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Optimization of Cold Atmospheric Pressure Plasma for Enhanced Nitrogen Species Generation in Soil to Improve Fertility and Wheat Crop Yield

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Cold Atmospheric Pressure Plasma treatment is an eco-friendly approach to enhancing soil properties by modifying its chemical composition and improving nutrient availability [1]. In this study, an Atmospheric Pressure Cold Plasma Dielectric Barrier Discharge (ACP-DBD) reactor [2] was employed to treat soil, with a focus on nitrogen transformations and elemental composition changes. Optical Emission Spectroscopy (OES) and Fourier Transform Infrared Spectroscopy (FT-IR) analysis revealed the presence of abundant reactive species, including excited atomic nitrogen, atomic oxygen, and nitrogen oxides (NO_x). These reactive species played a key role in altering soil composition by enhancing the levels of essential nutrients. Plasma treatment led to a significant increase in nitrogen species, including nitrite (NO_2^--N), nitrate (NO_3^--N), and ammonium (NH_4^+-N), which are vital for soil fertility. Elemental analysis using X-ray Fluorescence (XRF), X-ray Diffraction (XRD), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) demonstrated notable changes in phosphorus, potassium, calcium, magnesium, iron, and manganese content. Furthermore, soil stored for 30 days post-treatment exhibited variations in nitrogen species, indicating ongoing biochemical interactions and stabilization of plasma induced modifications. OES measurements indicated an electron density of approximately 10^{16} cm^{-3}. These findings suggest that ACP-DBD plasma treatment is a promising and sustainable method for improving soil quality, supporting agricultural productivity, and reducing reliance on chemical fertilizers.

References

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