# Ex-situ vs in-situ removal of antibiotic ciprofloxacin in soil by cold atmospheric plasma

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## ABSTRACT

Antibiotics are extensively used in clinical settings to treat or prevent human diseases, in veterinary science for farm and domestic animal health and in agriculture for crop protection. Once antibiotics are found in the environment, they pose a serious threat for soil and water quality since they inhibit active microorganisms of the ecosystem that could be vital in many subsurface processes. Ciprofloxacin is one of the most widely used antibiotics and one of the most persistent in the environment, which also possesses genotoxic properties. The concentration of ciprofloxacin in digested sludge and contaminated soil has been found in the range 0.3-3 mg/kg, whereas much higher concentrations have been reported in wastewater treatment plants effluents (i.e. 50 mg/L) [1].

Given that ciprofloxacin is strongly adsorbed onto soil surface and is recalcitrant to biodegradation, it is of vital importance to be removed from soil layers. Over the years various technologies have been proposed to remediate wastewater or sludge polluted by ciprofloxacin and/or other antibiotics (e.g. bioremediation, photocatalytic oxidation, adsorption, etc.), but studies regarding the removal of antibiotics from agricultural soils are scarce [2].

In this study, cold atmospheric plasma (CAP) was examined as an advanced oxidation process (AOP) for the remediation of antibiotic ciprofloxacin-polluted soil. Experiments were conducted in two different electrode configurations of dielectric barrier discharge (DBD) reactors (i.e. cylinder-to-cylindrical grid and plane-to-grid) driven by a high voltage nanosecond pulse generator. The aforementioned DBD reactor configurations correspond to in-situ and ex-situ soil remediation, respectively [3]. The residual ciprofloxacin concentration was determined by HPLC analysis and the effect of CAP operating conditions such as treatment time, applied voltage and discharge frequency was investigated and optimized.

Initial concentration of ciprofloxacin in soil was 200 mg/kg, and the effect of CAP operating conditions such as treatment time, applied voltage and pulse frequency were investigated and optimized. Increase of pulse frequency, applied voltage and plasma treatment time resulted in the increase of degradation efficiency of ciprofloxacin. In the plane-to-grid reactor, ciprofloxacin was completely removed after 5 minutes of CAP treatment in the optimized conditions. In addition, preliminary results showed that complete removal of ciprofloxacin can be also achieved in the cylinder-to-cylindrical grid reactor, indicating that DBD can be also applied for the in-situ remediation of ciprofloxacin-polluted soils.

### REFERENCES

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