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Potential of wood-based activated carbon to mitigate toxic elements uptake In spinach for safe consumption

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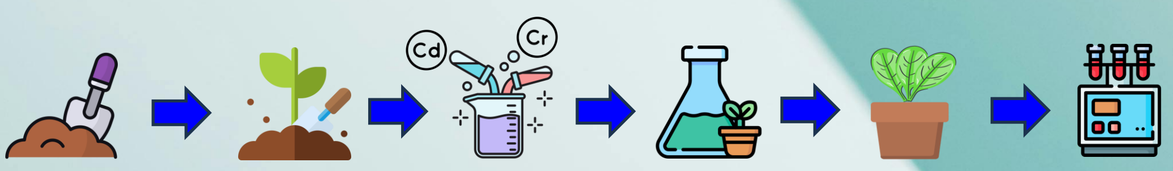
INTRODUCTION

- Toxic elements (TEs) are characterized by high toxicity, even at low concentrations, and have the potential to induce various harmful effects in living organisms. Pollution with TEs constitutes a major concern in the agricultural sector, as they decrease crop growth, yield, and food quality .
- Soil amendments derived from agricultural byproducts and waste can improve the physicochemical properties, fertility, and plant growth on TE-contaminated soils by providing nutrients and reduce the TEs bioavailability.
- Due to its high surface area, porosity and adsorption capacity, activated carbon emerges as a promising solution to remove TEs, increasing soil nutrient levels and improving soil water holding capacity and aeration, and consequently improving crop nutrition [1-3].
- This study investigates the effect of wood-based activated carbon on spinach growth under Cd and Cr stress. Specifically, it evaluates the efficacy of activated carbon in reducing Cd and Cr concentrations in artificially contaminated soils, as well as its influence on metal uptake and accumulation in spinach tissues.

EXPERIMENTAL PART

- A pot experiment was conducted to study the effect of wood-based activated carbon on the growth of spinach and the bioavailability of Cd and Cr in soils artificially contaminated at a concentration level of 10 mg/kg ($CdSO_4$ and $Cr(NO_3)_3$ - trace metals basis, Sigma-Aldrich), without NPK fertilization.
- TE-contaminated soil – wood-based activated carbon mixtures at 0% (control) – **C 0%**, 0% (contaminated control) - **CC 0%**, 1.0% - **AC 1.0%**, 1.5% - **AC 1.5%**, and 2% - **AC 2.0%**, were prepared in plastic pots and used as substrates for cultivating 15-day-old nursery spinach (*Spinacia oleracea* L. var. Matador) plants.
- Soil preparation, analysis, and pot design, as well as plant collection and analysis, were carried out similarly to the previous study [4].



- **Physiochemical characteristics of pre-experimental soil**

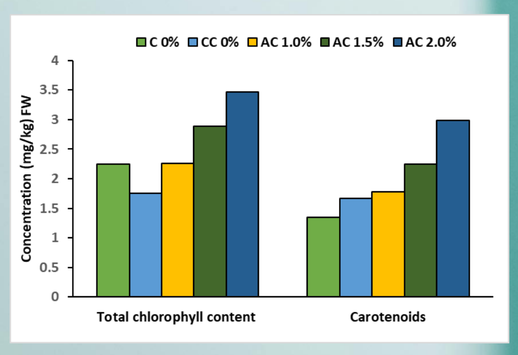
Sample	pH	C_T	N_T	Humic acids	Cd_T	Cr_T	CEC	Surface area
	-	%	%	%	mg/kg	mg/kg	meq/100 g	m^2/g
Soil	8.61	2.91	1.24	1.64	0.09	0.21	63.1	321

- **Textural parameters of wood-based activated carbon**

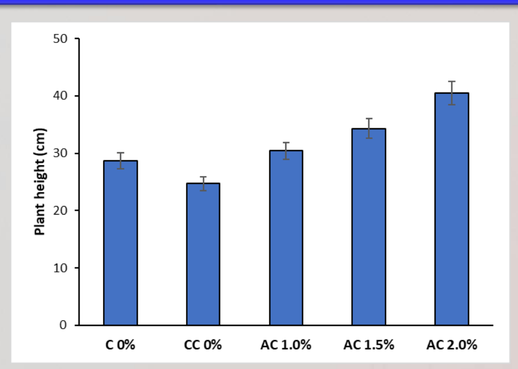
Material	Specific surface area		Pore volumes					
	A_{BET}	$S_{2D\text{-}NLDFT}$	$V_{0.95}$	V_t	V_{micro}	$V_{s\mu}$	$V_{u\mu}$	V_{meso}
	m^2/g	m^2/g	cm^3/g	cm^3/g	cm^3/g	cm^3/g	cm^3/g	cm^3/g
AC	931	1215	0.51	0.52	0.36	0.17	0.20	0.16

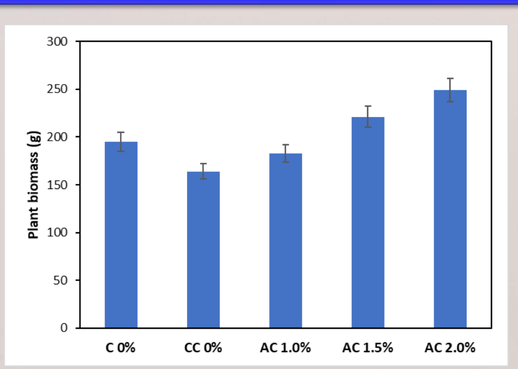
- **Soil texture**

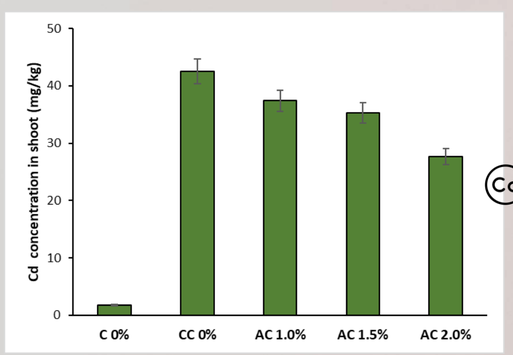
  - Sand (0.2–0.02 mm): 40 %
  - Fine dust (0.05–0.002 mm): 27%
  - Dust (0.02–0.05 mm): 11%
  - Coarse sand (2.0–0.02 mm): 12%

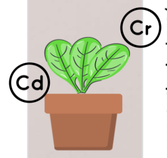


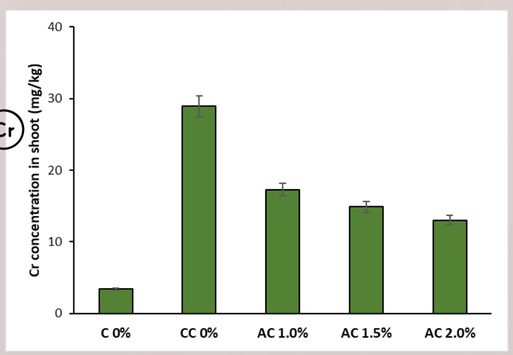
RESULTS & DISCUSSION

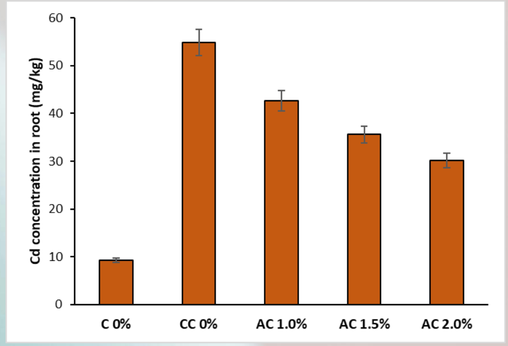


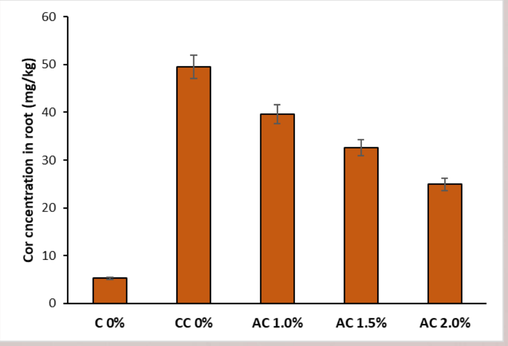












- The utilization of **2% wood-based activated carbon** significantly increased the soil pH (~4%) and organic matter content (~1.5%) compared to the contaminated control group.
- Compared to the contaminated control group, the greatest increase in plant height (~39%) and fresh biomass (~34%) was achieved with the highest concentration of wood-based activated carbon (2%).
- The application of 2% wood-based activated carbon amendments also reduced TE concentrations by ~**35% for Cd and ~55% for Cr in shoots and ~45% for Cd and ~50% for Cr in roots, respectively**, compared to the contaminated control group.
- The amendment with 2% wood-based activated carbon can **immobilize Cd and Cr in soil and increase chlorophyll and carotenoid content** of spinach grown in Cd- and Cr- artificially contaminated soils.

CONCLUSIONS

- Using 2% wood-based activated carbon as an organic amendment in contaminated soil is an effective method of improving soil quality and promoting plant growth.
- Wood-based activated carbon amendments can reduce the concentrations of toxic elements in soil as well as increase soil nutrient levels and chlorophyll contents.
- However, to mitigate the possible risks, it is essential to carefully optimize the application rate and timing of used organic amendments.
- Further research is needed to identify the optimal application rate and long-term effects of wood-based activated carbon amendments to enhance soil quality and promote plant growth in contaminated soils.

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