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"IN-SITU SOIL REMEDIATION OF ANTIBIOTIC CIPROFLOXACIN BY PULSED DIELECTRIC BARRIER DISCHARGE"

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Introduction

Ciprofloxacin is one of the most widely used antibiotics with concentration range in sludge and contaminated soil between 0.3-3 mg/kg [1]. It is strongly adsorbed onto soil surface and it is not easily biodegraded . Therefore, a cost-effective and environmentally friendly method has to be developed in order to remediate soil from ciprofloxacin. During the last decade, there is an increasing attention in CAP technologies for the removal of organic pollutants in soil [2]. CAP is a promising advanced oxidation process (AOP) due to its low energy consumption, short treatment time and low requirement for the pretreatment process of soil.

Objectives

- Exploration of **Cold Atmospheric Plasma (CAP)** method for ciprofloxacin-polluted soil remediation **.**
- **Investigation of experimental conditions** (treatment time; pulse voltage; pulse frequency; energy efficiency).
- **Testing** of a novel **cylinder-to-cylindrical grid Dielectric Barrier Discharge (DBD)** reactor (***in-situ*** remediation)

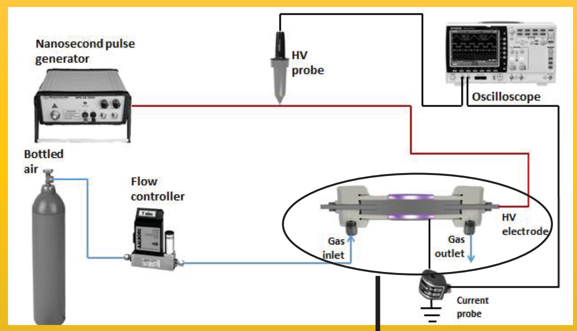
General Research Methodology

Artificial contamination of soil with ciprofloxacin (C_0=200 mg/kg-soil,) → Fill of the reactor with contaminated soil → Streaming of dry air into the reactor with stable flow rate → Sample treatment by DBD

- voltage range: 16.8- 26.8 kV
- time range: 30 sec-10 min
- frequency: 100 Hz

→ Soil samples extraction to recover the organic matter (solvent: 2% Tetramethylammonium Hydroxide in Methanol) → High-Performance Liquid Chromatography (HPLC) analysis of the extracts

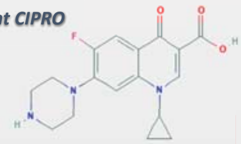
Experimental setup



Properties of model soil

Soil	pH	Color	Main Content
Sandy soil	7.5	White to beige	SiO_2

Model pollutant CIPRO



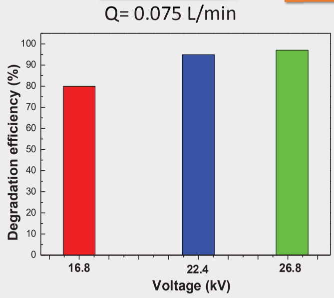
Results

Effect of pulse voltage

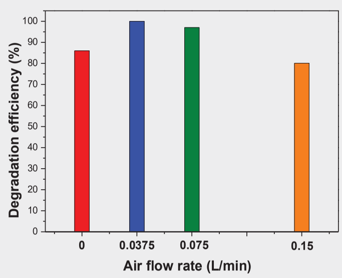
$t_{treatment}$ = 5 min
m_{soil}=6.1 g

Effect of air flow rate

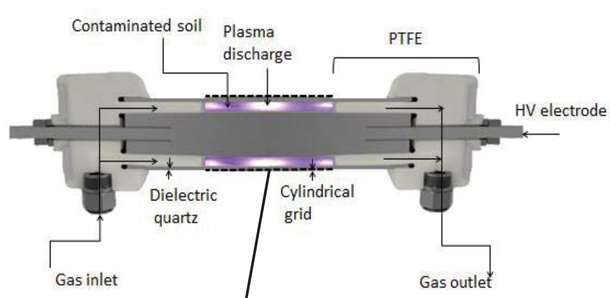
Q= 0.075 L/min



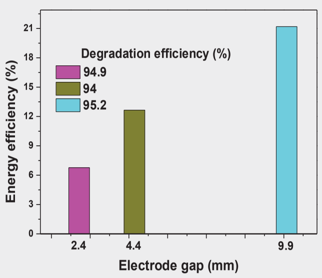
V= 26.8 kV



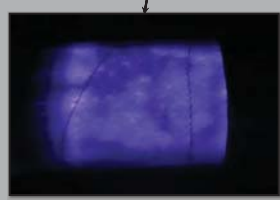
Cylinder-to-cylindrical grid DBD reactor



Energy efficiency-Effect of electrode gaps



Soil remediation technique	Pollutant/Soil	Soil mass (g)	Treatment time	Degradation efficiency (%)	Energy efficiency (mg/kJ)	Ref.
In-situ nsp-DBD	Ciprofloxacin (200 mg kg^{-1})/sandy soil	16.7	5 min	94,1	**21.2**	This work
Ex-situ nsp-DBD	Ciprofloxacin (200 mg kg^{-1})/sandy soil	5	3 min	99	**4.6**	[2]
Microwaves	hydrocarbons	20	100 min	100	**0.028**	[3]



Depiction of plasma discharges inside soil pores during CAP treatment of soil

References

1. E. Martinez-Carballo, C. Gonzalez-Barreiro, S. Scharf, O. Gans, (2007). Environ. Pollut., 148: 570–579.
2. C.A. Aggelopoulos, M. Hatzisymeon, D. Tataraki, G. Rassias, Chemical Engineering Journal, Volume 393, 2020, 124768, ISSN 1385-8947.
3. Falciglia, Pietro & Vagliasindi, Federico. (2015).. Journal of Soils and Sediments. 10.1007/s11368-015-1130-6.

Conclusions

- **Complete and fast removal of ciprofloxacin from sandy soil (< 3 min of CAP treatment).**
- **High impact of voltage and air flow rate on degradation efficiency.**
- **High energy efficiency (21.2 mg/kJ) of the nsp-DBD cylinder-to-cylindrical grid reactor (16.7 g contaminated, 95.2% degradation efficiency).**

Acknowledgments

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