Sixth Sustainable Nanotechnology Organization Conference 2017

Uptake and Accumulation of Co-existing Heavy Metals and Engineered Nanoparticles by Agricultural Crops

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Possible human exposure pathways to engineered nanoparticles














Drinking water

Surface water

Irrigation water

Crops

In soil

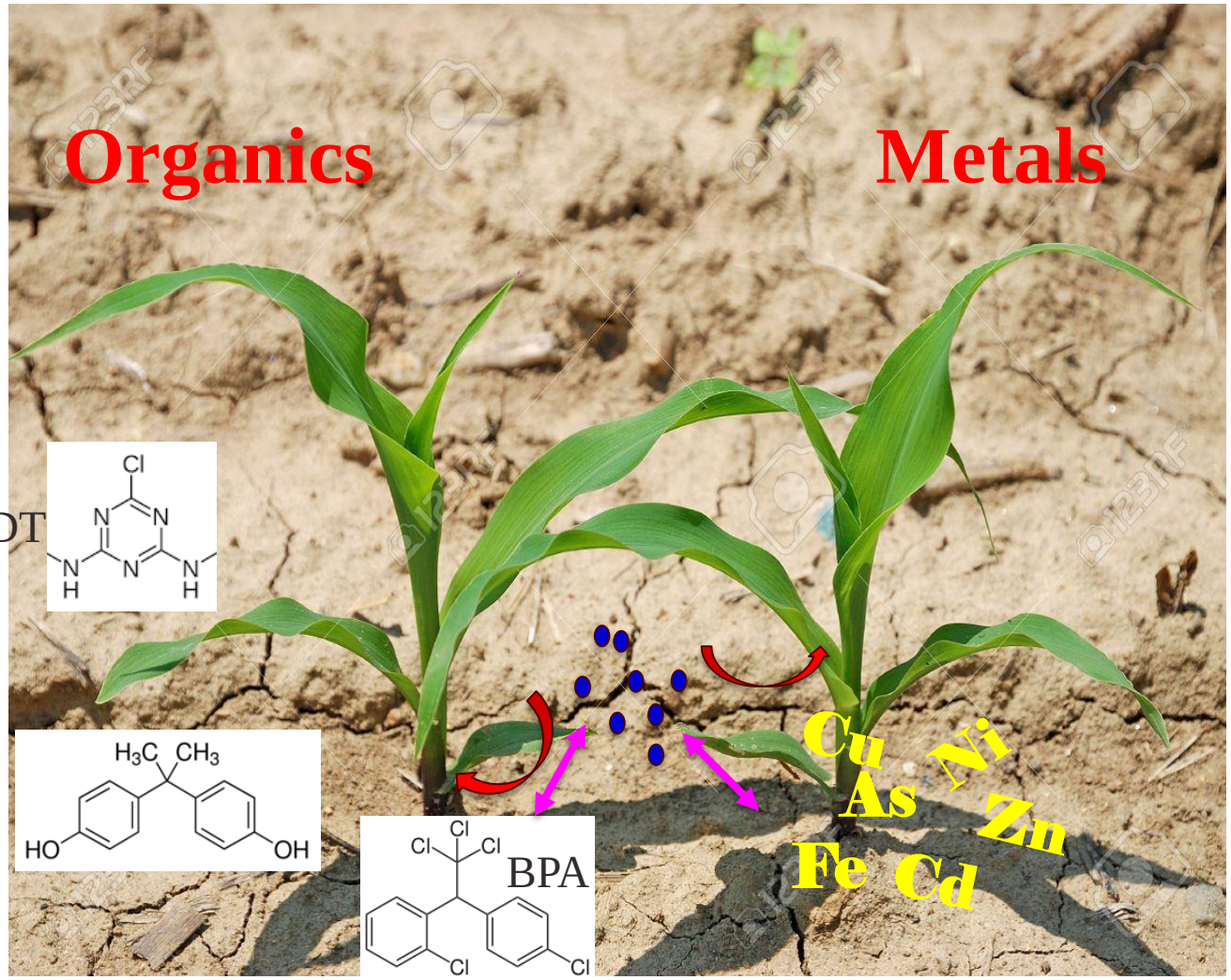
Dietary exposure

Transport

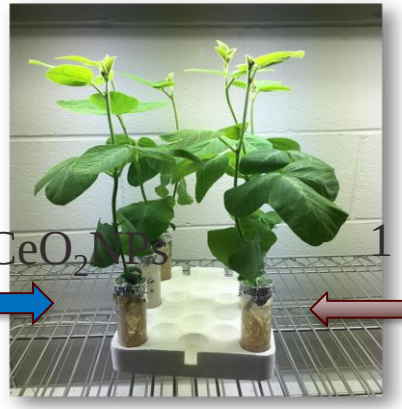
Biosolids

Sewage treatment

Environmental Pollutants in Soil



Soybean biomass

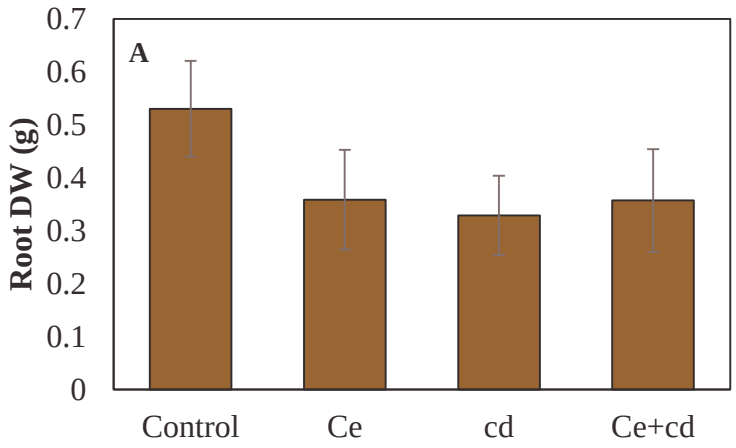


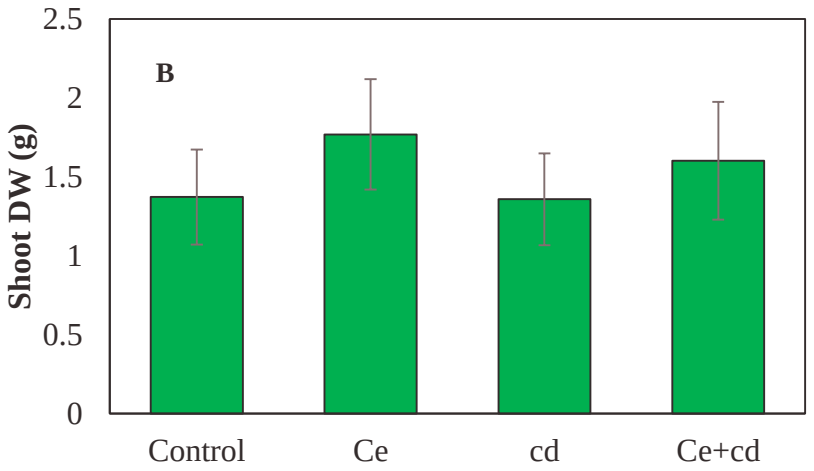
100 mg/L CeO_2NPs

1 mg/L Cd

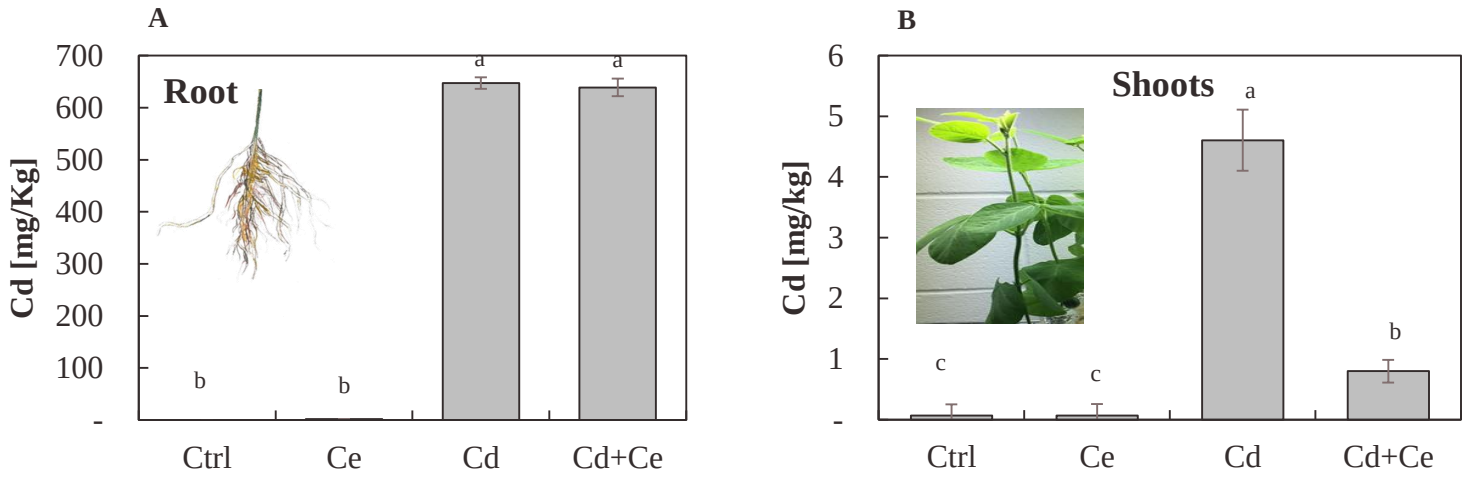
500 mg/kg CeO_2NPs

0.25 and 1.0 mg/kg Cd



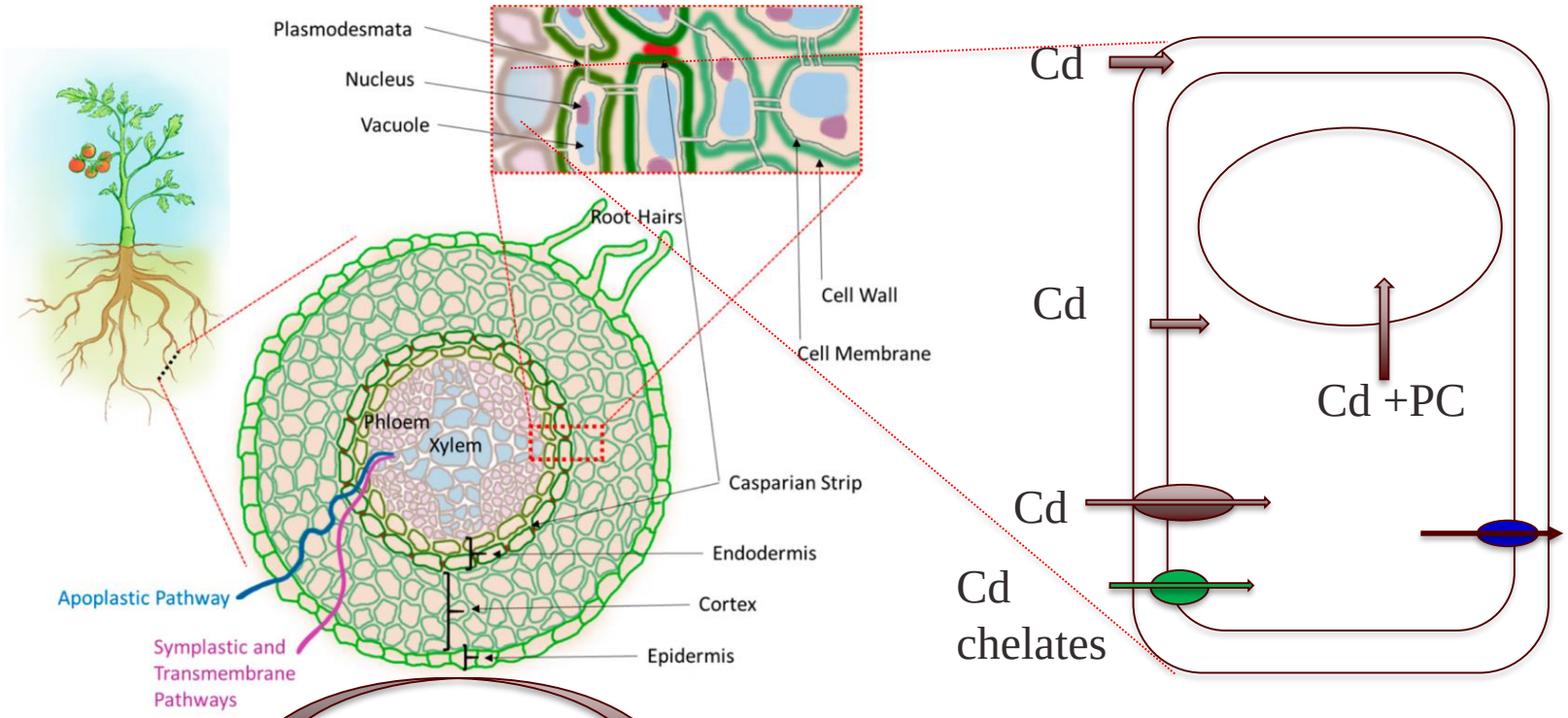


Cadmium Concentration



100 mg/L of CeO_2NPs did not affect the Cd concentration associated with soybean roots, but significantly reduced Cd concentration in shoots

Plant Uptake and Accumulation of Cd



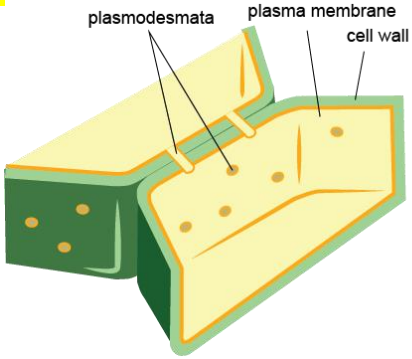
ENPs

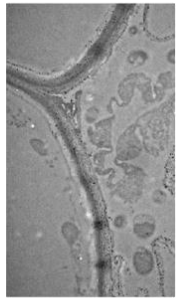
CeO_2NPs

- Attach to root surface and reduce pore sizes
- Affect membrane integrity
- Change root exudates excretion
- Adsorption of metals on ENPs

	Pore diameter (nm)
Control	7.33 ± 0.45 *a*
Ce NPs	4.80 ± 0.30 *b*
Cd	6.43 ± 0.41 *a*
Ce NPs + Cd	5.13 ± 0.25 *b*

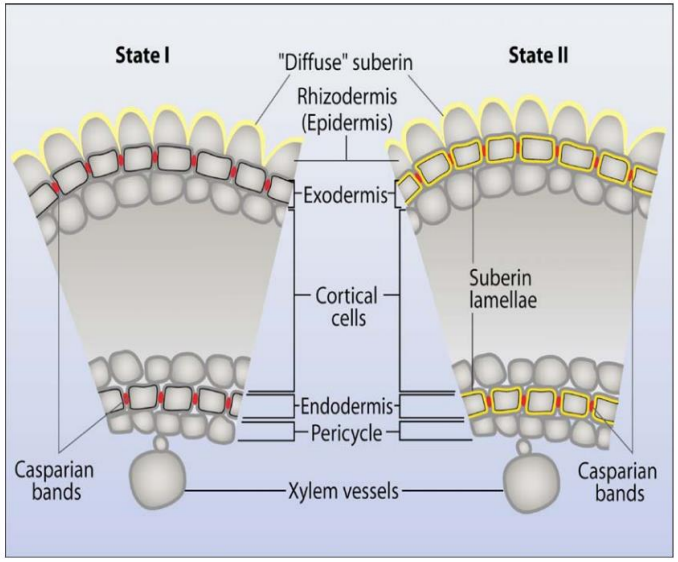
The mean diameters of the pores limiting nanoparticles and heavy metals transport through the cell walls of soybean roots determined by observation of cytorrhysis

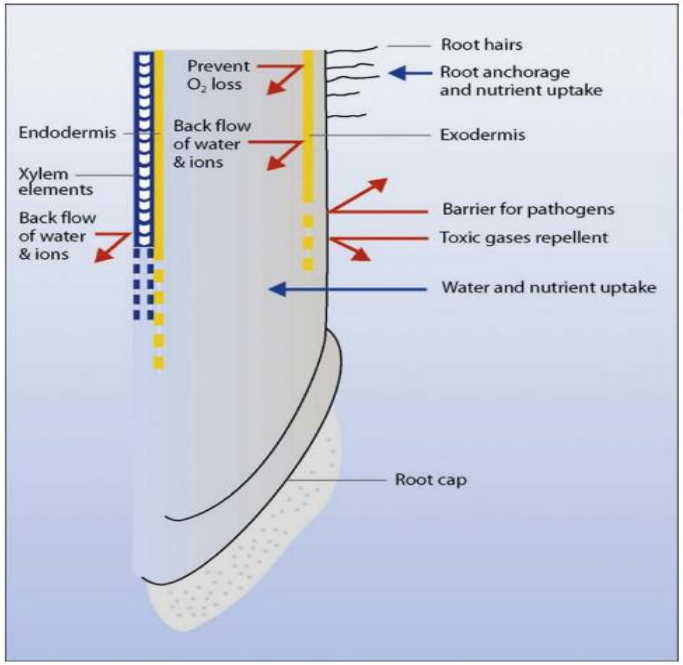


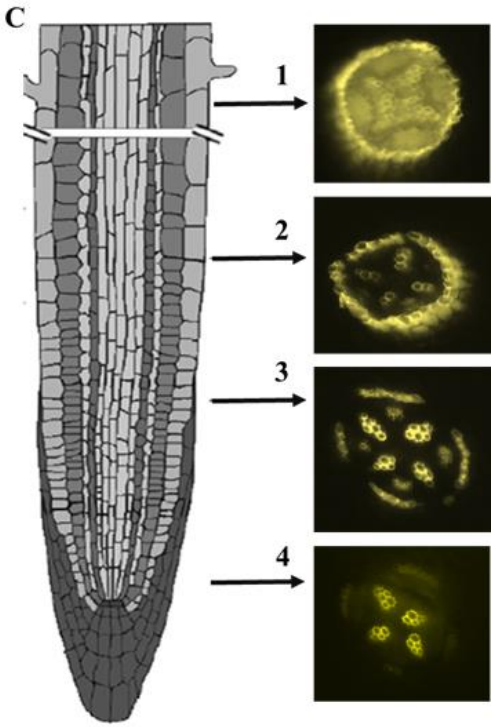


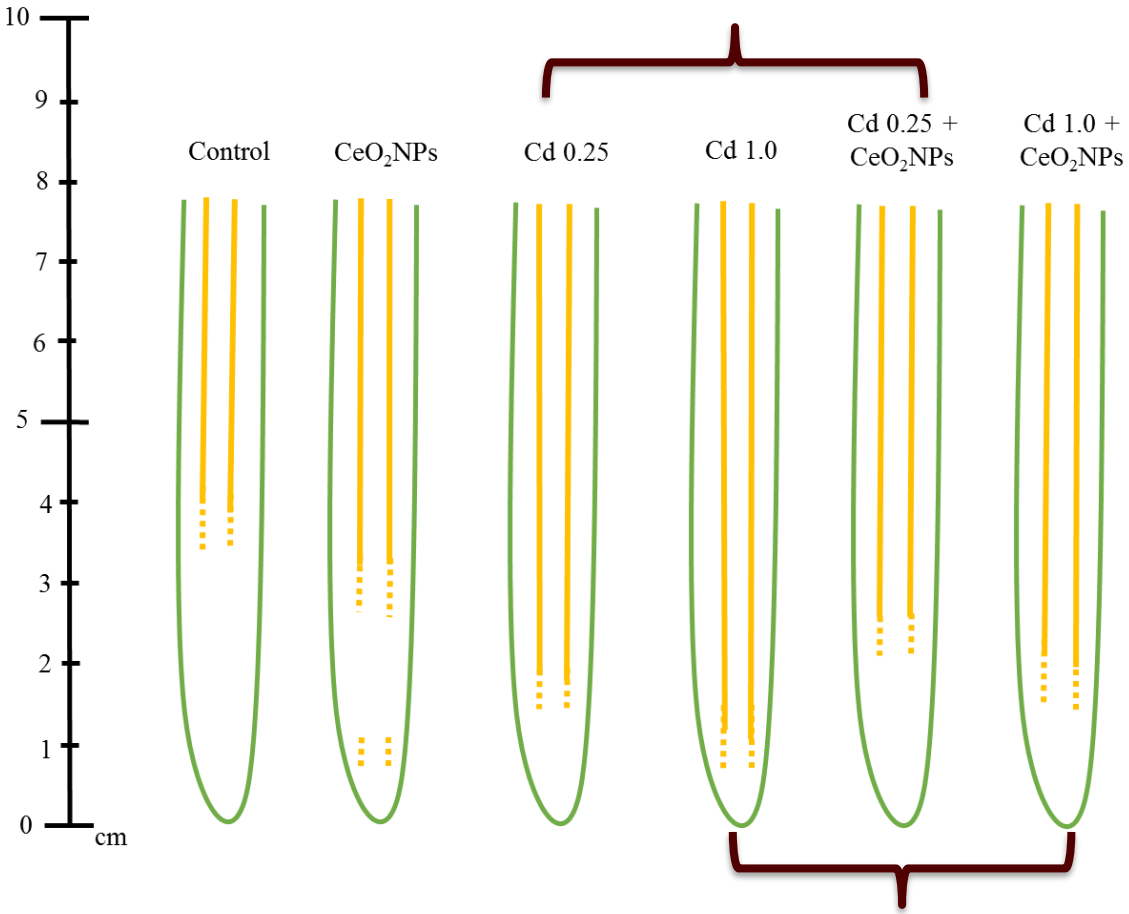
TEM image of cell wall structure in plant roots

http://www.shmoop.com/biology-cells/plant-fungi-algae-cells.html

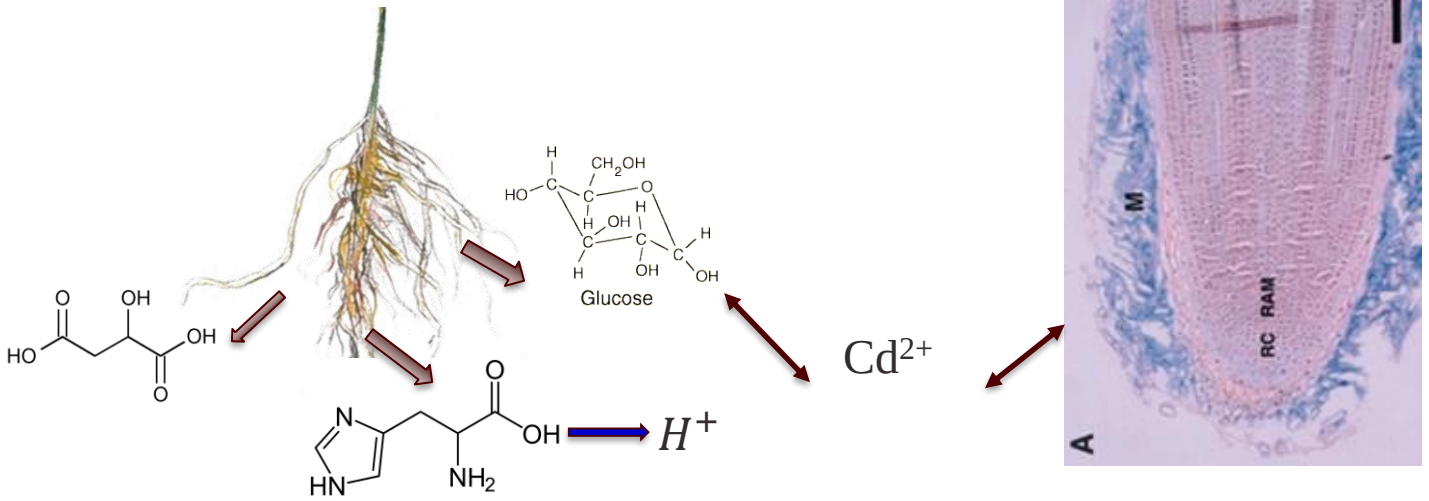

State I
"Diffuse" suberin
State II
Rhizodermis
(Epidermis)
Exodermis
Cortical
cells
Suberin
lamellae
Endodermis
Pericycle
Casparian
bands
Xylem vessels
Casparian
bands

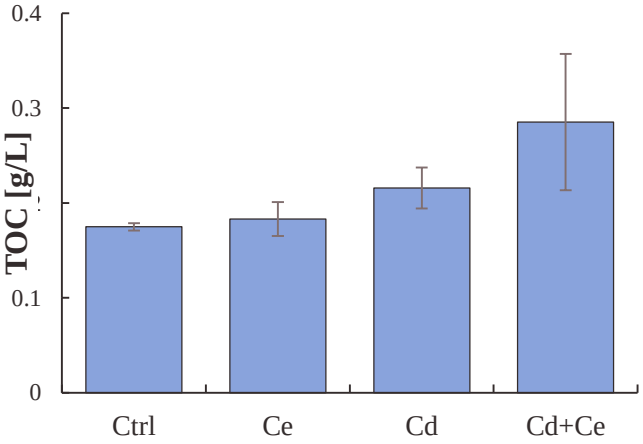

Root hairs
Prevent
O_2 loss
Root anchorage
and nutrient uptake
Endodermis
Back flow
of water
& ions
Exodermis
Xylem
elements
Barrier for pathogens
Back flow
of water
& ions
Toxic gases repellent
Water and nutrient uptake
Root cap


C
1
2
3
4



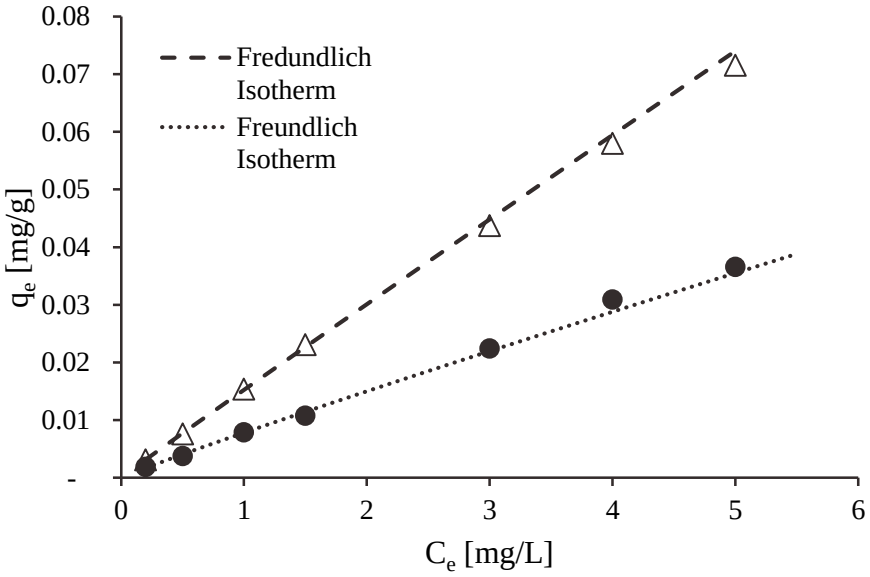
Distance from root tip (cm)	
Control	3.95 ± 0.42 a
CeO_2NPs	3.34 ± 0.27 ab
Cd 0.25	1.80 ± 0.40 cd
Cd 1.0	0.98 ± 0.34 d
Cd 0.25 + CeO_2NPs	2.78 ± 0.49 bc
Cd 1.0 + CeO_2NPs	2.18 ± 0.37 c

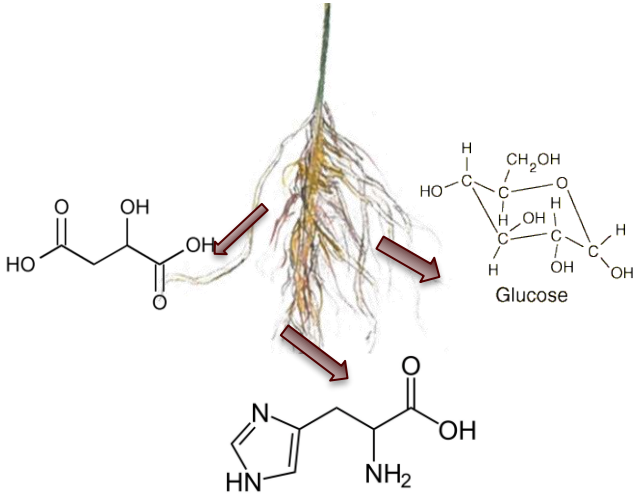


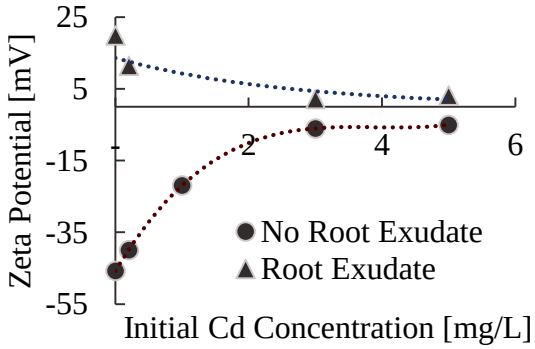


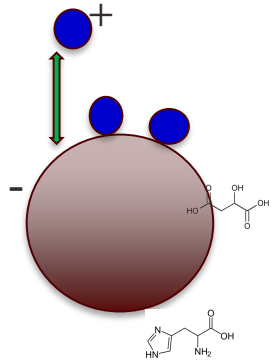
Treatments	*Root pH*	*Medium pH*
Control	7.40 ± 0.10 *b*	7.69 ± 0.15 *ab*
Ce NPs	7.53 ± 0.06 *ab*	7.80 ± 0.06 *a*
Cd	7.40 ± 0.10 *ab*	7.66 ± 0.13 *ab*
Ce NPs + Cd	7.20 ± 0.10 *a*	7.50 ± 0.07 *b*

Adsorption of Cd on CeO_2NPs surface



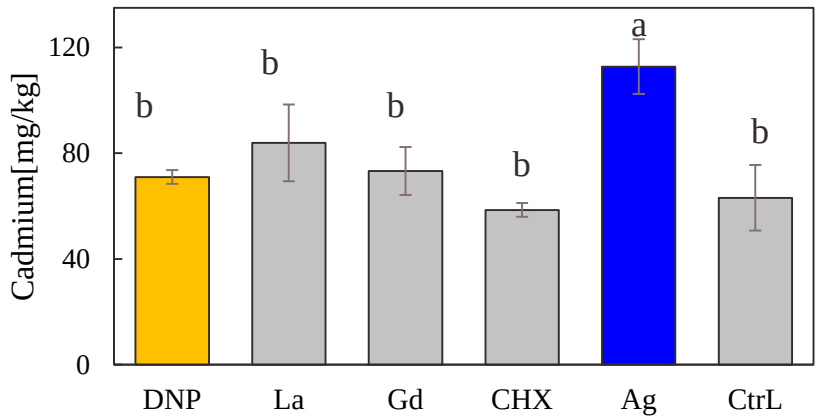




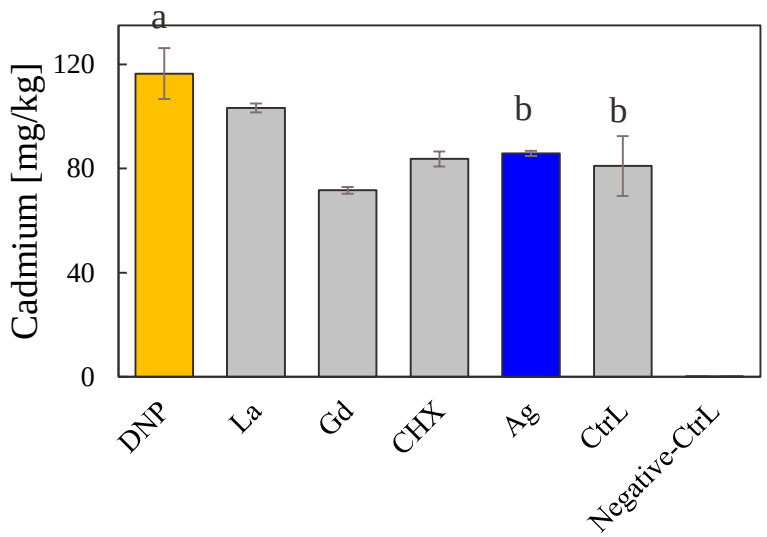


CeO_2NPs affect Cd Transport Proteins

Root



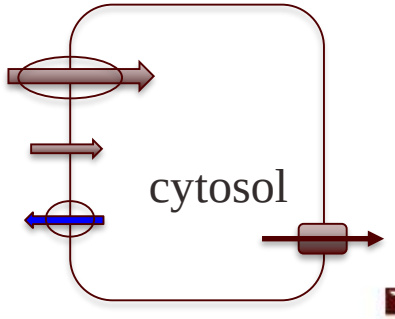
Roots



Gd & La Calcium Channel Blockers

DNP Metabolic Inhibitors

CHX Protein Synthesis Inhibitors



Conclusions

- CeO_2NPs alter the Cd uptake in soybean shoots in both hydroponically grown and soil grown soybeans; but did not affect Cd concentration associated with soybean roots;
- CeO_2NPs modify root apoplastic barriers and pore sizes which may affect the apoplastic transport of Cd;
- CeO_2NPs affect root exudation and may possibly change the speciation of Cd in rhizosphere;
- CeO_2NPs display adsorption capacity of Cd;
- CeO_2NPs may modify the function of certain Cd transporters.

Acknowledgement

- Current and Former Lab Members
- Collaborators
- Federal & State Agencies
- Conference Organizers

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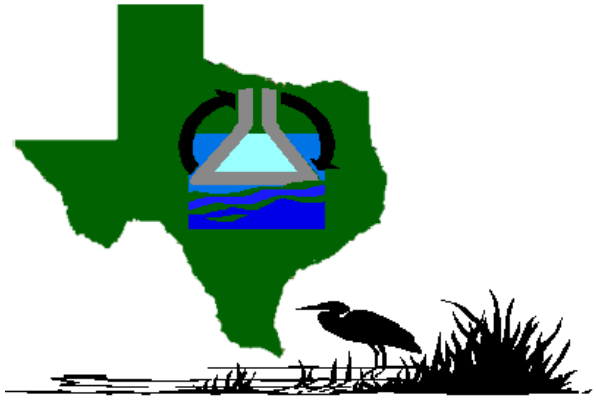
National Institute of Food and Agriculture



Texas Hazardous Waste Research Center

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Thank you!

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