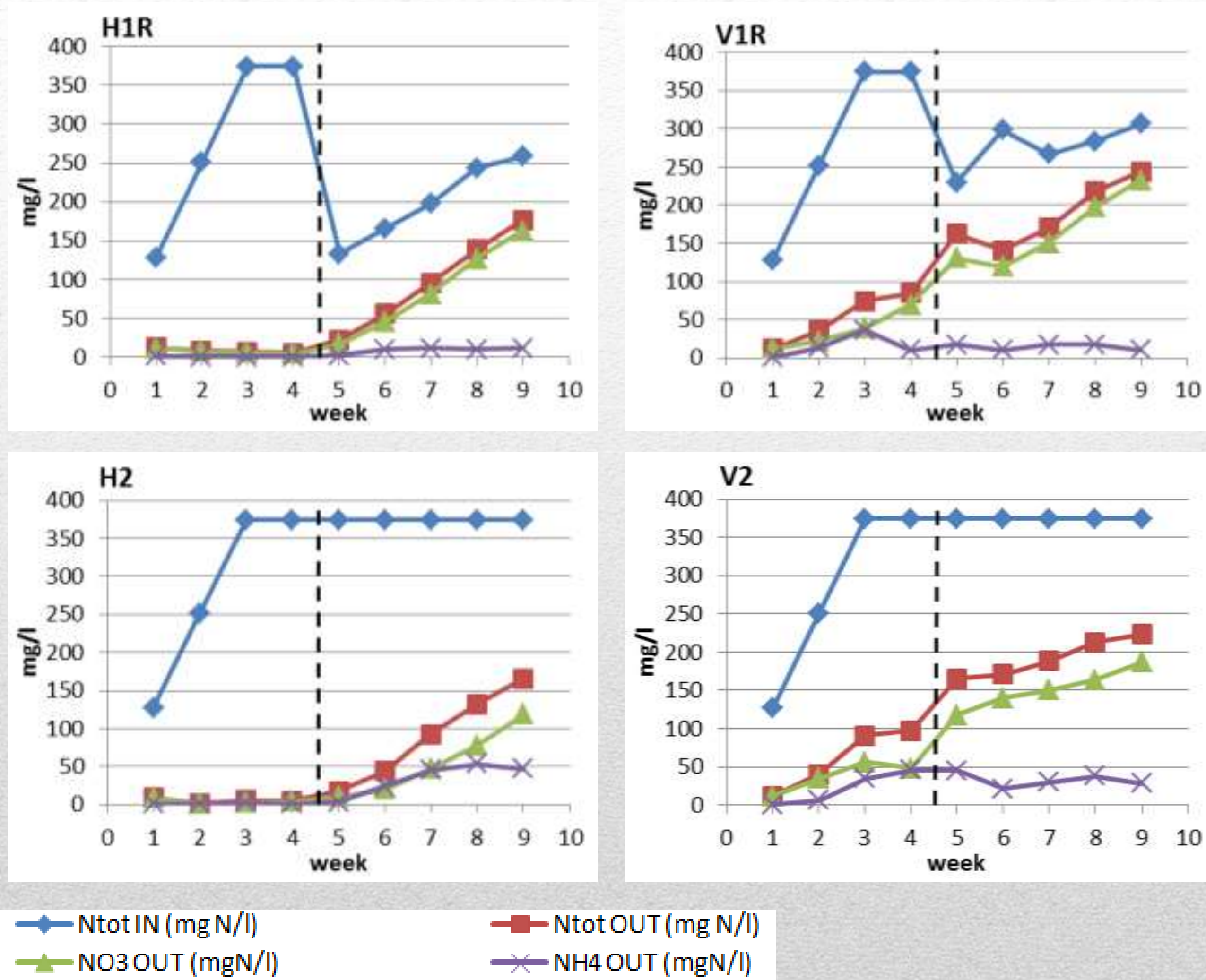


with recirculation

no recirculation

The dotted line indicates the beginning of Phase 3B.

Results: TKN inlet and outlet concentration

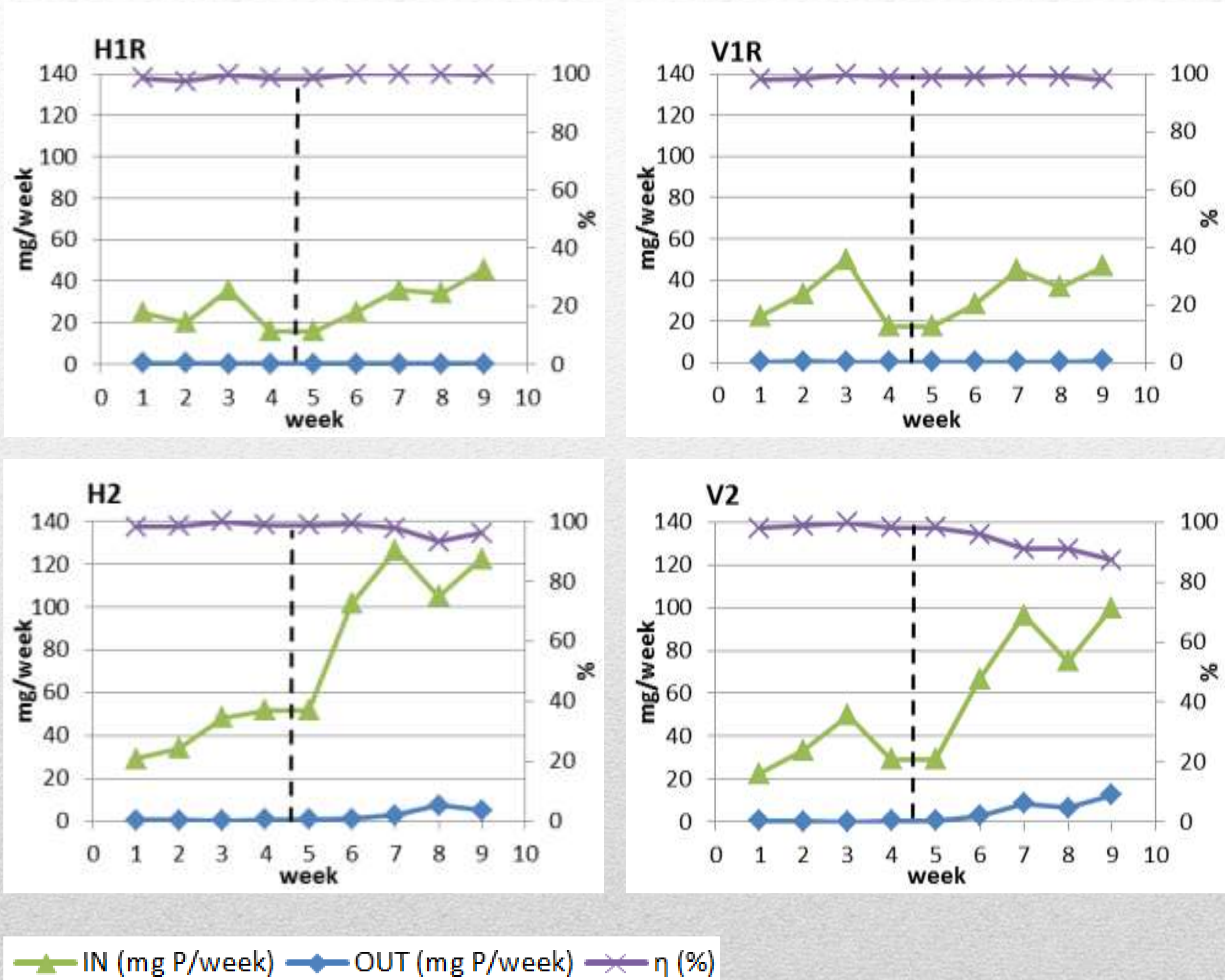


with recirculation

no recirculation

The dotted line indicates the beginning of Phase 3B.

Results: P loads and removal efficiency

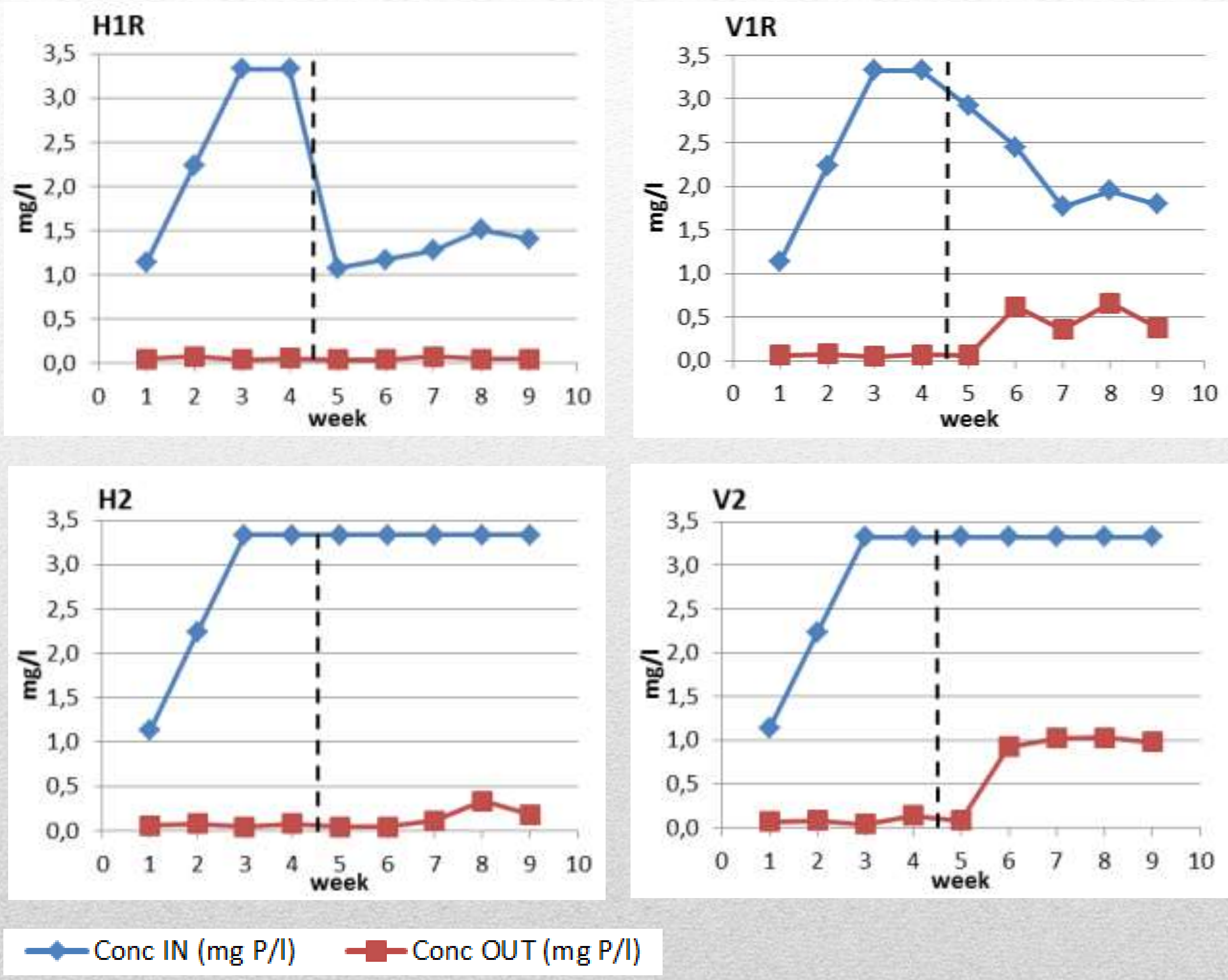


with recirculation

no recirculation

The dotted line indicates the beginning of Phase 3B.

Results: P inlet and outlet concentration



with recirculation

no recirculation

The dotted line indicates the beginning of Phase 3B.

Results: sunflowers growth

	Total dry weight (g)	***Average dry weight (g/plant)***
H1R	49.58	*12.40*
H2	56.33	*14.08*
HC	48.76	*12.19*
V1R	121.21	*20.20*
V2	123.86	*20.64*
VC	120.54	*20.10*

Landfill leachate did not inhibit sunflowers growth

N : P ratios between 10 and 20 in all vertical flow reactors, indicating balanced nitrogen and phosphorous supply (Gusewell, 2004)

Tank	**N : P ratios (mgN/mgP)**
H1R	27.50
H2	28.31
HC	21.75
V1R	19.81
V2	16.17
VC	19.67

Results: seeds production

Tank	Total seeds production (g)	Average seeds production (g)
H1R	8.57	2.14
H2	9.43	2.35
HC	8.87	2.21
V1R	22.00	3.67
V2	24.01	4.00
VC	23.16	3.86

The amount of seeds produced is proportional to the biomass development

Tank	Oil content (% on seeds weight)	FAME (% on oil content)
Tanks fed with leachate	22.1	21.1

FAME= fatty acid methyl ester

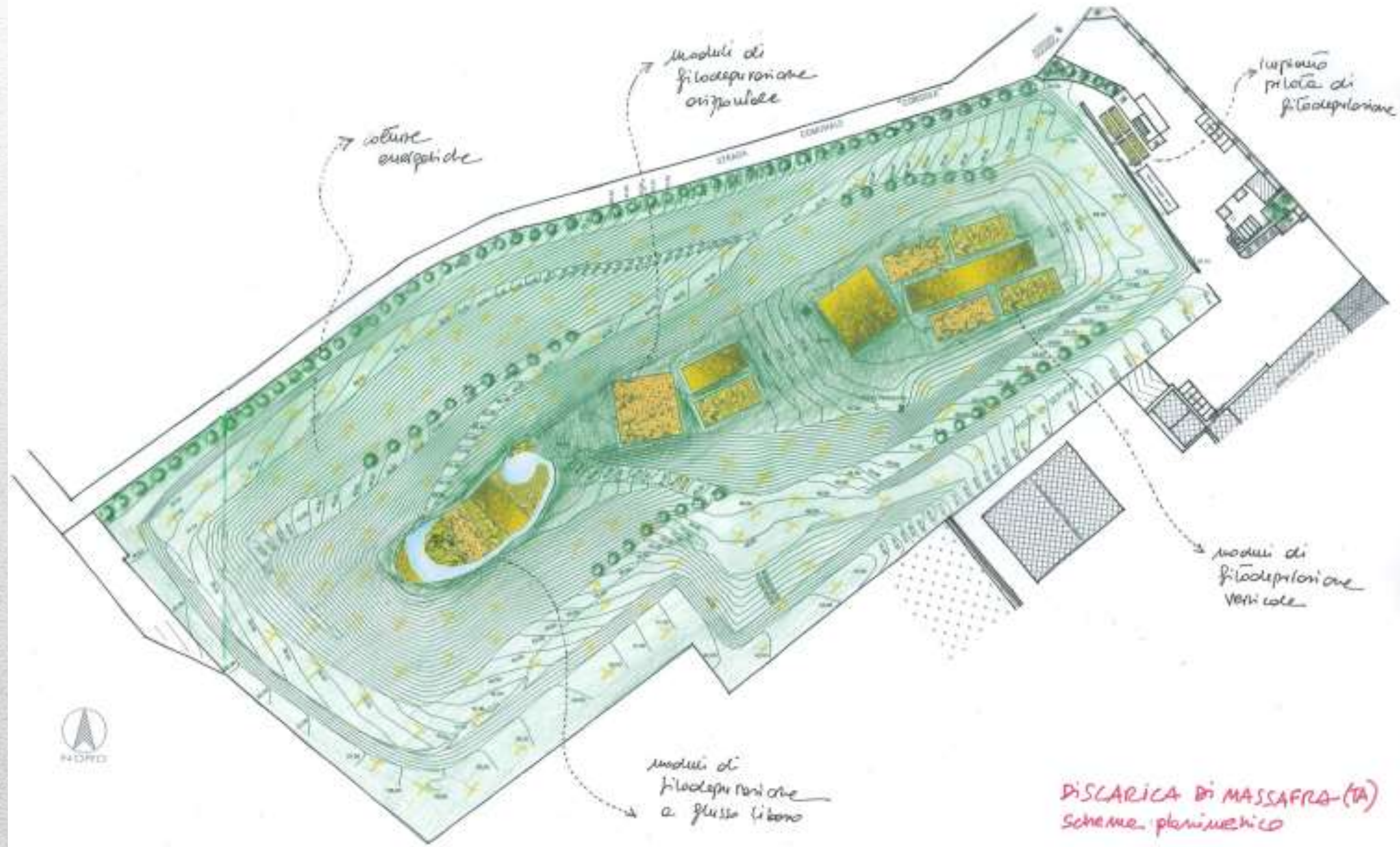
Oil content higher than results available in literature: 15 – 20% on seeds weight (*A. Karmakar, 2010)*

Conclusions

- Leachate treatment via sunflowers phytotreatment proved to be feasible under lab-scale conditions, with positive effects on the biomass development and seeds production
- Good removal efficiency of the main pollutants (N, P, COD) both in horizontal and vertical tanks; the removal rates are quite similar
- Ricirculation is not particularly affecting the removal rate, but nitrification increases also in the horizontal tank
- 20% of leachate in the irrigation water seems to be a limit concentration
- Vertical flow reactor seems more suitable to host sunflowers: higher biomass development and seed production

ENERGY CROPS on landfill: SCALE PROJECT

MASSAFRA (BA-ITALY) PILOT SCALE PROJECT
FUNDS FROM CISA SPA, PRIVATE COMPANY ON WASTE MANAGEMENT



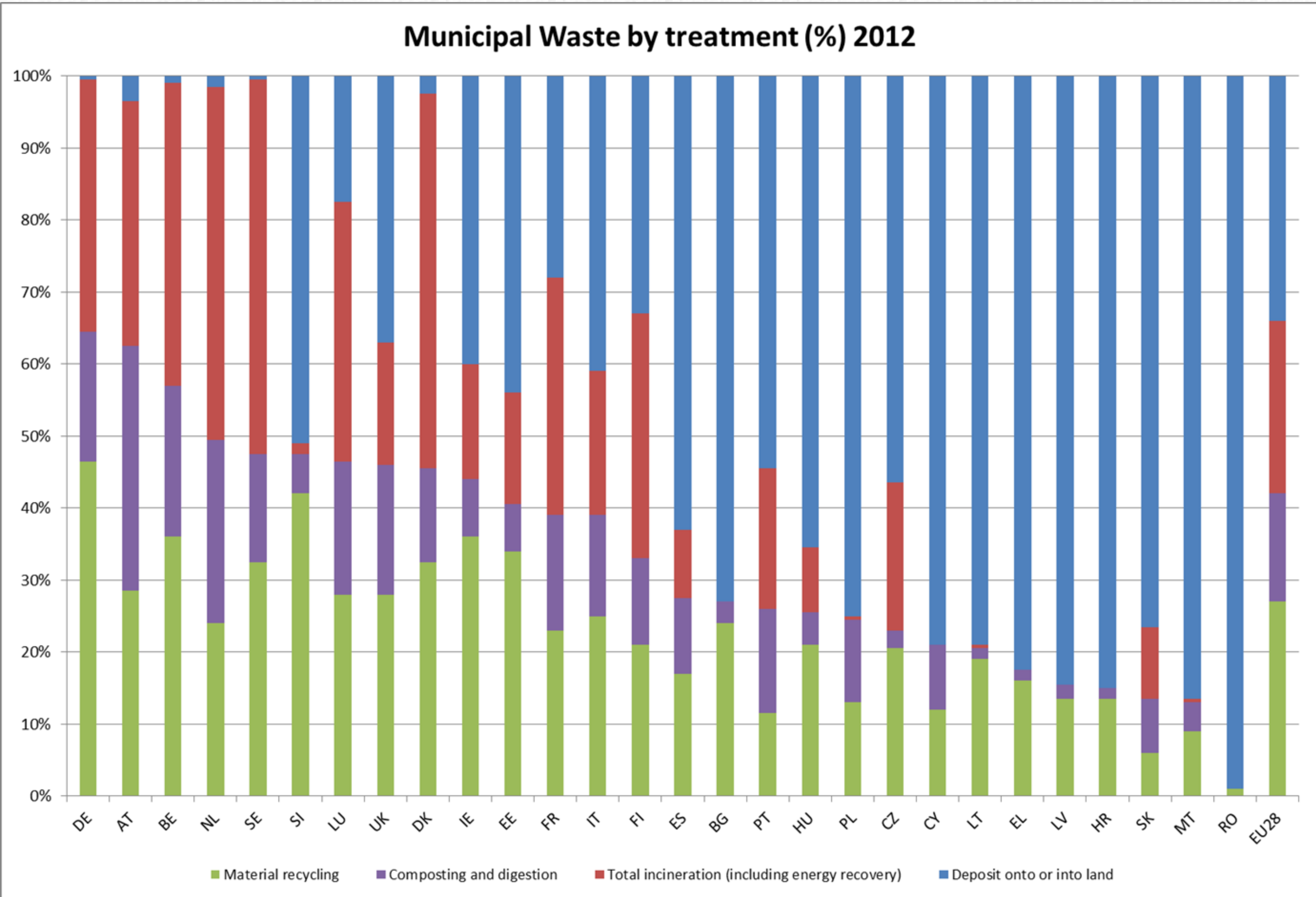
(ARCOPLAN, 2013)

MAZZANO FULL SCALE PROJECT
FUNDS FROM LOMBARDIA REGIONAL GOVERNMENT, WINNER OF 2012 CALL ON REQUALIFICATION OF OLD LANDFILLS

(ARCOPLAN, 2013)


Odio el lixiviado!
Prefiero Zacapa!

Manejo de residuos solido in Europa

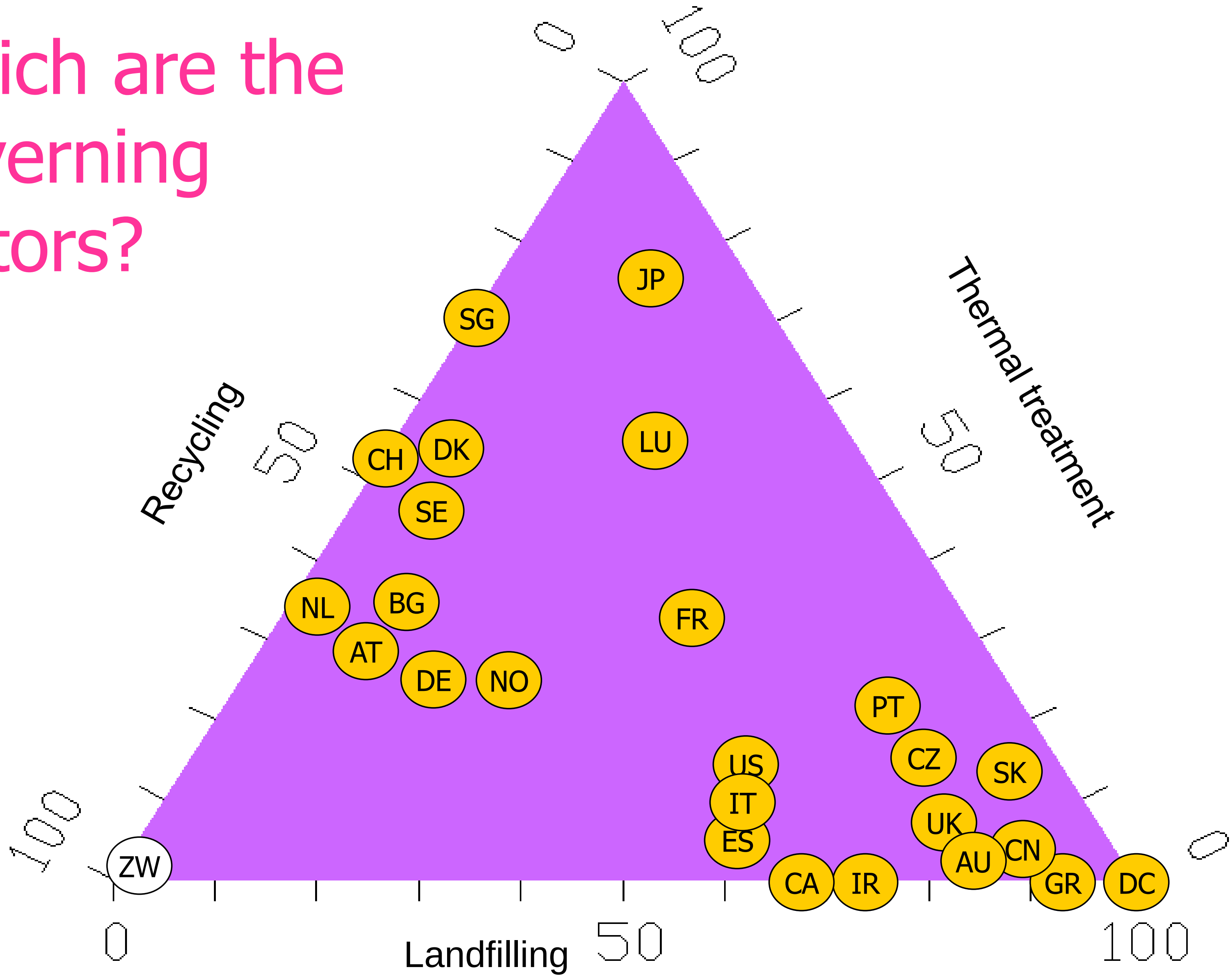


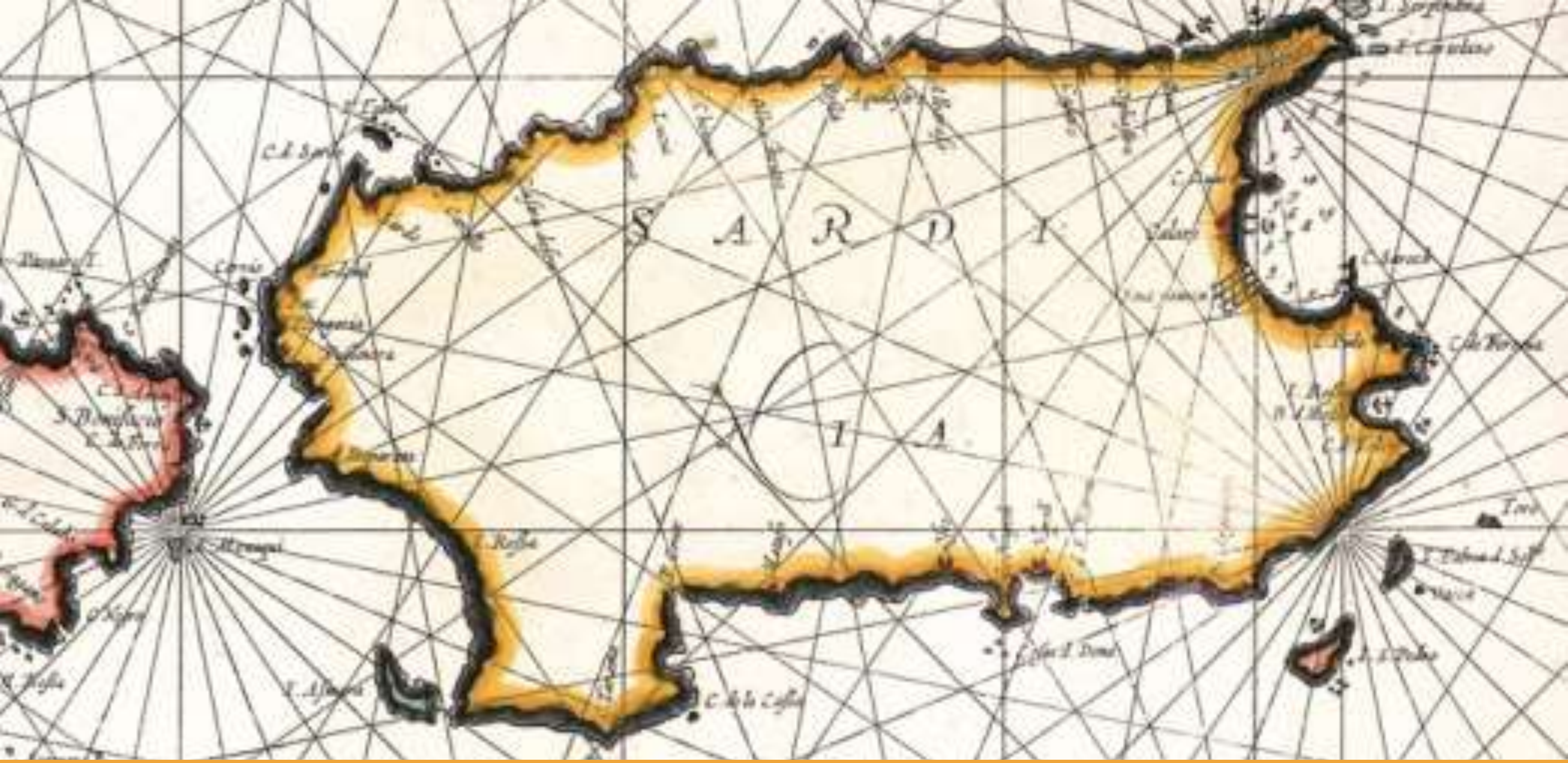
	Municipal waste generated,	Total municipal waste treated,	Municipal waste treated, %			Residual waste per person
	kg per person	kg per person	Recycled & composted	Landfilled	Incinerated	kg per person
EU28	**492**	**480**	**42**	**34**	**24**	285,36
Belgium	456	458	57	1	42	196,08
Bulgaria	460	433	27	73	0	335,8
Czech Republic	308	308	24	57	20	234,08
Denmark	668	668	45	3	52	367,4
Germany	611	610	65	0	35	213,85
Estonia	279	220	40	44	16	167,4
Ireland	570	570	45	39	16	313,5
Greece	503	493	18	82	0	412,46
Spain	464	464	27	63	10	338,72
France	534	534	39	28	33	325,74
Croatia	391	381	16	85	0	328,44
Italy	529	523	38	41	20	327,98
Cyprus	663	663	21	79	0	523,77
Latvia	301	301	16	84	0	252,84
Lithuania	469	458	21	79	1	370,51
Luxembourg	662	662	47	18	36	350,86
Hungary	402	402	26	65	9	297,48
Malta	589	559	13	87	0	512,43
Netherlands	551	551	50	2	49	275,5
Austria	552	528	62	3	35	209,76
Poland	314	249	25	75	1	235,5
Portugal	453	453	27	54	20	330,69
Romania	389	313	1	99	0	385,11
Slovenia	362	301	47	51	2	191,86
Slovakia	324	313	13	77	10	281,88
Finland	506	506	34	33	34	333,96
Sweden	462	462	47	1	52	244,86
United Kingdom	472	465	46	37	17	254,88

Source: Eurostat 2012

Waste management in the world

Which are the governing factors?





CALL FOR ABSTRACTS NOW OPEN!

please visit our new website
www.sardiniasymposium.it

sardinia_2015

15th INTERNATIONAL WASTE MANAGEMENT AND LANDFILL SYMPOSIUM

Forte Village _ S. Margherita di Pula (CA) _ Italy
5 _ 9 october 2015

Sardinia Symposium: the venue




people

900 delegates

72 different countries

Sardinia Symposium: DC's delegates

Special care of partecipants from developing countries: dedicated programmes and sessions, reduced entrance fees, fellowships.

Vamos a enconcontrarnos
in Sardinia
desde el 5 hasta el 9 October 2015…
www.sardiniasymposium.it

GRAL 2015, Guatemala, Conferencia de amor!

Amores academicos

Amores seguros y reales

Amores possibiles

Amores impossibiles

Amores bien consolidado y sin modernidad!

Amores vietados


Muchisima gracias!
GRAL 2015