5th European Biobed Workshop 2016

Effectiveness of biobed bioremediation systems using vermicompost from olive-oil waste to remove emerging contaminants from wastewater

Delgado-Moreno L., Nogales R. and Romero E.*

E-mail: esperanza.romero@eez.csic.es

Department de Environmental Protection, Estación Experimental del Zaidín,

Consejo Superior de Investigaciones Científicas (EEZ-CSIC),

c/ Profesor Albareda 1, 18008-Granada, Spain.

Study financed by MINECO and FEDER funds
Project CTM2013-44271-R

Introduction

Growing awareness of the impact that everyday activities have on the environment

Advances in measurement techniques

New pollutants in recent years that affect the quality of water.

Emerging Contaminants (ECs)

Pharmaceuticals, cyanotoxins, personal care products, nanoparticles, flame retardants, etc.

Unknown

- Concentration and persistence in the environment
- Effects
- Permisible level (no regulatory criteria for environmental and human risk)

Origin and main contamination focus

Wastewater

Treatment plants

***Diclofenac:* 17% removed**

83%

Environment

Solutions

- Ozonization
- Photodegradation
- Filtration Membranes
- Active carbon filtration

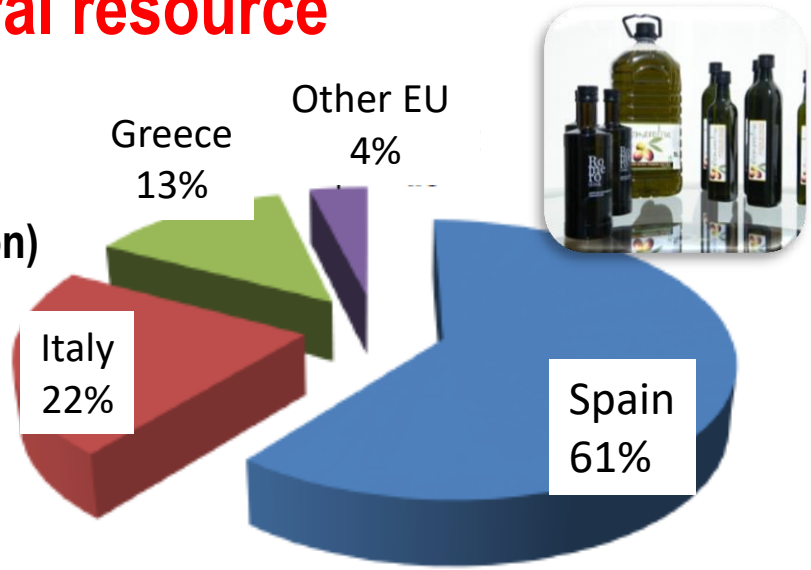
Expensive techniques, require maintenance support

- Biobed Bioremediation systems (BBSs)

A simple, versatile, low-cost technique, easy to install

In Spain: peat is a scarce natural resource

- Olive-oil Producción: 1,781,500 Tn 2013/2014
- 1760 extraction plants (818 in Andalusian region)
- Abundant generation of organic waste and by-products

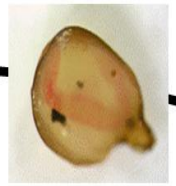


Objective

To determine the adsorption and degradation potential for three ECs by biomixtures composed of vermicompost from agroindustrial waste as a peat substitute, and olive pruning as a straw substitute, to select the most appropiate biomixture in BBSs for wastewater purification.

Material and methods

Wet olive cake or "*Alperujo*" *and* Vermicompost of wet olive cake



3%

Eisenia fetida

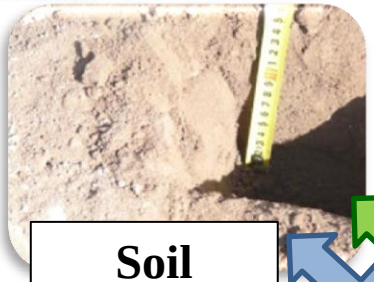
4 d.w.

1 d.w.

5 months +
1 month stabilization

Follows regulation (RD 506/2013) for organic fertilizers in agriculture or organic material for decontaminating soil and water

Two New Biomixtures



Soil

Vermicompost

Straw

Pruning+leaves

Soil (25%)
Vermic (25%)
Straw (50%)

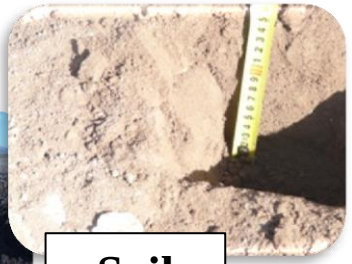
SVS

Soil (25%)
Vermic (25%)
Pruning (50%)

SVL

Peat Biomixture

Peat



Soil

Straw

Soil (25%)
Peat (25%)
Straw (50%)

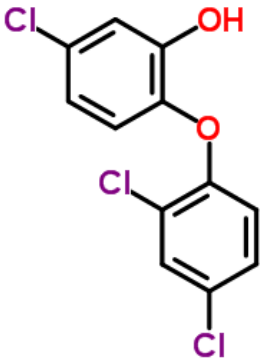
SPS

Stabilization under greenhouse conditions: 1.5 months

Emerging contaminants (ECs)

Triclosan (TRI) **(pKa =8,14)**

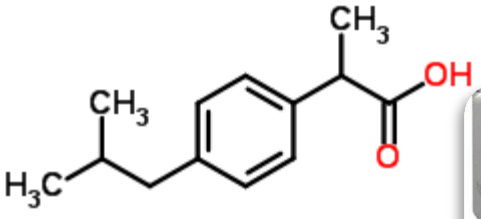
Is a preservative in cosmetic products. It is currently regulated in Annex VI, with a maximum concentration of 0.3%.



0,15%

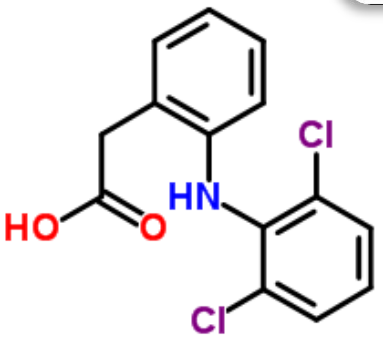
Ibuprofen (IBU) **(pKa = 4,91)**

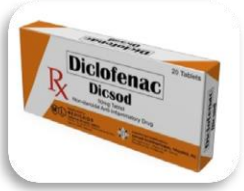
Is a nonsteroidal anti-inflammatory agent with analgesic and antipyretic properties used in treatment of rheumatism and arthritis



Diclofenac (DICLO) **(pKa = 4,0)**

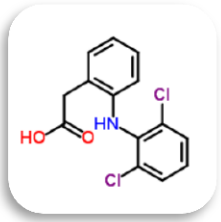
Is a non-steroidal anti-inflammatory agent (NSAID) with antipyretic and analgesic properties.



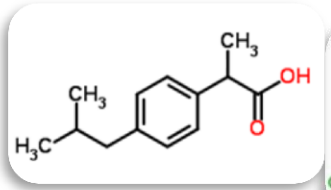


Standard solutions at 1 g L^{-1} in acetone

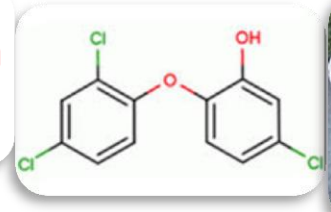
Adsorption studies



Diclofenac



Ibuprofen



Triclosan

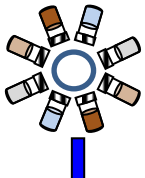
Biomixtures
(SVL SVS SPS)

Soil
(S)

ECs

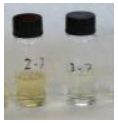
Agitation
(24h)

Centrifugation



Extraction of ECs in solid matrices (QuECheRS method)

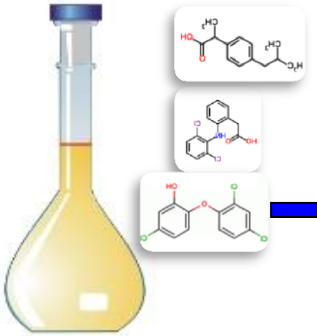
Filtration



Analysis

HPLC-DAD Cromatography

Incubation Experiments



EC standard solutions

1g

Application on quartz sand of <2mm particle size

Conc. 20 µg g^{-1}
Incubation at 20ºC, 75% FC

Extraction

Filtration

HPLC-DAD Analysis

Table 1. Physicochemical properties of the agricultural soil and biomixtures studied

Biomixture	FC (%)	pH	EC (dS m^{-1})	OC g Kg^{-1}	HA g Kg^{-1}	TEC g Kg^{-1}	Lig./Cel./Hemic. (%)
S	33.2	8.19±0.01	0.3±0.00	14.5±0.93	0.16±0.00	0.47±0.00	2.7 / 0.5 / 29
SVL	64.7	8.31±0.03	1.3±0.08	171±0.44	1.25±0.12	3.35±0.16	98 / 62 / 103
SVS	75.4	8.17±0.02	2.1±0.04	118±0.64	0.97±0.32	2.70±0.66	70 / 43 / 82
SPS	79.3	7.04±0.02	3.0±0.03	145±0.18	3.92±0.02	5.87±0.02	24 / 17 / 29

FC: Field Capacity EC: electrical conductivity; OC: organic carbon; C/N: carbon/nitrogen ratio; WSC water soluble carbon; HA: Humic acid, TEC: Total extractable carbon; Lig./Cel./Hemic. · Lignin/Celullose/Hemicellulose

The topsoil (S) is a silt clay loam (34% clay, 56% silt and 10% sand) with 43% Ca CO_3

SVL: Soil + Vermicompost of alperujo + olive pruning

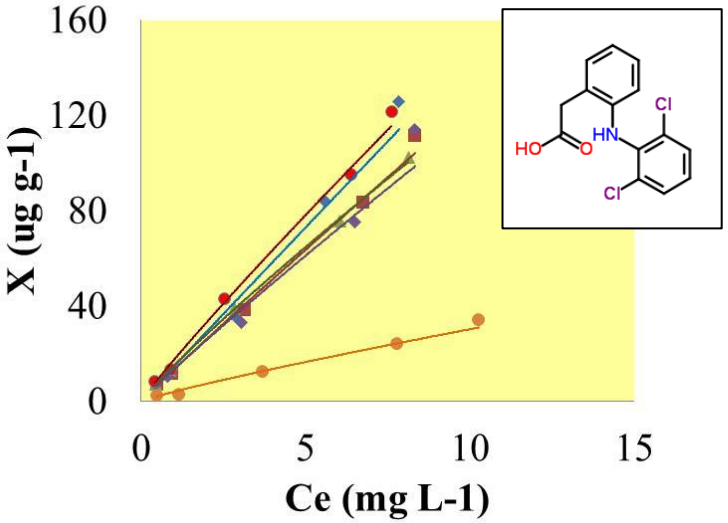
SVS: Soil + Vermicompost of alperujo + Straw

SPS: Soil + Peat+ Straw

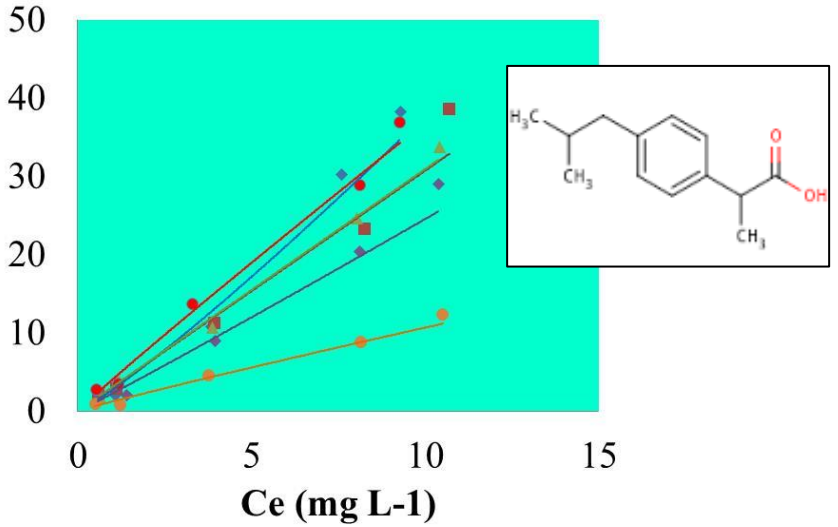
RESULTS: Adsorption of the ECs by the biomixtures

Amount adsorbed

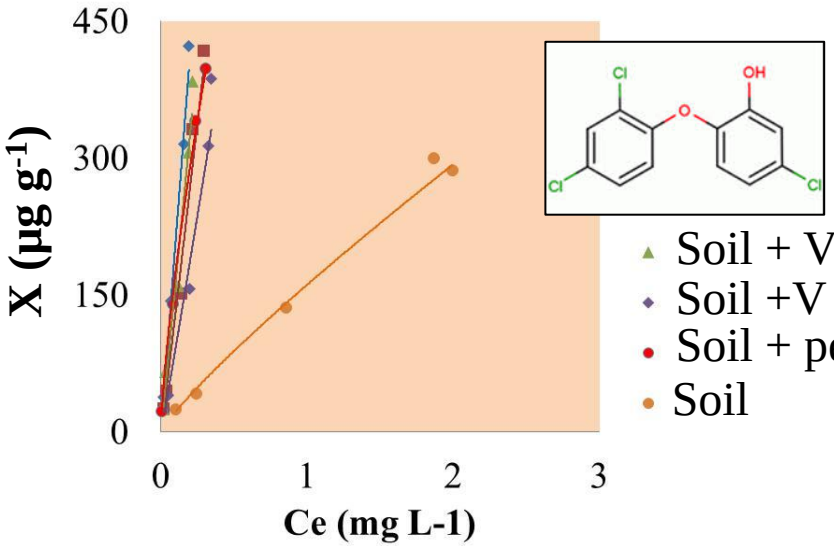
Diclofenac



Ibuprofen



Triclosan



- Soil + V+ olive pruning
- Soil +V + straw
- Soil + peat + straw
- Soil

Freundlich equation $(X = K_f \times C_e^{1/n})$

Table 2. Freundlich adsorption parameters and determination coefficients (R^2) for diclofenac, ibuprofeno and triclosan in the soil and in the biomixtures

	DICLOFENAC			IBUPROFEN			TRICLOSAN		
	Kf±ES	1/n±ES	R^2	Kf±ES	1/n±ES	R^2	Kf±ES	1/n±ES	R^2
S	3.3±0.5	1.0±0.1	1.00	1.1±0.2	1.0±0.1	0.99	160.5±9.0	0.9±0.1	0.99
SVL	14.7±0.6	0.9±0.0	0.92	2.5±0.3	1.1±0.1	1.00	2416.6±802.3	1.2±0.2	0.98
SVS	8.3±2.4	1.2±0.1	0.99	1.6±0.3	1.2±0.1	1.00	1698.4±489.1	1.5±0.3	0.98
SPS	16.5±2.1	1.0±0.1	1.00	3.8±0.9	1.0±0.1	0.99	1022.8±83.3	0.8±0.1	1.00

- **Kf (S) < Kf (Biomixtures SVL, SVS, SPS)**
- **The pruning waste used as a texturizing agent was more effective in the sorption of the ECs than straw as shown by the Kf values**
- **The novel biomixtures SVL and SVS have greater retention capacity for triclosan than SPS. However, this was not the case for diclofenac and ibuprofen.**

Dissipation of the ECs in the biomixtures

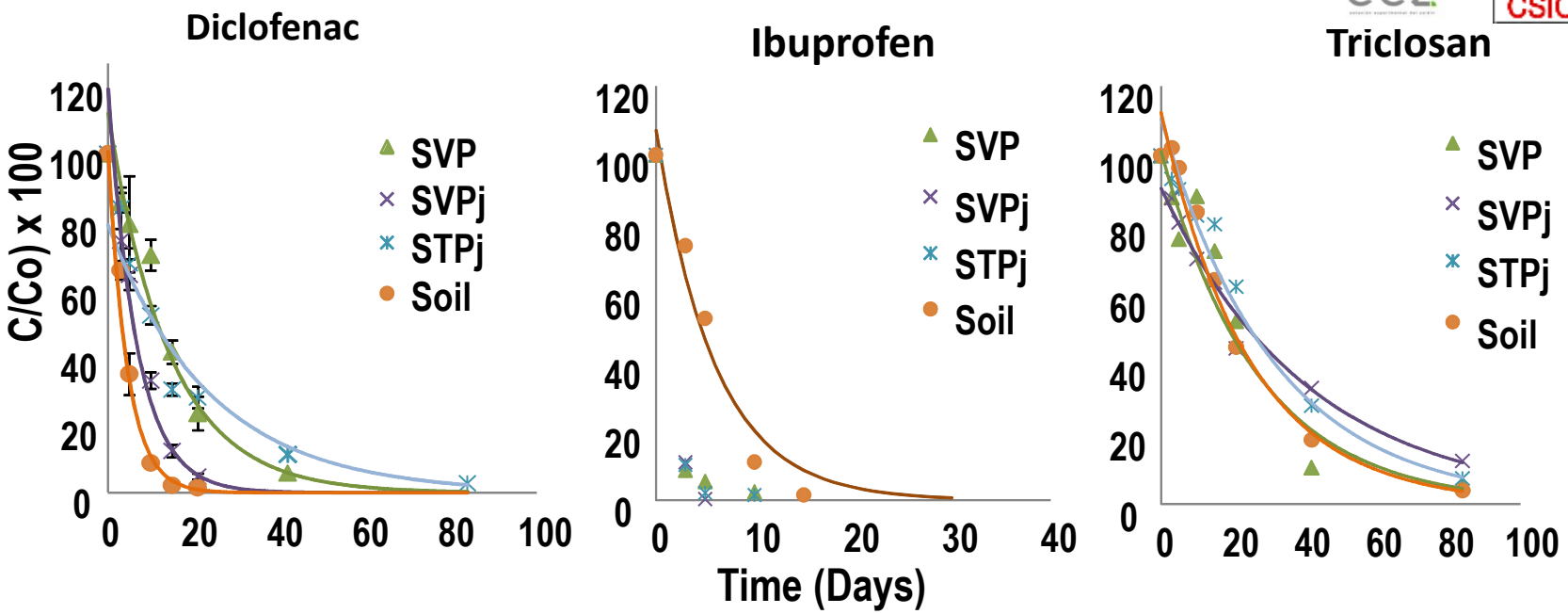


Table 2. Parametrers from the first − order dissipation kinetic ($C = C_0 \times e^{-kt}$)

Biomixture	DICLOFENAC				IBUPROFEN				TRICLOSAN			
	Co	K	R^2	Ln2/K	Co	K	R^2	Ln2/K	Co	K	R^2	Ln2/K
S	100.6	0.224	0.968	3.1	107.1	0.167	0.948	4.1	112.5	0.041	0.995	16.9
SVL	111.7	0.07	0.987	9.9					101.2	0.037	0.916	18.7
SVS	119.1	0.149	0.986	4.6					90.66	0.024	0.984	28.9
SPS	78.98	0.042	0.971	16.5					110.7	0.032	0.99	21.7

Conclusions

1. The biomixtures from SVS and SVL vermicomposts have greater retention capacity than Soil and SPS which may be due to their higher lignin/ cell. / hemicell. content.

2. The fastest degradation of the ECs occurred in Soil which can be attributed to its lower retention capacity with respect to the biomixtures.

3. The degradation potential of the biomixtures is related to the type of EC involved.

4. Ibuprofen was rapidly degraded in all the biomixtures, with a half-life of < 1 day.

5. The degradation of Diclofenac was faster in SVS and SVL than in SPS.

6. Triclosan was rapidly dissipated in the three biomixtures SVL, SVS and SPS, with a half-life of < 1 month.

Thank you