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CONGRESO INTERNACIONAL

Capitalización de Resultados del Proyecto IDiAqua. I+D+i sobre Depuración de Aguas Residuales en Pequeñas Aglomeraciones Urbanas.

ENTORNO VIRTUAL

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INNOVATION IN VEGETATION FILTERS FOR WASTEWATER TREATMENT AND RESOURCE RECOVERY

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INTRODUCTION

- In the frame of Challenges defined by the Spanish Strategy of Science, Technology and Innovation, the R&D&i related to efficiency in use of resources and raw materials and the integrated management and sustainable use of water resources in **rural areas**, is a priority.

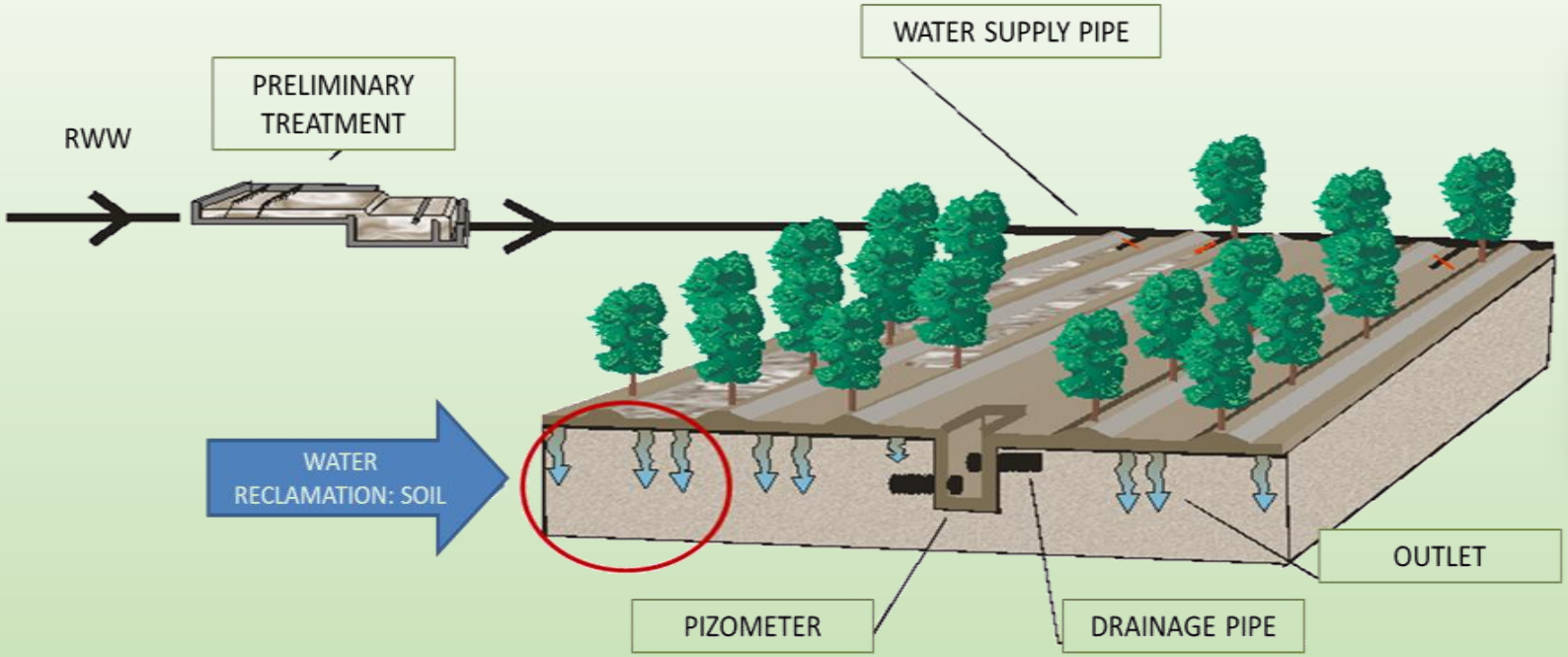
- In this context, **Vegetation Filters (VFs)** can be a sustainable solution to treat wastewater and to recover resources such as **water, nutrients and biomass** from small municipalities and isolated dwellings.

INTRODUCTION

Vegetation Filters (VFs), as a part of **Land Application Systems**, are **Nature based Solutions (NbS)** that take advantage of the natural treatment mechanisms to remove wastewater contaminants.

The wastewater is applied to irrigate forestry (mostly poplars and willows, but also eucalyptus) that can be used mainly for biomass production.

VFs. THE PROCESS



The treated effluent percolates through the soil to be incorporated into the aquifers. The quality of percolated water is controlled by lysimeters (unsaturated zone) and/or piezometers (groundwater).

VFs. ATTENUATION CAPACITY

- The efficiency of VFs to remove traditional wastewater-originated contaminants has already been reported (de Miguel et al., 2014; Martínez et al., 2018).

- However to our knowledge, their capacity to attenuate microparasites/pathogen (*E. coli*, intestinal helmints eggs) has not been sufficiently evaluated.

CHALLENGES OF FVs

Like other extensive technologies, the implementation of FVs faces the following major challenges to overcome:

- ✓ the requirement of large land areas (20-25 m^2 /p.e),
- ✓ the potential leaching of pollutants, such as nitrogen, ECs and parasitic micro-organisms/pathogens, into the underlying aquifer;
- ✓ the lack of responsiveness of the FV to changes in operating conditions,
- ✓ the actual assessment of its environmental implications, including transfers to other environmental compartments (water, soil and atmosphere).

FILVER + PROJECT

WATER RECLAMATION THROUGH A NEW CONCEPT OF VEGETATION FILTERS

State Programme on R&D&I oriented to society's challenges

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OVERALL OBJECTIVES:

Water reuse for forestry and removal of pollutants for aquifer recharge;

Development of an Amended Land Application System (ALAS) as a wastewater treatment technology, to maximizing removal of organic matter, nutrients, microparasites/pathogens and emerging pollutants, by application of low cost and easy acquisition amendments.

AIM OF THE PRESENT WORK

To evaluate the treatment capacity of a VF to remove contaminants (organic matter, nutrients and pathogen microorganisms) from a high organic load wastewater and contribute to reduce the surface requirements for the implementation of this solution and to improve further the contaminants attenuation by the evaluation of sustainable soils amendments.

AIM OF THE PRESENT WORK

The present study reports the results of a 4 years of the above-mentioned contaminants monitoring carried out using a poplar VF for the treatment of wastewater originating from an office building, as well as the results from the evaluation of the capacity of two sustainable soils amendments, woodchips from pruning remains and biochar to improve further the contaminants studied attenuation.

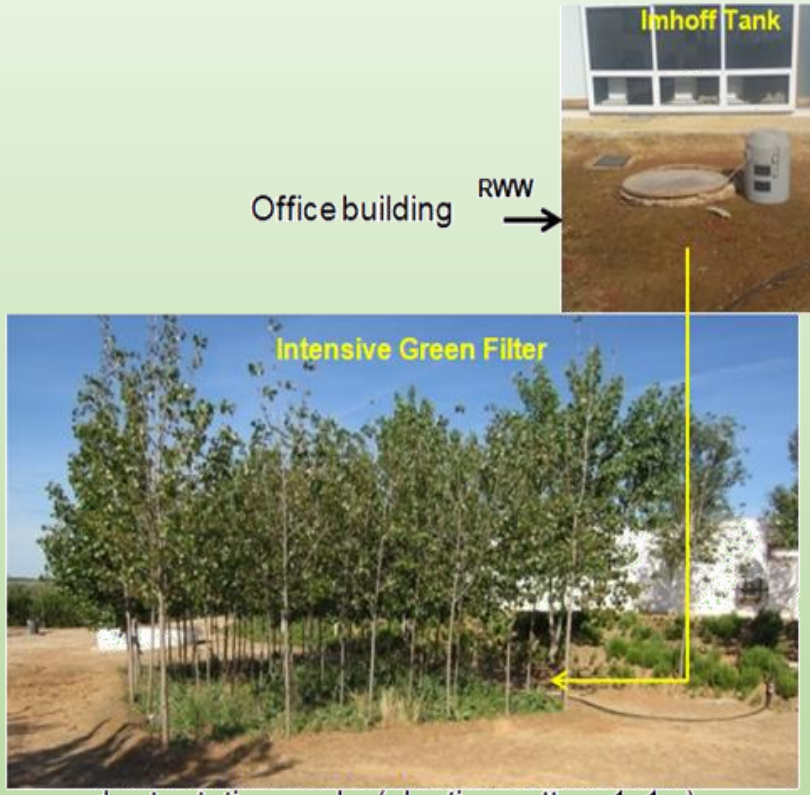
STUDY SITE DESCRIPTION

The study site is located in South-East of Spain at the R&D&I Centre of Carrión de los Céspedes (Seville).

STUDY SITE DESCRIPTION

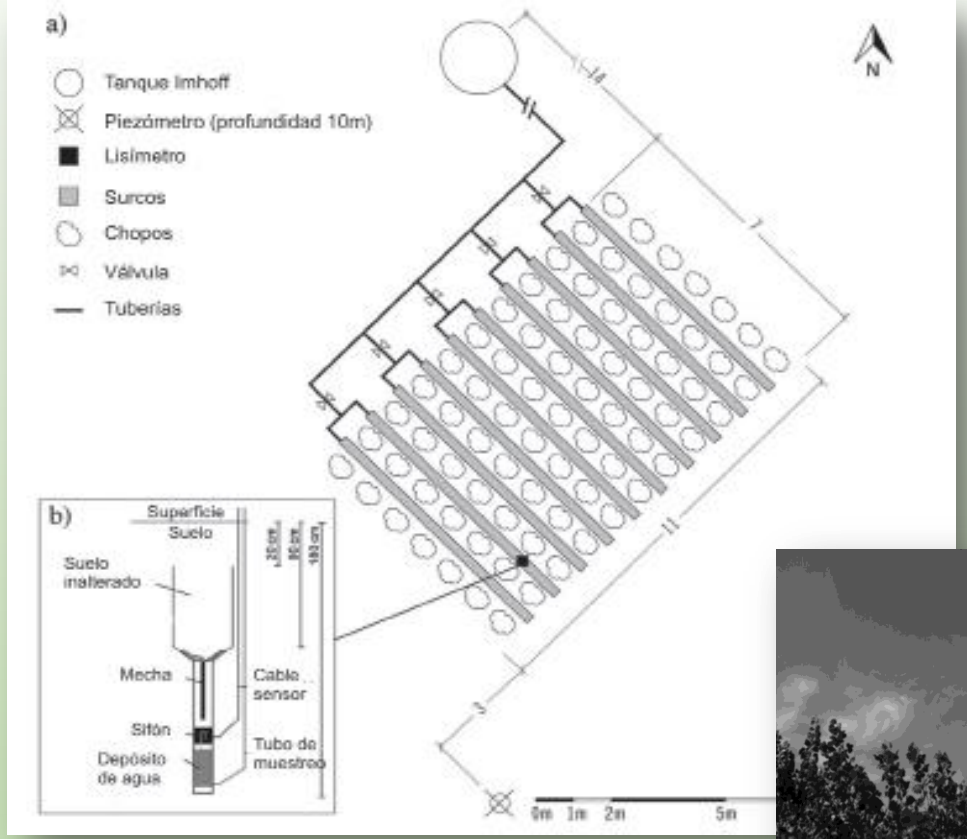
The system (77 m^2) is based on short-rotation coppice of poplars (*Populus alba*) with a high plantation density (10,000 plants/ha).

During the period of study the VF has treated a wastewater effluent from an office building that produce an average volume of 0.21 m^3/day, primarily treated in an Imhoff tank of 2.5 m^3 capacity.



short-rotation poplar (planting pattern 1x1m)

STUDY SITE DESCRIPTION



a) VF scheme; b) lysimeter

Real image of the VF with the piezometer in the foreground

- The Imhoff tank effluent was applied according to its production-depending on daily sanitary.
- The wastewater is applied by free drainage in 5 streets filled with gravel to avoid odours and direct contact.
- The experimental plot is equipped with a passive suction lysimeter (Ø = 24.5 cm) that allows periodic sampling of infiltrated water through the SNZ at a depth of 90 cm.
- In addition, for groundwater quality monitoring, there is a 10 m deep monitoring piezometer located 4 m downstream of the VF.

INFILTRATION EXPERIMENTS

- To identify which amendment will improve the attenuation of contaminants during vadose zone infiltration at the VF, three unsaturated infiltration-column experiments at laboratory scale were performed.

- The systems contain natural soil , natural soil amended with woodchips from poplar pruning remains and natural soil amended with biochar.

INFILTRATION EXPERIMENTS

(A) General view of the infiltration columns for laboratory-scale tests. (B) General view of the column test with percolated water extraction. (C) Sample of woodchips from poplar pruning. (D) Biochar sample. (E) Samples of percolated water for pollutant analysis. (F) Vials with *Ascaris* sp. eggs inactivated with 4% formalin and resuspended in aqueous solution. (G,H) Processing of samples extracted from columns for analysis of *Ascaris* sp. eggs in percolated water (Bailenger method).

RESULTS

Assessment of the soil attenuation capacity

	TSS (mg/l)	BOD_5 (mg/l)	COD (mg/l)	TN (mg/l)	N-NH4 (mg/l)	N-NO3 (mg/l)	TP (mg/l)	P-PO4 (mg/l)	*E. coli* (CFU/100ml)	Intestinal helminths (eggs/10l)
Inlet (outlet Imhoff tank)	390.9	445.6	767.3	298.4	268.4	5.0	31.9	27.5	2.5E + 06	ND
Lysimeter	10.0	13.0	30.3	81.6	20.1	47.9	1.0	1.0	9.9	ND
Piezometer (10 m)	12.1	14.4	27.9	5.4	1.3	4.7	1.0	1.0	1.0E+02	ND

- There are significant differences between the residual water and the infiltration and underground water; resulting in significantly lower mean concentrations.

- Significant attenuation of unsaturated soil zone (first 90 cm of soil)

RESULTS

Infiltration tests in columns under unsaturated conditions

The results obtained from the evaluation of the amendments (poplar woodchips and biochar) by means of infiltration tests in columns under unsaturated conditions, have allowed to determine that:

- Biochar is the amendment that presents the best elimination results at the level of suspended solids, COD, *E. coli* and eggs of *Ascaris* sp.

- Woodchips have turned out to be the amendment that shows the best performance removal at the nutrient level (total nitrogen, ammonia nitrogen, nitrates, total phosphorus and phosphates).

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RESULTS

Infiltration tests in columns under unsaturated conditions

Some of the properties of biochar, such as its high porosity, high pore number with a wide range of pore sizes, organic leaching and hydrophobicity, can enable high removal of microbial contaminants.

In the case of intestinal helminth eggs, the biochar acts as a filtration system, so that a large part of these eggs are retained in the filter, mainly the larger ones such as *Ascaris sp*.

RESULTS

Infiltration tests in columns under unsaturated conditions

Wood chips, being a labile carbon source, stimulate microbial activity and thus biodegradation processes.

In fact, the nitrification-denitrification cycles promoted by woodchips are responsible for the high nitrogen attenuation (>85%) observed at laboratory-scale tests.

Phosphorus, is almost completely removed by the processes occurring naturally in the soil (adsorption and precipitation) without the intervention of amendments.

CONCLUSIONS

The high removal rates show the role of the soil in the unsaturated zone during infiltration into groundwater, as well as its capacity as a natural reclamation technology for the recharge of aquifers by percolation through the ground.

Also, the results obtained in the project invite us to incorporate woodchips from pruning remains and biochar as sustainable soil amendments and potential wastewater treatment improvement.

In this sense, Vegetation Filters can be considered, in addition to highly effective natural systems in the purification and reclamation of wastewater, with low costs in O&M, a clear example of a circular economy; providing highly valuable inputs for the sustainable development of small agglomerations.

Thank you!

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