

GARDELEGI TECHNOSOILS (2013-2016) VITORIA-GASTEIZ

TECNOSUELOS

DE GARDELEGI



NEIKER
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

eman ta zabal zazu



Universidad
del País Vasco

Euskal Herriko
Unibertsitatea

<https://tecnosuelosgardelegi.blogspot.com>
email: jvilela@vitoria-gasteiz.org



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**

CITY'S GREEN INFRASTRUCTURE

VITORIA-GASTEIZ
Infraestructura Verde
Urbana



ELEMENTOS NÚCLEO

- Anillo Verde
- A. Verde:
Áreas Agrícolas

NODOS

- Nodos Principales
y Secundarios
- Nodo Difuso

CONECTORES

- Este-Oeste
- Norte-Sur fluvial
- N-S no fluvial

0 1000 2000 m



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

VITORIA
GASTEIZ

CITY'S VACANT LAND

VITORIA-GASTEIZ

ANÁLISIS DE PARCELAS VACANTES EN SUELO URBANO Y URBANIZABLE

FECHA: Septiembre 2018

NOTAS:
No tiene por qué existir correlación directa entre los datos inventariados en este mapa y los datos del Catastro, el Registro de la Propiedad o el Impuesto de Actividades Económicas. En este análisis se ha utilizado la información contenida en el Planamiento Urbanístico de la ciudad y los datos obtenidos mediante cartuchos y vistas de campo "in situ".

Parcelas Vacantes de Equipamiento en ámbito urbanizado

NOTA: Se consideran parcelas vacantes de equipamiento aquellas parcelas cuyo uso actual coincide con el uso regulado en el planeamiento.

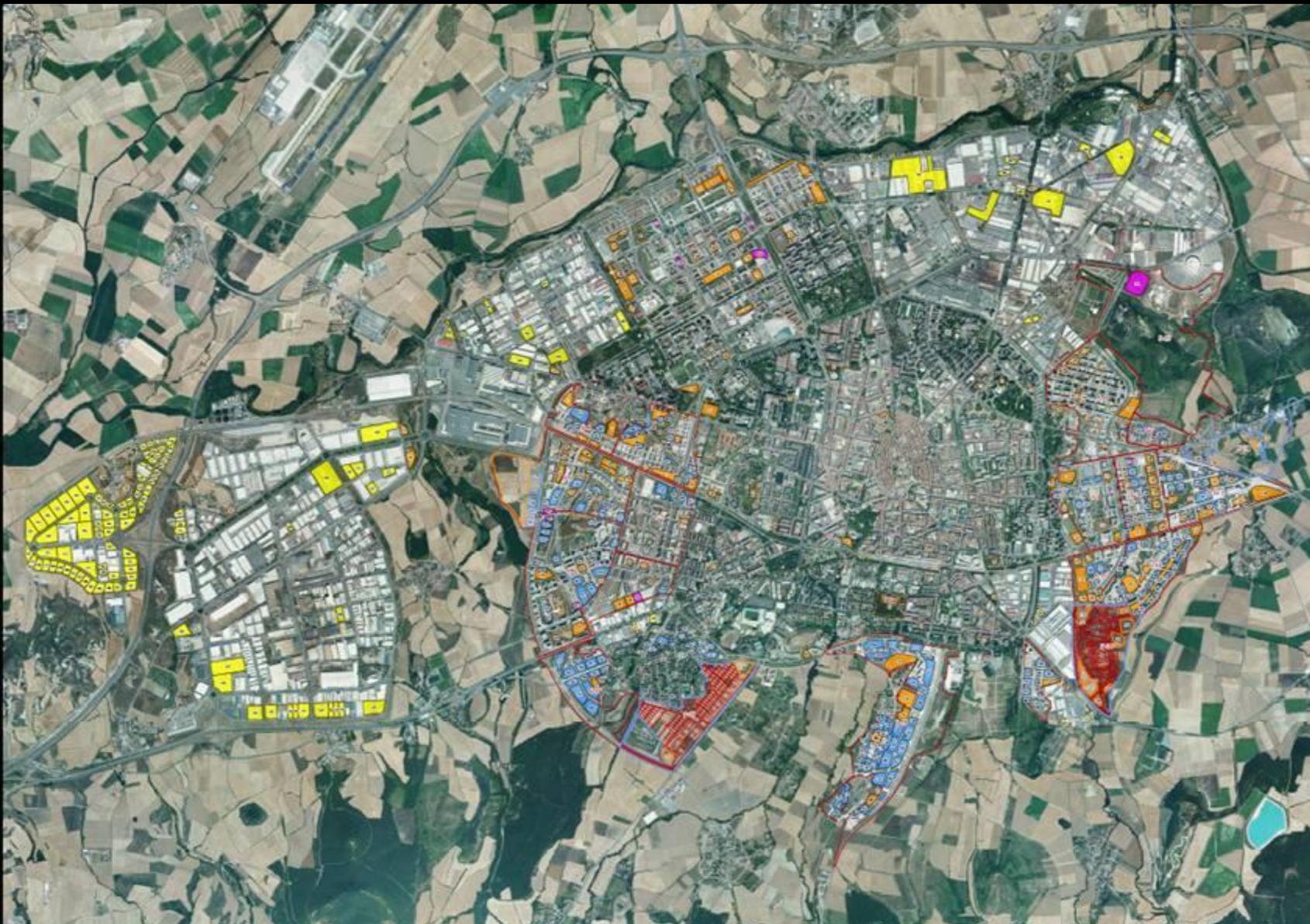
- Equipamiento con uso consensuado diferente al regulado en el planeamiento: 52 Ubs. (104705 m²)
- Equipamiento municipal sin uso consensuado: 144 Ubs. (179436 m²) (los parcelas marcadas con * corresponden al uso residencial en plantas altas)

Parcelas Vacantes resto de categorías en ámbito urbanizado

- Productivo: 128 Ubs. (1111386 m²)
- Residencial: 262 Ubs. (2670342 m²)
- Terciario: 11 Ubs. (88338 m²)

Parcelas Vacantes en ámbito no urbanizado

- Equipamiento en ámbito no urbanizar: 17 Ubs. (239619 m²)
- Residencial en ámbito no urbanizar: (384744 m²) (no se actualizan en el plano las parcelas correspondientes a los sectores 14, 17 y 20)



HEALTHY SOILS FOR RESTORATION



MUNICIPAL RESIDUES (C&D's, Urban waste)

FROM RESIDUES TO RESOURCES



- LACK OF HEALTHY SOIL
- 1.000.000 M2 OF VACANT LAND
- UNUSED WASTE MATERIALS TO LANDFILL



Tabla 2: formulación de las mezclas de tecnosuelo.

Mezcla	RCD	Material bioestabilizado	Poda	Bentonita	Tierras de Vitoria	TOTAL
M11	85 %	10 %	5 %	0 %	0 %	100 %
M12	70 %	20 %	10 %	0 %	0 %	100 %
M21	65 %	10 %	5 %	0 %	20 %	100 %
M22	50 %	20 %	10 %	0 %	20 %	100 %
M31	70 %	10 %	5 %	15 %	0 %	100 %
M32	55 %	20 %	10 %	15 %	0 %	100 %

RCD: construction and demolition waste

Biostabilized material: compost from domestic waste

Poda: chipped pruning

Bentonita: recycled bentonite from foundry sands

Tierras de Vitoria: in-situ existing soil



EXPERIMENTAL DESIGN

24 EXPERIMENTAL PLOTS

- 18 mix plots (3 x 6 mixes) + 4 ingredient plots
- 4 types of vegetation cover
- 3 year program control



CONSTRUCTION PHASES



VEGETATION COVERS



Centro
de Estudios Ambientales

CEA

Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**

WORKING AND MONITORING CALENDAR

	2013				2014								2015		2016	
	SEP	OCT	NOV	DIC	ENE	FEB	ABR	MAY	JUN	JUL	AGO	OCT	DIC	JUN	DIC	DIC
FASE I - EJECUCIÓN DE PARCELAS DE TECNOSUELOS																
Acopio ingredientes	Ing															
Ejecución mezclas	Mez															
Maduración		Mez														
Formación celdas																
Relleno celdas			Cel													
FASE II - EJECUCIÓN DE SIEMBRAS Y PLANTACIONES																
Plantaciones																
Siembras																
Siegas																
FASE III - SEGUIMIENTO Y CONTROL																
Muestreos	Ing	Mez		Cel		Cel	Cel		Cel		Cel	Cel	Cel	Cel	Cel	Cel
Lixiviados naturales																
Tratamiento pulgón colza																
Medición cosecha																
Medición crecimiento bosque																
Medición biomasa pradera																
Medición crecimiento sauces																
Corta sauces																



MONITORING PROGRAM

- SOIL
- SOIL EULATES (FORCED LIXIVIATION)
- SOIL LIXIVIATES

SUELO BRUTO	
NORMATIVA 4/2015	LÍMITE VIE-B
<i>Metales pesados (ppm)</i>	
Arsénico	30
Cadmio	25
Cobre	10000
Cromo (total)	400
Mercurio	15
Molibdeno	250
Níquel	500
Plomo	450
Zinc	10000
<i>Otros compuestos inorgánicos (ppm)</i>	
Cianuros	5
<i>Compuestos inorgánicos volátiles (ppm)</i>	
Benceno	5
Etilbenceno	20
Tolueno	40
Xileno	40
Fenol	25
<i>Hidrocarburos aromáticos policíclicos (ppm)</i>	
Antraceno	500
Benzo(a)pireno	2
Fluoranteno	60
Naftaleno	10
<i>Pesticidas (ppm)</i>	
a-HCH	1
b-HCH	0.10
c-HCH	0.10
<i>Otros (ppm)</i>	
PCB	0.80

SUELO BRUTO			
NORMATIVA 49/2009	LÍMITE		
Parámetro (mg/kg)	Inerte	No peligroso	Peligroso
COT	30000	50000	60000
BTEX	6	-	-
PCB	1	-	-
Aceite mineral (C10 a C40)	500	-	-
pH	-	<6	-
NORMATIVA ITR 01/08			
LÍMITE			
<i>Parámetros</i>			
Salmonella sp	Ausente		
Escherichia coli	1000 NMP/g		
Tasa ecotoxicidad (%)	< 85 %		
<i>Parámetros físicos</i>			
Arena gruesa (%), Arena fina (%), Limo (%), Arcilla (%)			
Densidad (g/ml), Humedad (%), Conductividad eléctrica (µS/cm), Materia orgánica (%), Nitrógeno total (mg/kg), Carbono total (mg/kg), Potasio total (mg/kg), Fósforo total (mg/kg)			
ELUATO			
NORMATIVA 9/2009			
LÍMITE			
Componente (mg/kg de materia seca)	Inerte	No peligroso	Peligroso
Arsénico	0.50	2.00	25.00
Cadmio	0.04	1.00	5.00
Cromo total	0.50	10.00	70.00
Cobre	2.00	50.00	100.00
Mercurio	0.01	0.20	2.00
Molibdeno	0.50	10.00	30.00
Níquel	0.40	10.00	40.00
Plomo	0.50	10.00	50.00
Antimonio	0.06	0.70	5.00
Selenio	0.10	0.50	7.00
Zinc	4.00	50.00	200.00
Bario	20.00	100.00	300.00
Fluoruro	10.00	150.00	500.00
Cloruro	800.00	15000.00	25000.00
Sulfato	1000.00	20000.00	50000.00
Índice de fenol	1.00	-	-
COD	500.00	800.00	1000.00

LIXIVIADO	
NORMATIVA RD 849/1986 D.P.H.	LÍMITE
<i>Componente (mg/l)</i>	
pH	5.5-9.5
Conductividad eléctrica (µS/cm)	-
SS	80.00
DQO	160.00
Aluminio	1.00
Arsénico	0.50
Bario	20.00
Boro	2.00
Cadmio	0.10
Cromo total	-
Hierro	2.00
Manganeso	2.00
Níquel	2.00
Mercurio	0.05
Plomo	0.20
Selenio	0.03
Estaño	10.00
Cobre	0.20
Zinc	3.00
Cianuros	0.50
Cloruros	2000.00
Sulfatos	2000.00
Fluoruros	6.00
Fósforo	10.00
Fenoles	0.50



SOIL SAMPLING – INGREDIENT ANALYSIS



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**

SOIL SAMPLING – 24 CELLS ANALYSIS



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**

SOIL SAMPLING –ELUATE ANALYSIS



LEACHATES SAMPLING AND ANALYSIS



BIOMASS AND VEGETATION MONITORING



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**

RESULTS – Pre-installation analysis (ingredients)

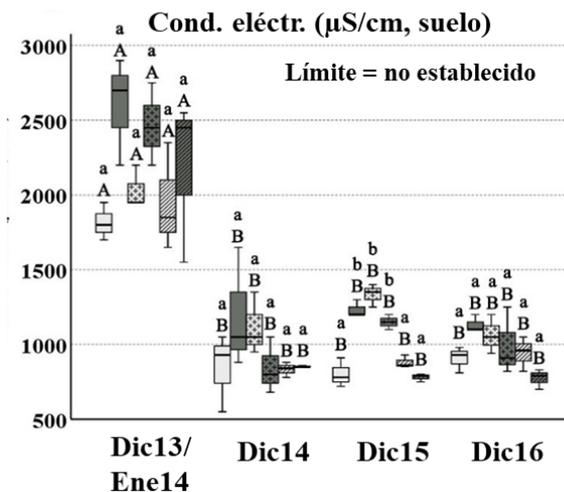
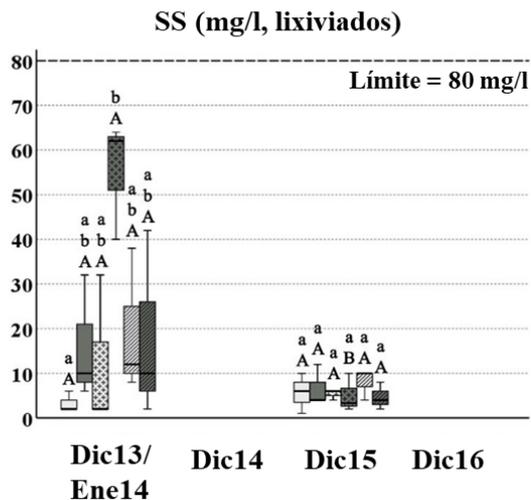
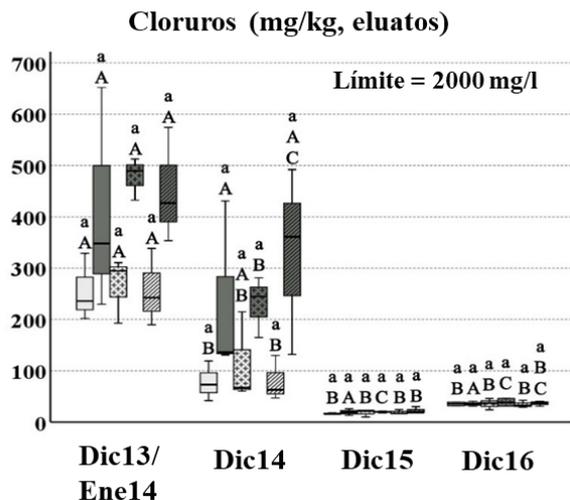
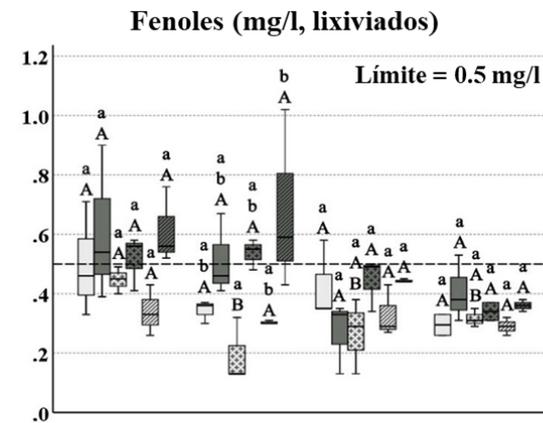
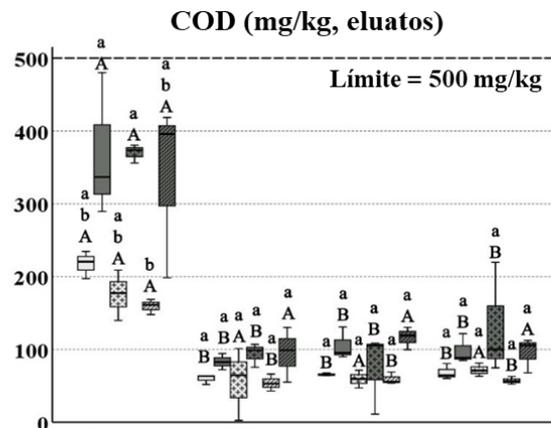
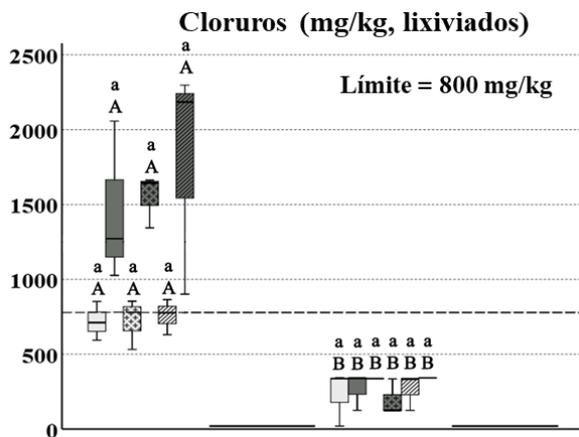
LEYENDA	Límite (inerte)	INGREDIENTES				
	Límite (no peligroso)	Tierras RCD	Material Bioestabilizado	Poda triturada	Bentonita	Tierras Vitoria
FECHA DE MUESTREO		27/09/2013	27/09/2013	11/10/2013	27/09/2013	27/09/2013
ELUATO - NORMATIVA 49/2009						
Componente (mg/kg de materia seca)						
Arsénico		0.10	0.20	0.00	0.10	0.03
Cadmio		0.04	0.00	0.00	0.02	0.02
Cromo total		0.18	0.00	0.00	0.04	0.03
Cobre		0.47	8.20	0.00	0.00	0.08
Mercurio		-	-	-	-	-
Molibdeno		0.27	0.30	0.00	0.26	0.04
Níquel		0.09	0.90	0.00	0.05	0.02
Plomo		0.00	0.30	0.00	0.05	0.02
Antimonio		0.07	0.40	0.10	0.02	0.01
Selenio		0.12	0.50	0.00	0.04	0.03
Zinc		0.22	13.20	0.00	0.36	0.16
Bario		0.52	0.00	0.00	0.18	0.84
Fluoruro		44.80	1.00	1.00	74.30	6.50
Cloruro		-	-	-	-	-
Sulfato		-	-	-	-	-
Índice de fenol		-	-	-	-	-
COD		80.20	10500.00	6875.00	155.00	63.40
<i>Salmonella sp.</i>		Ausente	Ausente	Ausente	Ausente	Ausente
<i>E.coli</i> (NMP/g)		93.00	0.00	>2400	0.00	7.40
<i>C. perfringens</i> (ufc/g)		82.00	<10	360.00	<10	200.00

RESULTS – Pre-installation analysis (mixes)

LEYENDA	Límite (inerte)	MEZCLAS					
	Límite (no peligroso)	M11	M12	M21	M22	M31	M32
FECHA DE MUESTREO	21/10/2013	21/10/2013	21/10/2013	21/10/2013	21/10/2013	21/10/2013	21/10/2013
ELUATO - NORMATIVA 49/2009							
Componente (mg/kg de materia seca)							
Arsénico	0.08	0.09	0.07	0.10	0.07	0.08	
Cadmio	0.01	0.02	0.01	0.01	0.01	0.02	
Cromo total	0.03	0.05	0.02	0.04	0.02	0.04	
Cobre	0.39	0.26	0.15	0.17	0.14	0.13	
Mercurio	-	-	-	-	-	-	
Molibdeno	0.14	0.18	0.13	0.16	0.16	0.21	
Níquel	0.10	0.17	0.10	0.17	0.14	0.22	
Plomo	-	-	-	-	-	-	
Antimonio	0.03	0.03	0.02	0.02	0.02	0.02	
Selenio	0.02	0.03	0.03	0.02	0.02	0.03	
Zinc	0.14	0.37	0.15	0.40	0.18	0.53	
Bario	0.34	0.33	0.61	0.58	0.37	0.30	
Fluoruro	2.80	2.20	2.70	2.50	4.00	4.60	
Cloruro	-	-	-	-	-	-	
Sulfato	-	-	-	-	-	-	
Índice de fenol	-	-	-	-	-	-	
DOC: dissolved organic carbon	579.00	1272.00	459.80	1108.00	610.80	1328.00	
<i>Salmonella sp.</i>	Ausente	Ausente	Ausente	Ausente	Ausente	Ausente	
<i>E.coli</i> (NMP/g)	>2400	1100.00	>2400	>2400	1100.00	>2400	
<i>C. perfringens</i> (ufc/g)	<40	<40	<10	<40	<10	<40	



RESULTS – Soil analysis



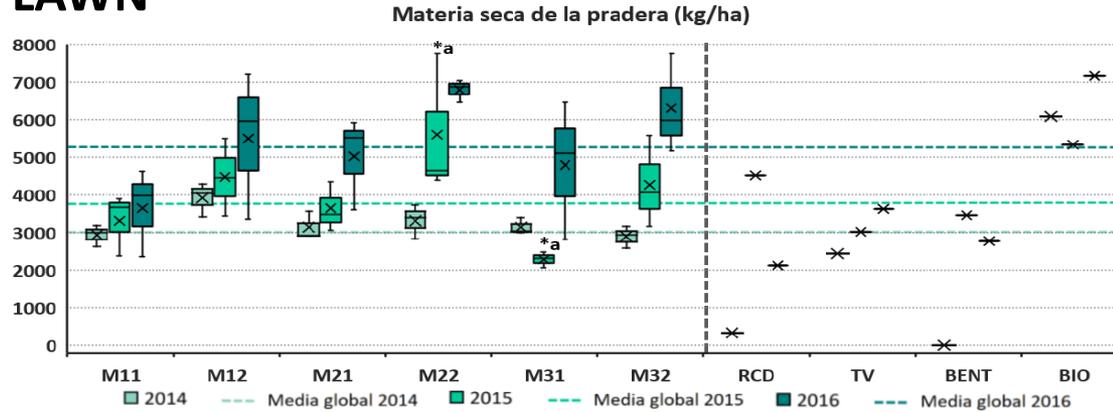
M11
 M12
 M21
 M22
 M31
 M32
 --- Legislation limit

RESULTS – Vegetation analysis



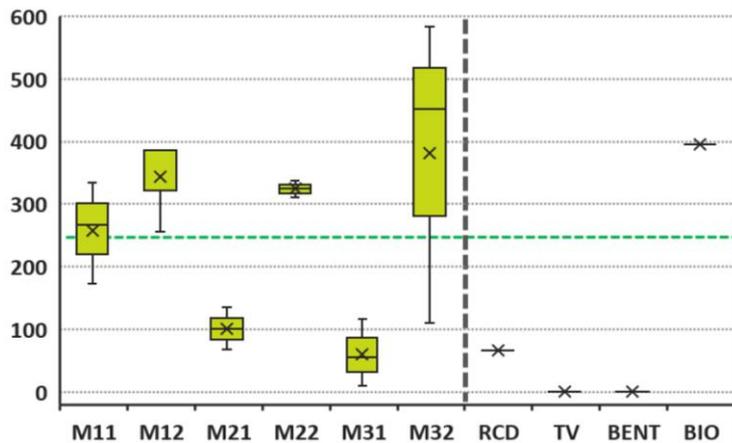
RESULTS – Vegetation analysis (biomass)

■ LAWN

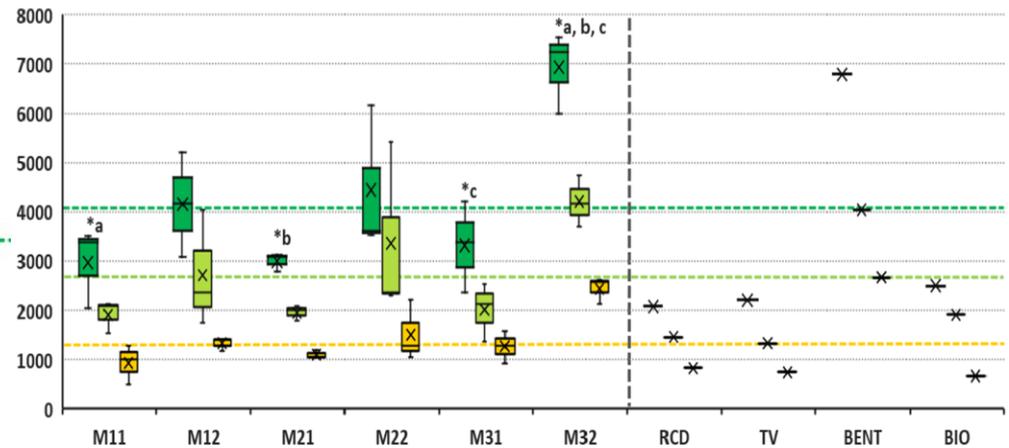


■ CROPS: rapeseed (2014) wheat (2015)

Materia seca de la colza (kg/ha)



Producción de trigo (kg/ha)



■ Peso cosechado - - - Media global ■ Peso restos - - - Media global ■ Peso grano - - - Mediana global

RESULTS – Vegetation analysis

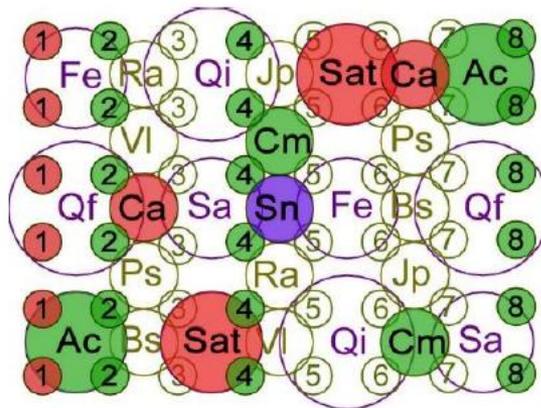
FOREST PLANTATIONS (% Survival rate by type)

	Año	M11	M12	M21	M22	M31	M32	RCD	TVG	BENT	BIO
Árbol Tree	2014	97.22 ± 6.80	88.89 ± 8.61	100 ± 0.00	88.89 ± 17.21	88.89 ± 13.61	80.56 ± 26.70	100	83.33	83.33	66.67
	2015	86.11 ± 12.55	69.44 ± 12.55	88.89 ± 13.61	63.89 ± 26.70	75.00 ± 17.48	66.67 ± 23.57	83.33	58.33	41.67	50.00
	2016	69.44 ± 26.70	58.33 ± 31.18	63.89 ± 34.53	50.00 ± 29.81	69.44 ± 16.39	55.56 ± 17.21	83.33	50.00	25.00	33.33
Arbusto Shrub	2014	95.83 ± 7.72	85.40 ± 18.77	93.75 ± 8.63	85.42 ± 18.77	91.67 ± 12.60	87.50 ± 17.25	100	100	68.75	37.50
	2015	89.58 ± 15.27	64.58 ± 27.37	85.42 ± 18.77	70.83 ± 31.81	72.92 ± 21.71	68.75 ± 25.88	100	93.75	6.25	6.25
	2016	85.42 ± 24.30	70.83 ± 23.15	83.33 ± 21.82	68.75 ± 31.42	75.00 ± 33.33	60.42 ± 36.66	100	81.25	18.75	6.25
Mata Bush	2014	94.44 ± 7.86	93.06 ± 11.40	94.44 ± 11.50	95.14 ± 6.92	97.22 ± 4.20	85.42 ± 12.58	100	91.67	54.17	66.67
	2015	86.81 ± 19.68	76.39 ± 27.82	73.61 ± 29.81	77.08 ± 27.13	84.03 ± 19.34	66.67 ± 25.00	95.83	85.42	43.75	47.92
	2016	63.39 ± 33.07	60.42 ± 32.72	59.72 ± 30.39	61.11 ± 35.51	65.97 ± 33.39	53.47 ± 36.00	85.42	70.83	31.25	25.00

RESULTS – Vegetation analysis

FOREST PLANTATIONS (Species growth)

ESPECIE	MIXES						INGREDIENTS			
	M11	M12	M21	M22	M31	M32	RCD	TV	BENT	BIO
ALTURA										
<i>Acer campestre</i>	↑	↑	↓	↘	→	→	↓	↑	↘	↘
<i>Fraxinus excelsior</i>	↗	↗	↓	↗	↗	↑	↓	↑	↘	→
<i>Quercus faginea</i>	→	→	↑	↘	↓	→	↘	↗	X	X
<i>Quercus ilex</i>	↗	↘	↘	↗	↑	↓	↗	↑	↓	X
<i>Sorbus aria</i>	→	→	↗	↓	↑	↗	↘	↗	X	X
<i>Salix atrocinerea</i>	↓	X	→	X	→	↑	↘	X	X	X
DIÁMETRO										
<i>Acer campestre</i>	→	↑	↘	↓	→	→	→	↑	↓	→
<i>Fraxinus excelsior</i>	↘	↘	↓	↗	↘	↑	↑	↗	↓	→
<i>Quercus faginea</i>	↗	↘	↑	↘	↓	↗	↗	↘	X	X
<i>Quercus ilex</i>	↗	↑	↓	→	↘	→	↑	↗	↓	X
<i>Sorbus aria</i>	↗	→	↑	↓	→	↗	↓	↑	X	X
<i>Salix atrocinerea</i>	→	X	↓	X	→	↑	↘	X	X	X

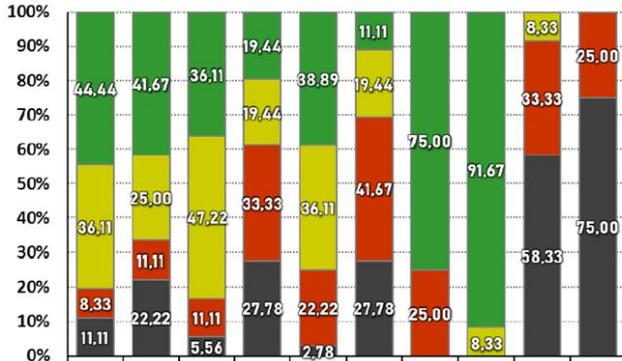


TREES	SHRUBS	SCRUBS
Qf: <i>Quercus faginea</i> Qi: <i>Quercus ilex</i> Fe: <i>Fraxinus excelsior</i> Ac: <i>Acer campestre</i> Sa: <i>Sorbus aria</i> Sat: <i>Salix atrocinerea</i>	Ra: <i>Rhamnus alaternus</i> Sn: <i>Sambucus nigra</i> Cm: <i>Crataegus monogyna</i> VI: <i>Viburnum lantana</i> Ca: <i>Corylus avellana</i> Ps: <i>Prunus spinosa</i> Bs: <i>Buxus sempervirens</i> Jp: <i>Juniperus communis</i>	1: <i>Genista hispanica</i> 2: <i>Thymus vulgaris</i> 3: <i>Salvia lavandulifolia</i> 4: <i>Lonicera periclymenum</i> 5: <i>Lavandula latifolia</i> 6: <i>Origanum vulgare</i> 7: <i>Dorycnium pentaphyllum</i> 8: <i>Lonicera xylosteum</i>

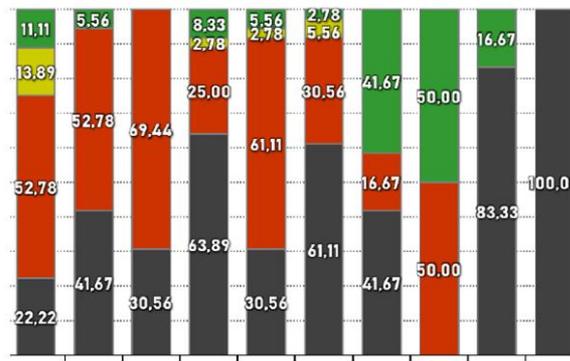
RESULTS – Vegetation analysis

■ WILLOWS (Survival)

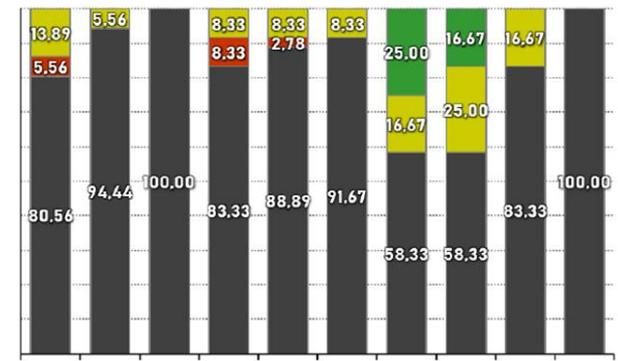
Vigor sauces (2014)
Método Americano



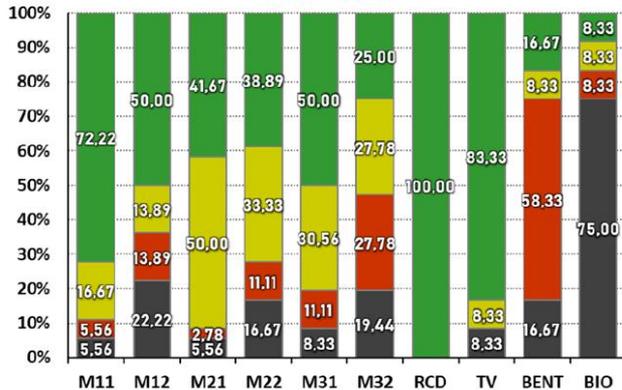
Vigor sauces (2015)
Método Americano



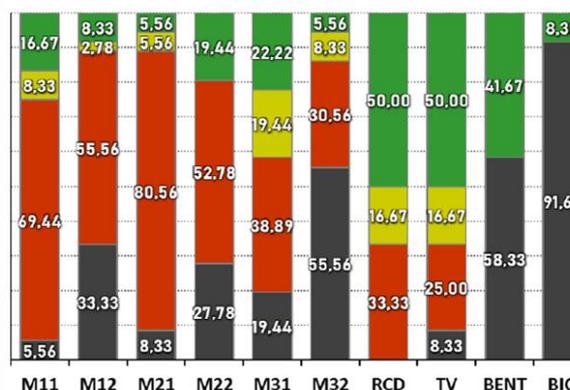
Vigor sauces (2016)
Método Americano



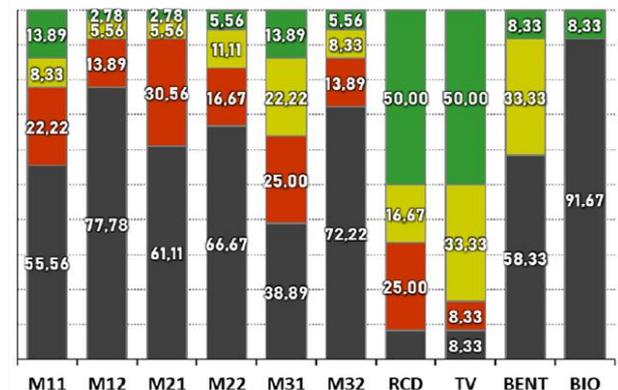
Vigor sauces (2014)
Método Sueco



Vigor sauces (2015)
Método Sueco



Vigor sauces (2016)
Método Sueco



■ Bueno ■ Regular ■ Malo-seco ■ Ausencia

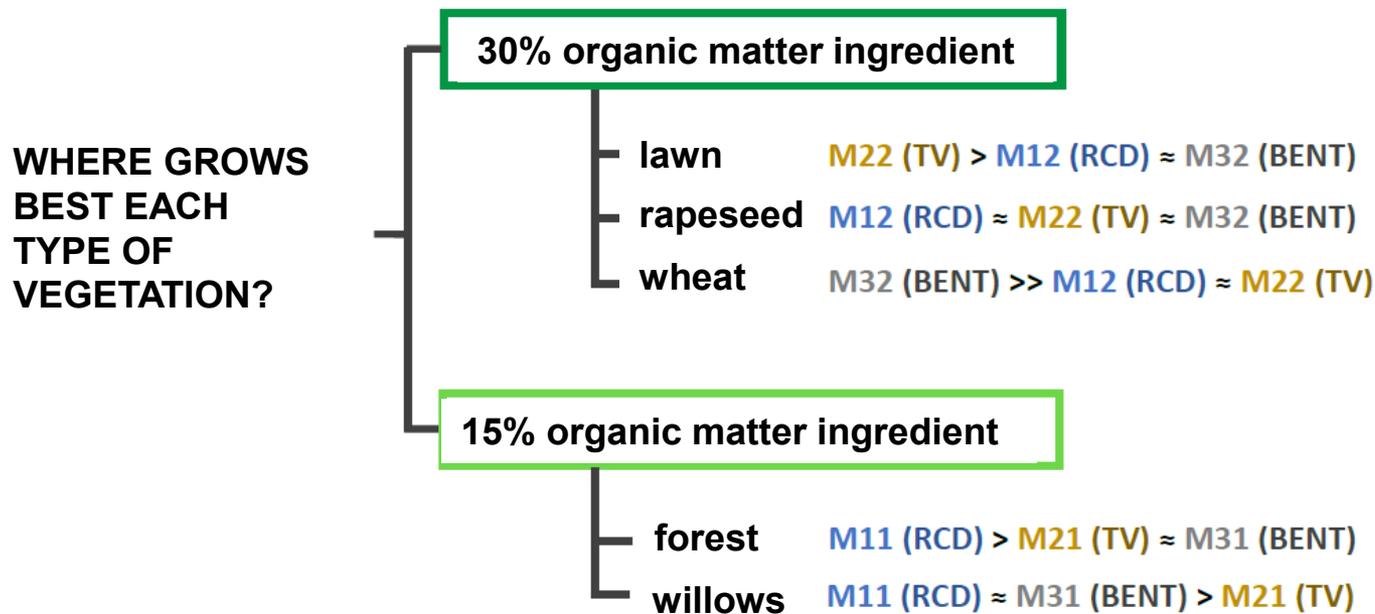
CONCLUSIONS – Soil

- **Time** proved to be a **fundamental factor** in understanding the dynamics of technosols.
- **Most of the variations** in the parameters analyzed occurred **during the first year**; after this period, the mixtures fluctuate less and tend to become more homogeneous.
- It is recommended to **allow a time frame of one year** prior to the installation of **technosols** to ensure the stability of the parameters analyzed and reduce environmental risks.
- Mixtures with a **single dose of organic matter** were more stable than those with a double dose. It is recommended to reduce the initial amount of this ingredient and/or add it in successive stages.
- The **M11 mixture seems to be the most suitable for use**, as it obtained the most stable results overall.

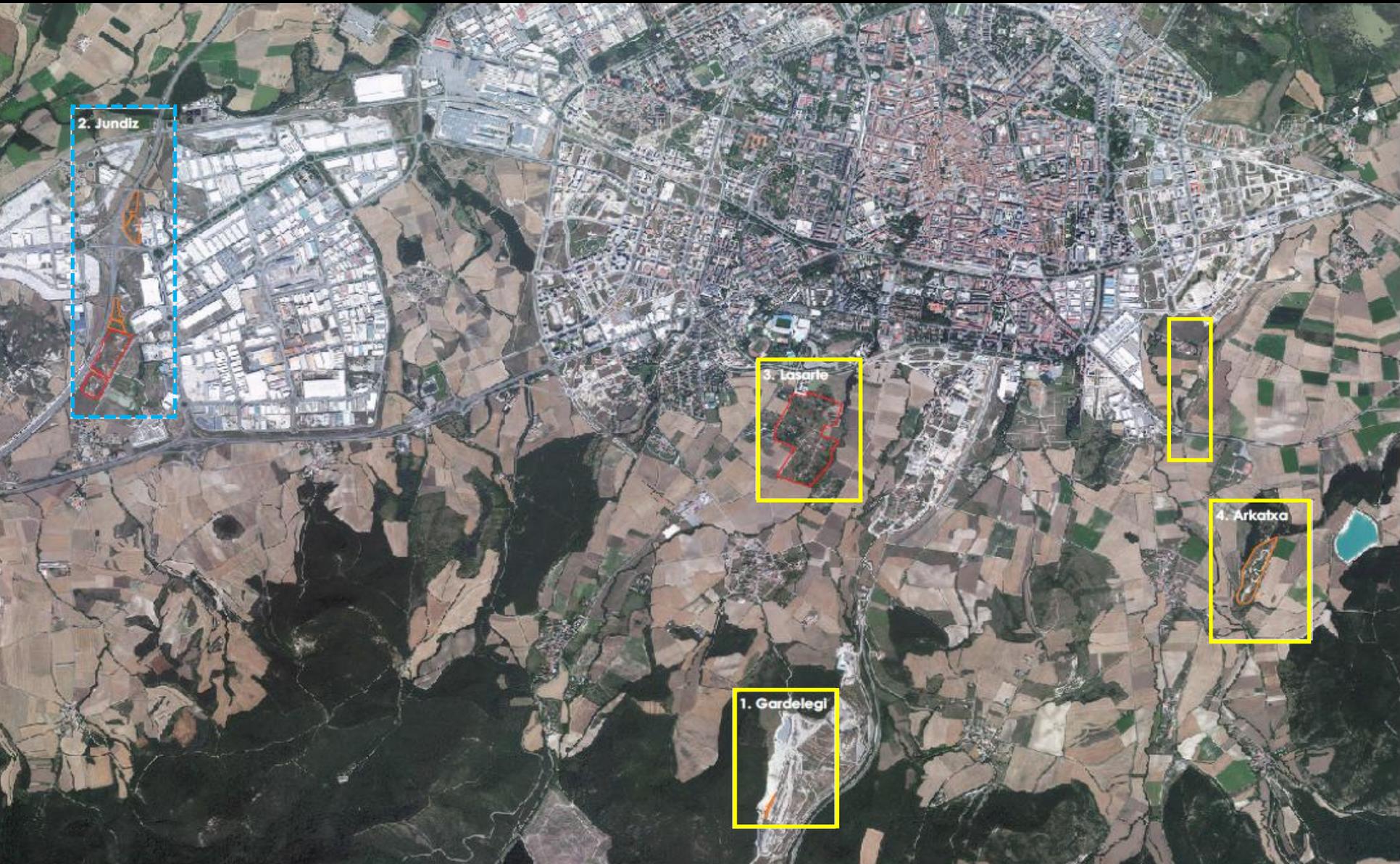


CONCLUSIONS – Vegetation

- **Lawn (grassland), agricultural crops, and forest plantations (especially shrubs) showed the most satisfactory growth results.** These types of vegetation would be the most recommended option soil restoration.
- **Each type of vegetation showed a different preference** for a particular type of mixture, due to the biological needs of each plant.



SOIL RESTORATION PROJECTS

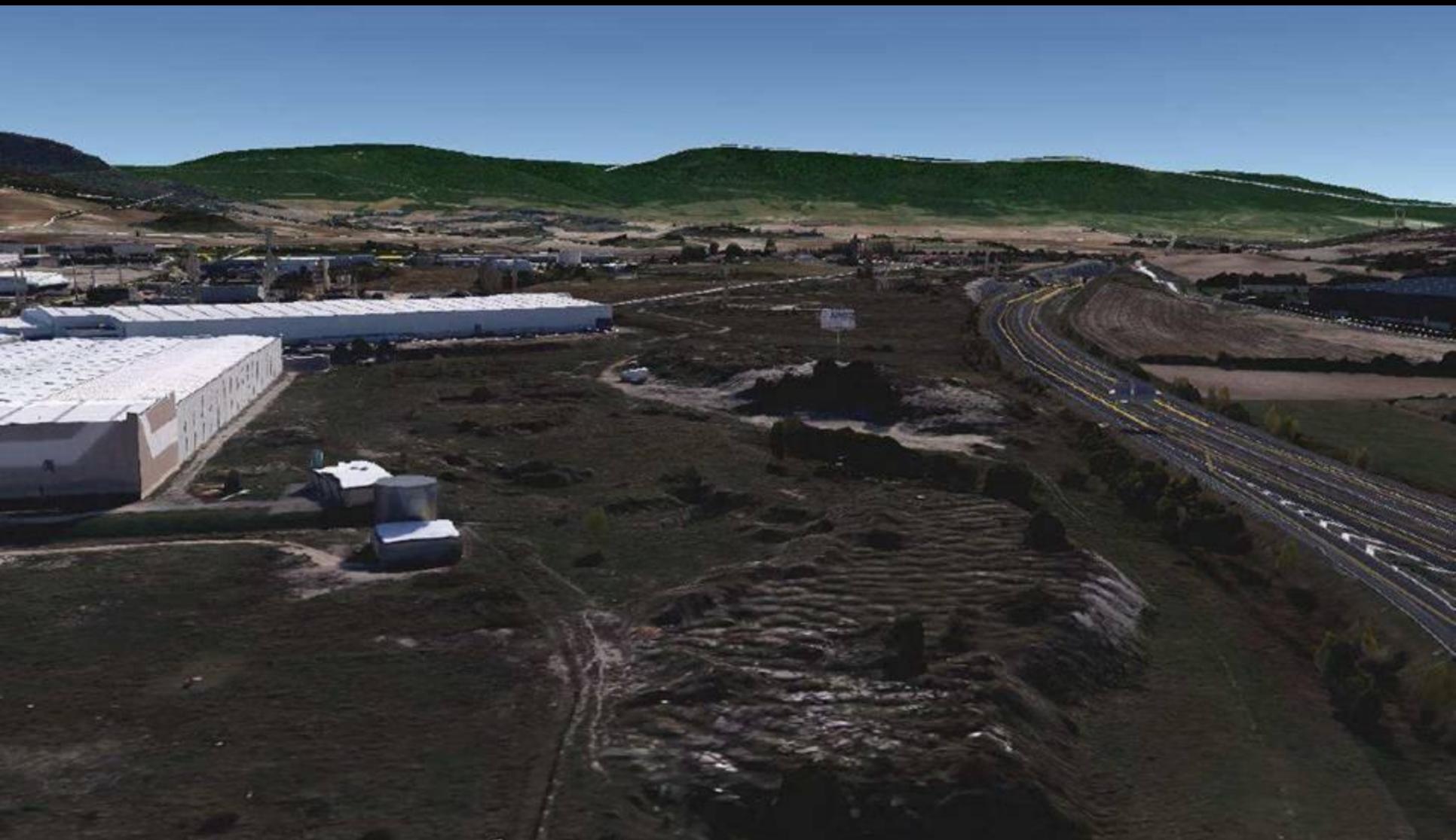


2. Jundiz

3. Losarte

4. Arkatxa

1. Gardelegi



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**



Centro
de Estudios Ambientales
CEA
Ingurugiro
Gaietarako Ikastegia

**VITORIA
GASTEIZ**



SOIL HEALTH PARAMETERS

Physico-chemical analysis, Heavy Metals, Organic Matter

Basal respiration (microbial activity) and **Induced respiration** (potential microbial biomass)

Functional microbial diversity through Community-level physiological profiles Biolog Ecoplates and enzymatic activities

Soil phytotoxicity tests

Structural diversity of soil microbial communities through DNA metabarcoding



MENDEBALDEA PROJECT (2016-2026)

<https://cea.vitoria-gasteiz.org/portal/es/w/mendebaldea>

PHYTOSUDOE PROJECTS (2018-20, 2020-23)

<https://www.phytosudoe.eu/en/>

URSOILL PROJECT Innovative solutions for sustainable urban soil restoration through Living Labs (2025-2030) <https://usroill.eu>



THANKS!
ESKERRIK ASKO!
GRAZAS!
MERCII!



ELSEVIER

Geoderma

Volume 377, 1 November 2020, 114563



Technosols made from urban and industrial wastes are a good option for the reclamation of abandoned city plots

Odei Barredo ^{a 1}, Juan Vilela ^{a 1}, Carlos Garbisu ^b, Gerardo Besga ^b, Itziar Alkorta ^c, Lur Epelde ^b  

Highlights

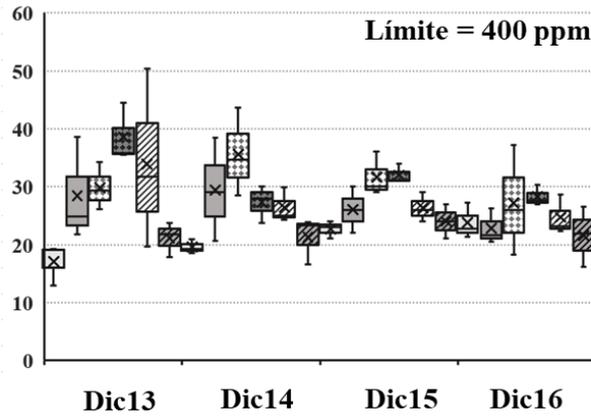
- **Technosols** were tested for the reclamation of abandoned city plots.
- Most parameters monitored along the 3-yr experiment complied with the legislation.
- The concentration of sulphates in the eluates exceeded the “inert” legal limit.
- All plant treatments showed a satisfactory growth except for willow trees.
- A higher amount of organic matter favoured the growth of meadows and crop rotations.



RESULTS – Soil analysis

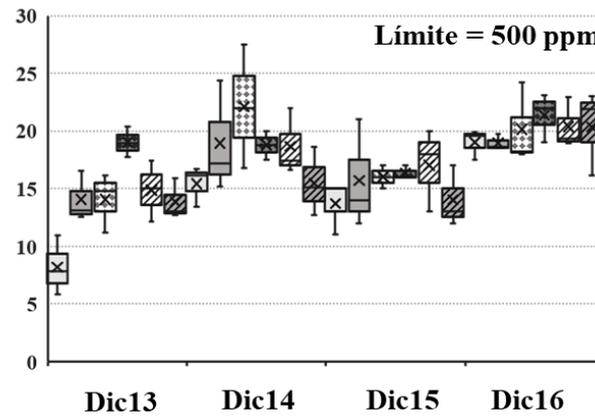
Cr (ppm, suelo)

Límite = 400 ppm



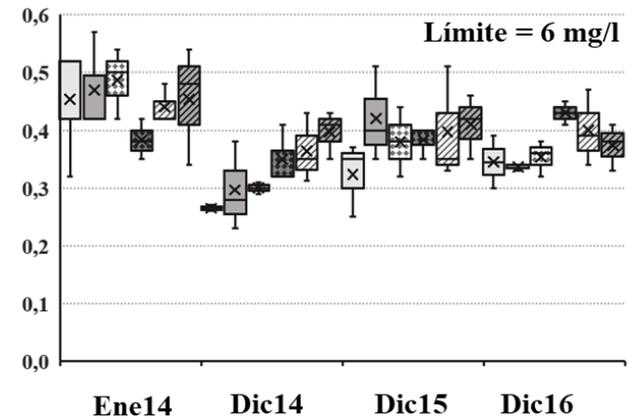
Ni (ppm, suelo)

Límite = 500 ppm



Fluoruros (mg/l, lixiviados)

Límite = 6 mg/l

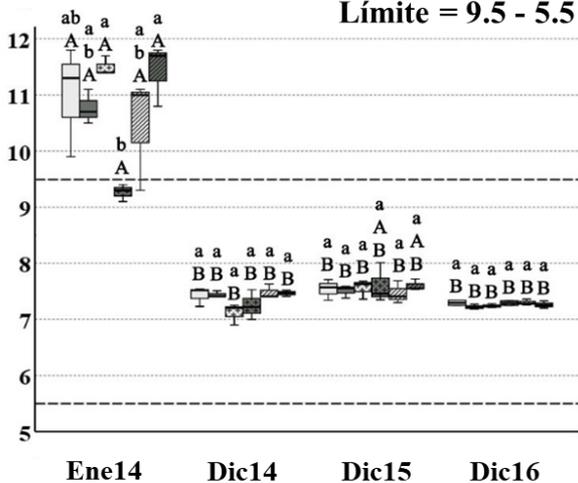


M11
 M12
 M21
 M22
 M31
 M32

RESULTS – Soil analysis

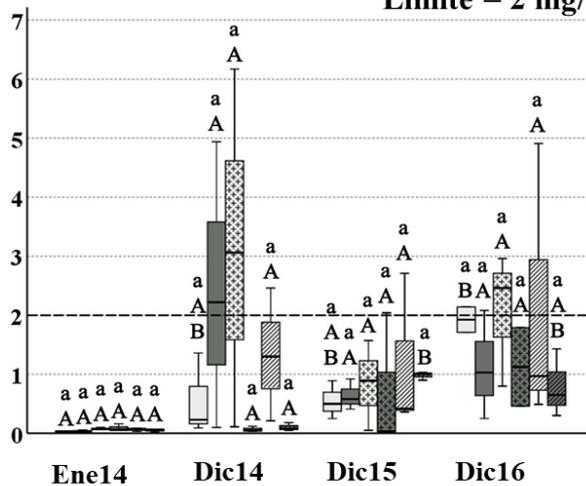
pH (lixiviados)

Límite = 9.5 - 5.5



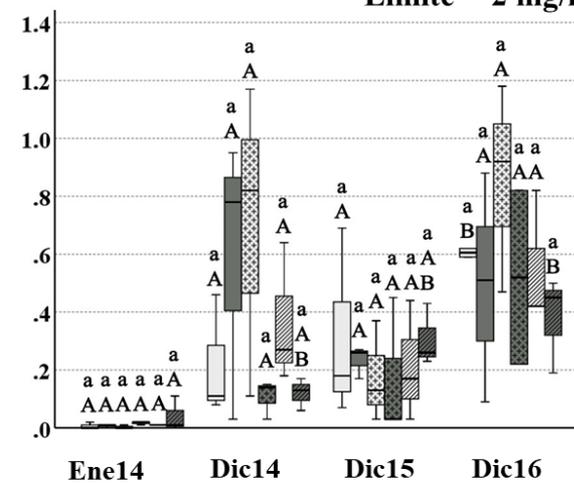
Fe (mg/l, lixiviados)

Límite = 2 mg/l



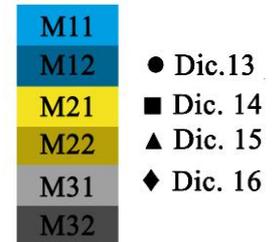
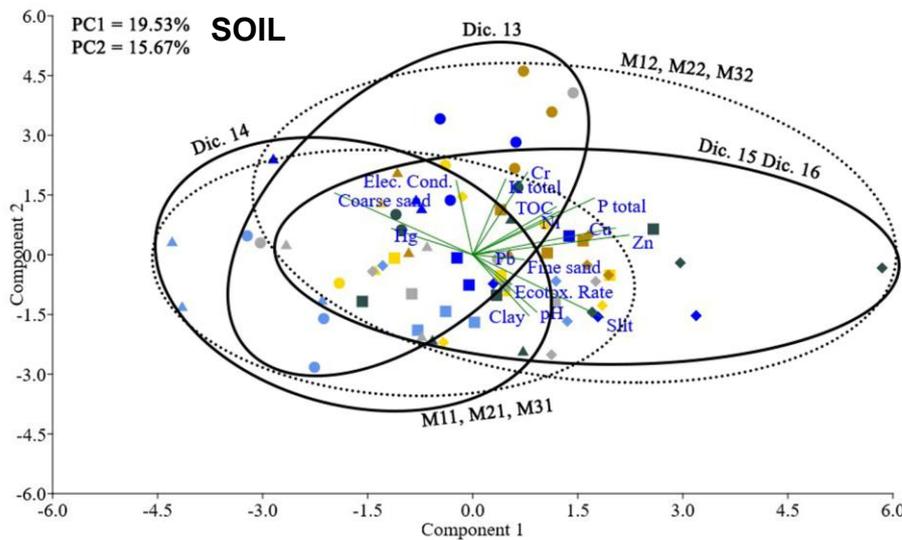
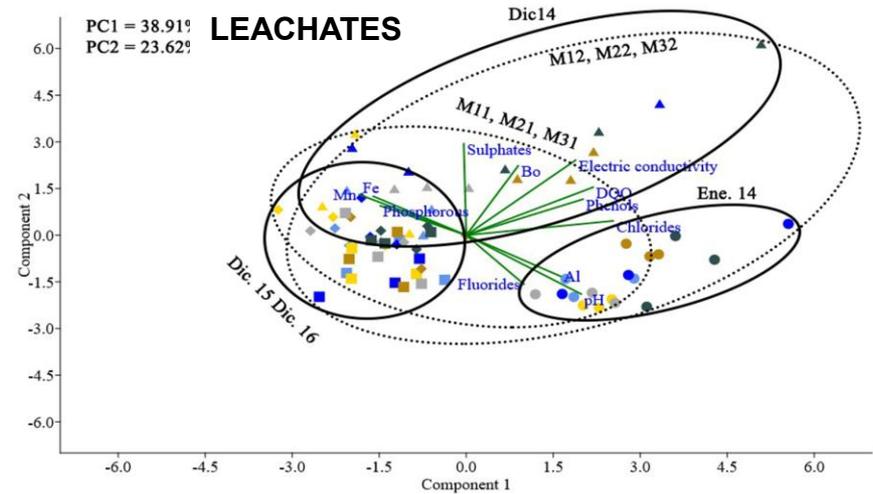
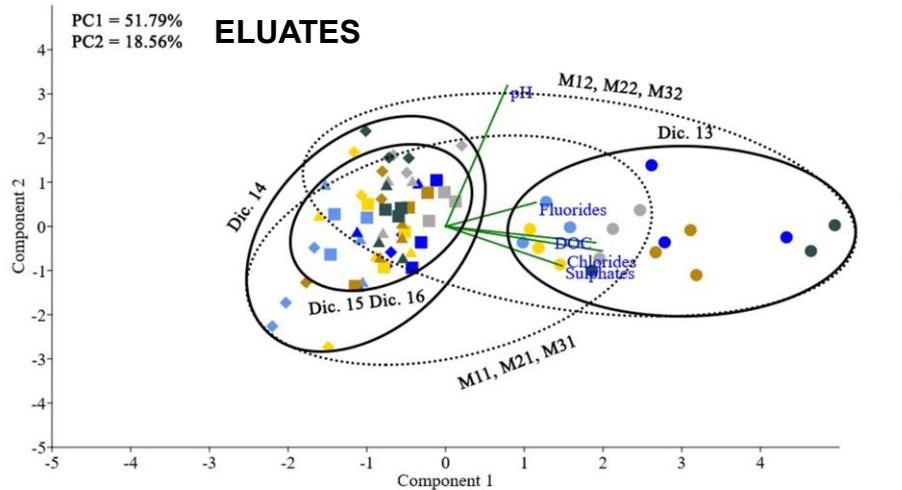
Mn (mg/l, lixiviados)

Límite = 2 mg/l



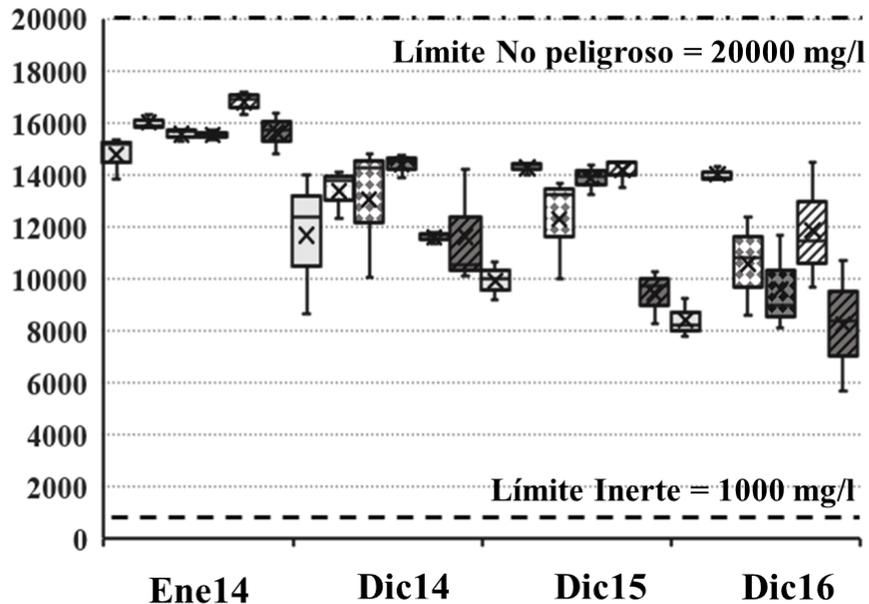
M11
 M12
 M21
 M22
 M31
 M32
 --- Legislation limit

RESULTS – temporal and compositional differences



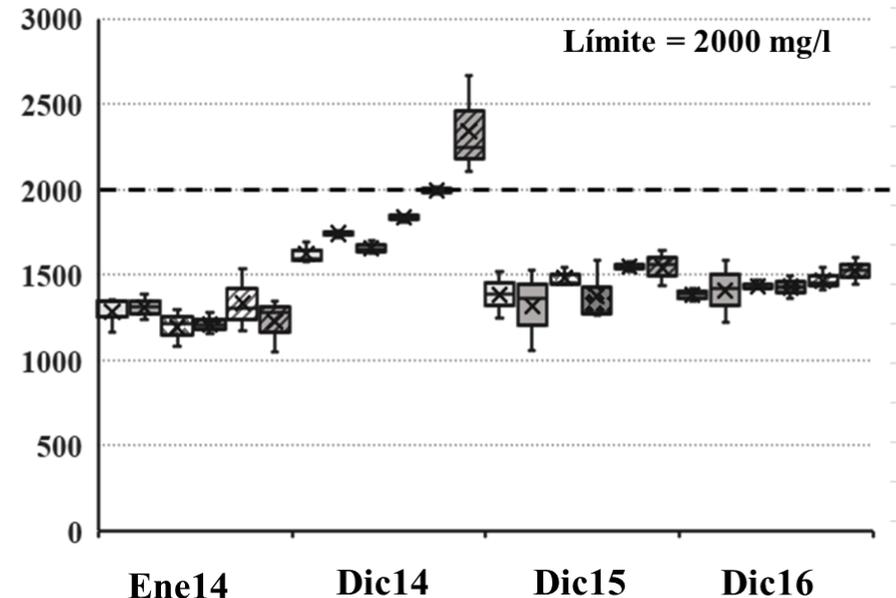
RESULTS – Legal limits

Sulfatos (mg/kg, eluatos)



M11
 M12
 M21
 M22
 M31
 M32
 --- Legislation limit

Sulfatos (mg/l, lixiviados)



Sulfates are naturally present in gypsiferous soils and have high solubility