ELECTROCHEMICAL TECHNOLOGY AS A REMEDIATION STRATEGY FOR EMERGING ORGANIC CONTAMINANTS IN EFFLUENT-IRRIGATED SOIL

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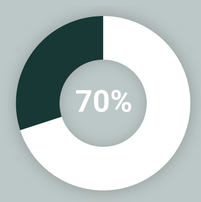
1 BACKGROUND

The problem

Water scarcity affects one in three people on every continent of the globe.
Only 3% of the total water covering earth is freshwater.

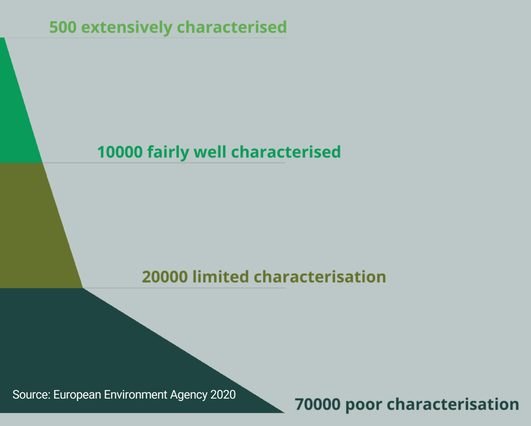


of freshwater use is in agriculture

The solution

Reclaimed wastewater use for irrigation is a reliable water supply independent of seasonal drought and weather variability and can cover peaks of water demand.

The problem behind the solution



Wastewater can be a source of contamination Emerging organic contaminants - pharmaceuticals and personal care products (PPCPs) - are not fully removed by wastewater treatment plants.

The **adverse effects** of these contaminants on human health and agroecosystems are still being studied.

OBJECTIVE 2

Assess the **potential of Electrokinetic (EK) remediation** as a cost-efficient and non-invasive technique **for environmental risk mitigation when wastewater is used for irrigation.**

METHODOLOGY 3

Study objects

Soil
Rice culture
(silty clay, Table 1)

RWW
Municipal wastewater
(Table 2)

PPCPs
Sulfamethoxazole (SFM)
Diclofenac (DCF)
Ibuprofen (IBF)
Carbamazepine (CBMP)
Ethinylestradiol (EE2)
Oxybenzophenone (MBPh)

EK conditions

EK stationary cell (Figure 1)

Current strategies applied Continuous current (CC)
•On/Off period
•Polarization reversal (REP)
•On/Off + REP

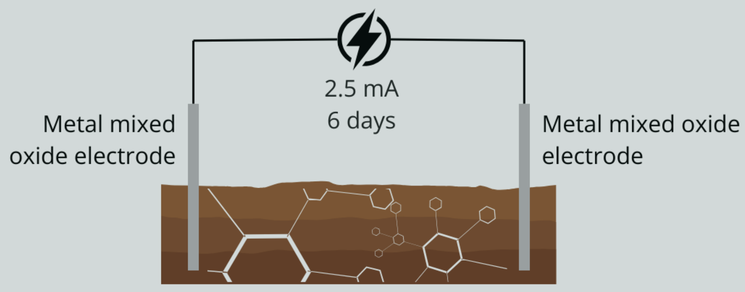


Figure 1. Schematic representation of EK system used.

Parameters monitored: PPCPs degradation and mobilization, pH, conductivity, moisture content, voltage drop.

4 MAIN RESULTS

- **EK improved the removal of EOCs by up to 30% when compared to natural attenuation** (Figure 2).

Table 1 – Soil characterisation (sampled at a rice field located at Paul de Magos, Salvaterra de Magos, Portugal, at 0–20 cm depth, corresponds to a Fluvisol - World Reference Base for Soil).

Soil parameters	Value
Sand (%)	19.7
Silt (%)	26.9
Clay (%)	53.4
$pH_{(H2O)}$	6.23
Conductivity (mS cm^{-1})	0.28
Total carbon (g kg^{-1})	24.6
Organic content (g kg^{-1})	42.4
Cation exchange capacity ($cmol_{(+)}$ kg^{-1})	22.7
Exchangable cations ($cmol_{(+)}$ kg^{-1})	
Ca^{2+}	11.3
Mg^{2+}	5.7
K^{+}	0.5
Na^{+}	1.2
Sum of exchangable cations ($cmol_{(+)}$ kg^{-1})	18.7

Table 2 – Effluent characterisation (Collected after the secondary settler in a WWTP located in Quinta do Conde, Sesimbra, Portugal).

Color	Pale yellow
Odor	Very weak
pH	8.02 ± 0.03
Conductivity (mS cm^{-1})	1.18 ± 0.08
Total phosphorus - P (mg L^{-1})	1.67 ± 1.17
Total chloride - Cl^{-} (mg L^{-1})	< 0.10
Total suspended solids - TSS (mg L^{-1})	< 10 - 30
Chemical oxygen demand - COD (mg O_2 L^{-1})	52.50 ± 31.82
5-day biochemical oxygen demand - BOD_5 (mg O_2 L^{-1})	< 3 - 18

- Sulfamethoxazole (SFM) showed the highest remediation rate (75 - 83%) when EK was applied, with around 57% of the removal estimated to be due to enhanced bioremediation.

- Ibuprofen (IBF) and diclofenac (DCF) removals were highly dependent on the directionality of the current.

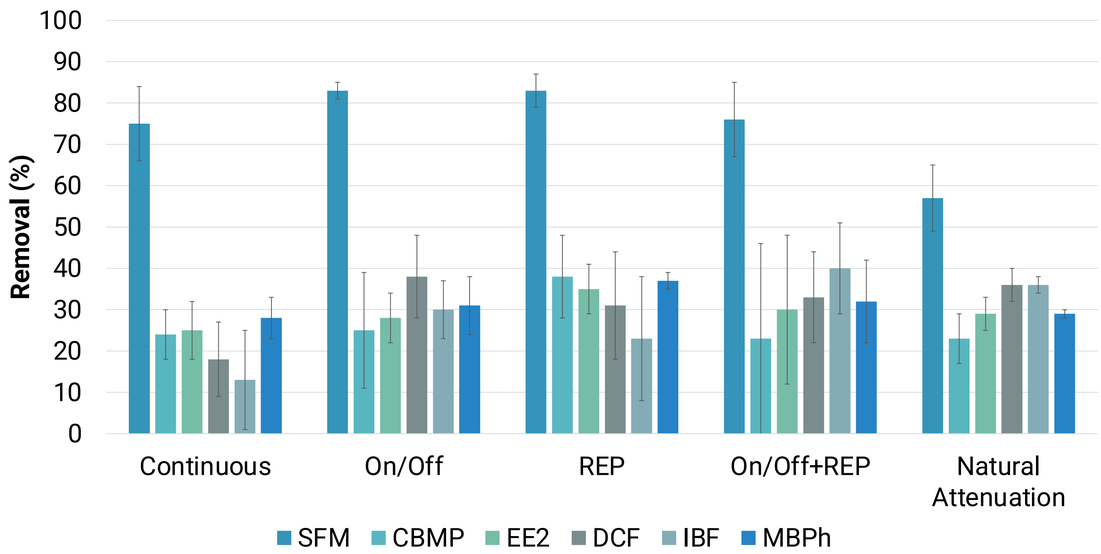


Figure 2. Percentage of each EOC remaining in the soil after natural attenuation and after applying EK with different current strategies: continuous, switching On/Off, reversed polarity, and combination of On/Off and reversed polarity.

5 CONCLUSIONS

The combination of **On/Off periods with reversed polarity** was found to be the **most suitable strategy** as it did not change the soil characteristics in terms of pH and resulted in a more homogenous removal of the studied PPCPs in the soil for the tested conditions.

The removals were dependent of site (anode, central and cathode) and PPCPs characteristics.

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