



# Copper nanoparticles and compounds impact agronomic and physiological parameters in cilantro (*Coriandrum sativum*)



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The University of Texas at El Paso  
Dr. Gardea-Torresdey's Research Group  
March, 2015*

## El Paso, Texas



- 19th largest city in the US
- Ranked as the safest large city in the US during the last three years



(Annual City Crime Rankings by CQ press)



# Copper nanoparticles and compounds impact agronomic and physiological parameters in cilantro (*Coriandrum sativum*)

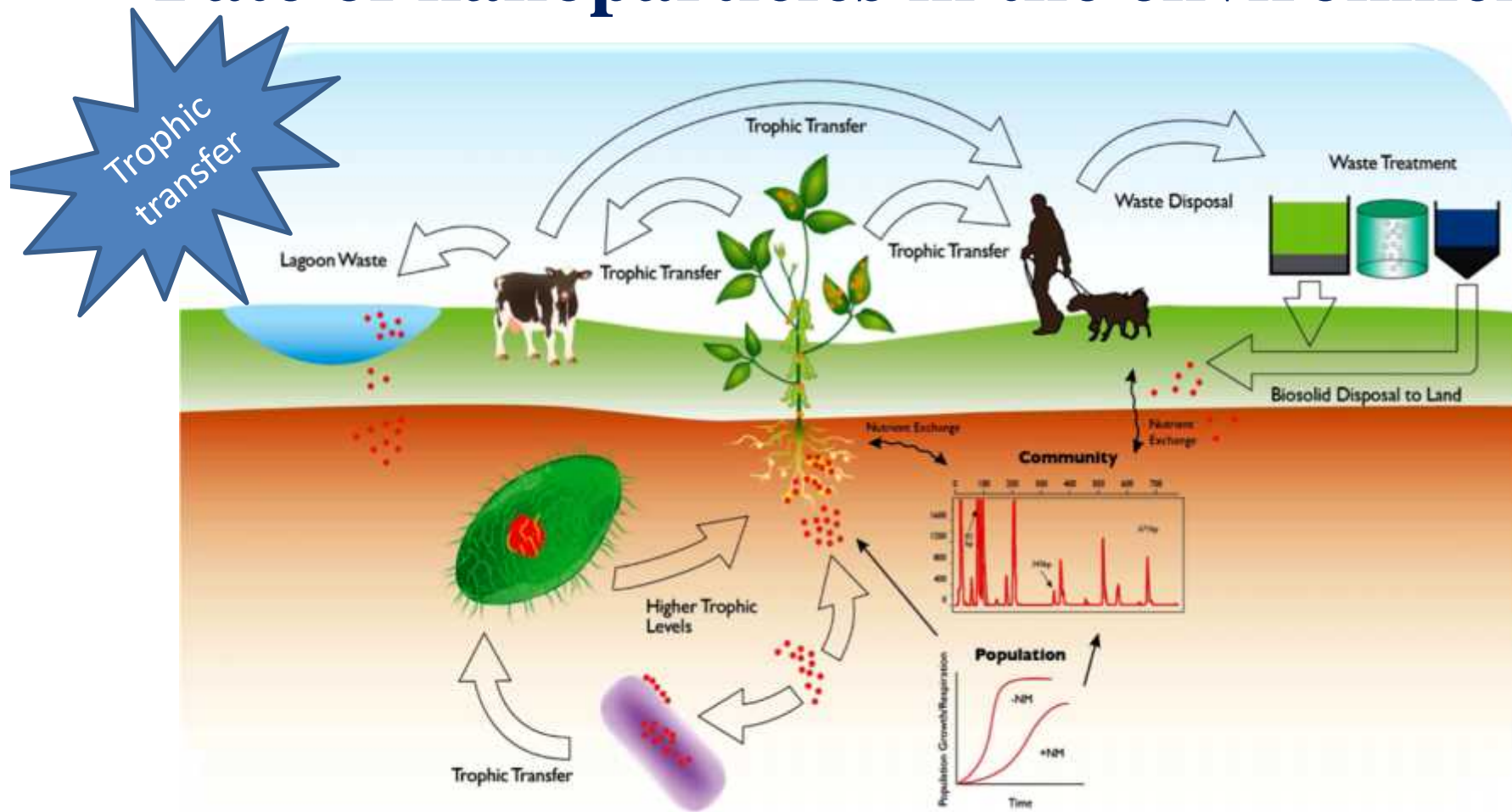
## Outline

- Introduction
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  - Cilantro
  - Copper products
- Procedure
  - Soil treatment
  - Plant growth and harvest
  - Sample preparation and analysis
- Results
  - Agronomic parameters
  - Nutritional value (physiological parameters)
- Summary



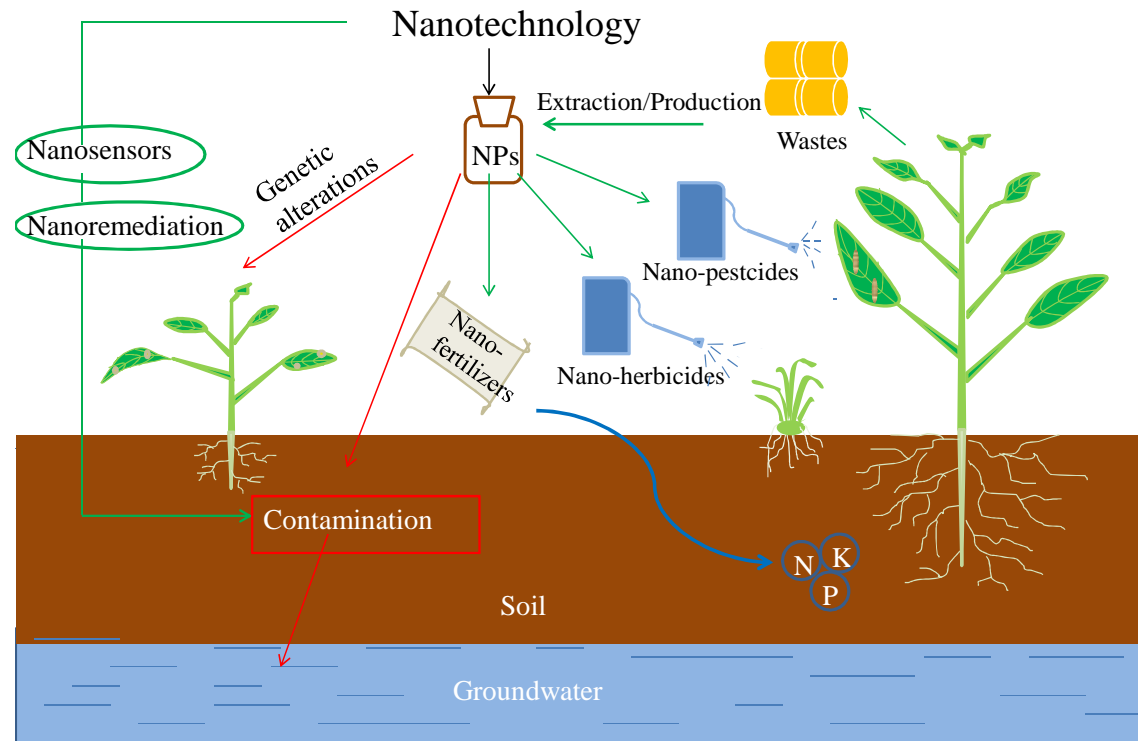
[http://www.renaissanceherbs.com.au/system/0000/0167/08\\_31\\_52\\_944\\_coriander\\_Medium\\_.jpg](http://www.renaissanceherbs.com.au/system/0000/0167/08_31_52_944_coriander_Medium_.jpg)

# Fate of nanoparticles in the environment



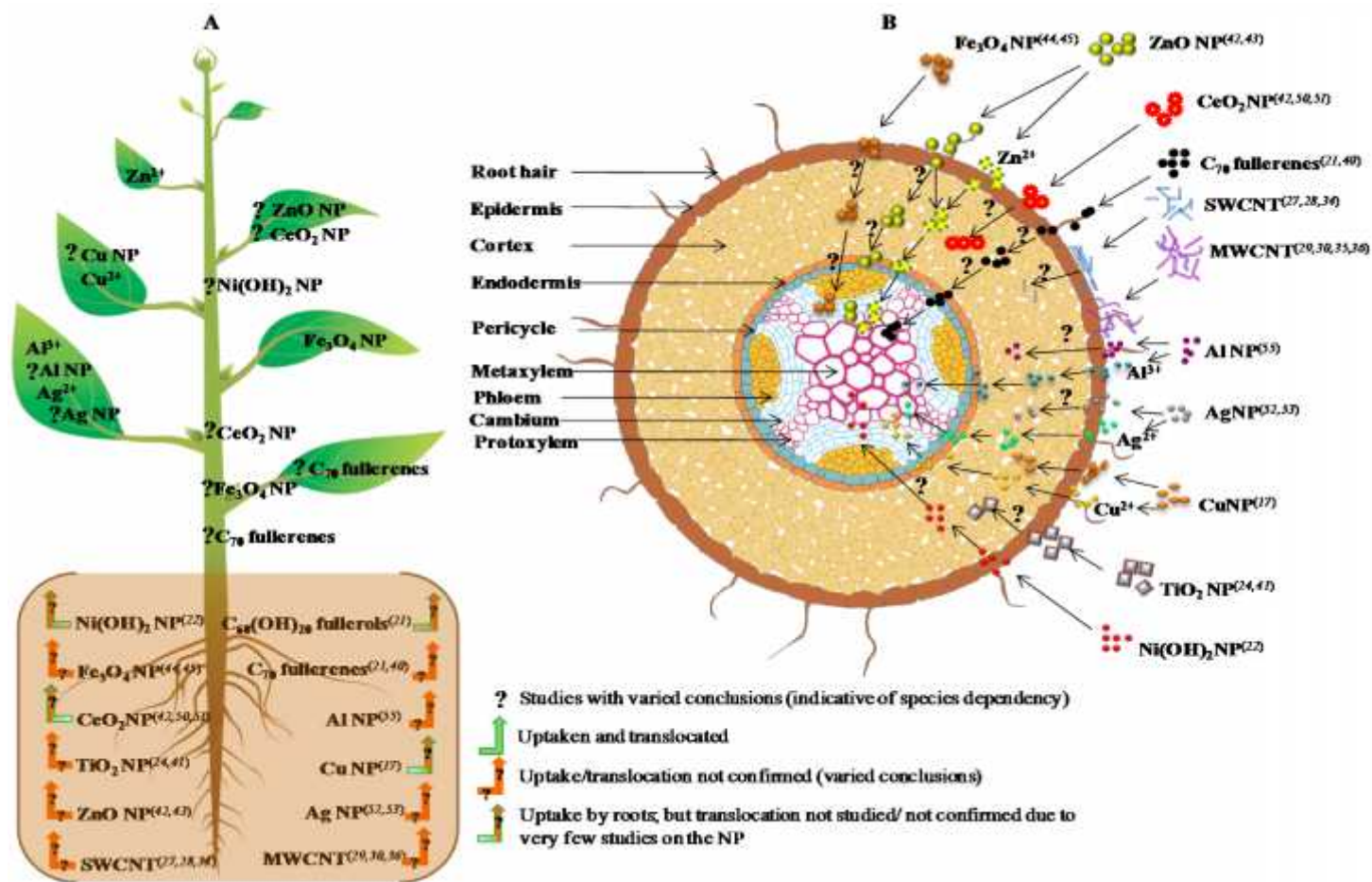
Holden, P.A.; Nisbet, R.M.; Lenihan, H.S.; Miller, R.J.; Cherr, G.N.; Schimel, J.P.; Gardea-Torresdey, J.L. *Accounts Chem. Res.* **2013**, *46*, 813-822.

# Use of nanomaterials in agricultural activities



Hong, J., Peralta-Videa, J.R., Gardea-Torresdey, J.L. 2013. Nanomaterials in agricultural production: benefits and possible threats? In: Sustainable Nanotechnology and the Environment: Advances and Achievements. Edited by Sharma, V. and Shamin, A.N., ACS Symposium Series Vol. 1124, 73-90 (DOI:10.1021/bk-2013-1124).

# ENMs and Plants



Rico, C. M.; Majumdar, S.; Duarte-Gardea, M.; Peralta-Videa, J. R.; Gardea-Torresdey, J. L. Interaction of nanoparticles with edible plants and their possible implications in the food chain. *J. Agric. Food Chem.* **2011**, *59*, 3485-3498.

## Introduction

FOR IMMEDIATE RELEASE

ACS News Service Weekly PressPac: June 1, 2011

### **Safety of nanoparticles in food crops is still unclear**

Scientists are reporting a huge gap in knowledge about the effects of nanoparticles on corn, tomatoes, rice and other food crops.



Credit: iStock

["Interaction of Nanoparticles with Edible Plants and Their Possible Implications in the Food Chain"](#)

*Journal of Agricultural and Food Chemistry*

With the curtain about to rise on a much-anticipated new era of "nanoagriculture" — using nanotechnology to boost the productivity of plants for food, fuel, and other uses — scientists are reporting a huge gap in knowledge about the effects of nanoparticles on corn, tomatoes, rice and other food crops. Their article appears in ACS' *Journal of Agricultural and Food Chemistry*.

Jorge Gardea-Torresdey and colleagues at The University of Texas at El Paso, a co-investigator for the NSF/EPA University of California Center for Environmental Implications of Nanotechnology, note that nanoparticles, which are 1/50,000th the width of a human hair, are used in products ranging from medicines to cosmetics. The particles also could end up in the environment, settling in the soil, especially as fertilizers, growth enhancers and other nanoagricultural products hit the market. Some plants can take-up and accumulate nanoparticles. But it is unclear whether this poses a problem for plants or for the animals (like humans) that eat them. So, the researchers sorted through the scientific literature looking for evidence to settle the safety question.

# Nanotechnology in agriculture



**“GRAND  
ENTRY TO  
THE  
FOODCHAIN”**

**Nanopesticide**



**Nanofertilizers**

Nano Bio Marketing 2011. <http://nanobiomarketing.com/en/contents/view/knowledge/101>



Introduction



Gardea-Torresdey, J. L.; Rico, C. M.; White, J.C. Trophic Transfer, Transformation, and Impact of Engineered Nanomaterials in Terrestrial. *Environ. Sci. Technol.* **2014**, *48*, 2526-2540.

## Copper NPs and compounds

- $\text{Cu}(\text{OH})_2$  CuPRO 2005
  - 53.8% copper hydroxide
- $\text{Cu}(\text{OH})_2$  Kocide 3000
  - 46.1% copper hydroxide
- $\text{CuCl}_2$
- Cu NPs, 40nm
- Cu bulk, <60  $\mu\text{m}$
- CuO NPs, <50nm
- CuO bulk, <5 $\mu\text{m}$



## Materials - cilantro



<http://clatl.com/omnivore/archives/2010/04/16/cilantro-its-not-just-for-food-snobs>



<http://pixgood.com/rabbit-eating-lettuce.html>

# Cilantro



[http://www.grubstreet.com/2012/01/foreign\\_cinemas\\_gayle\\_pirielo.html](http://www.grubstreet.com/2012/01/foreign_cinemas_gayle_pirielo.html)



<http://www.roadfood.com/Forums/What-Is-a-taco-m145993.aspx>



<http://cocinaycomparte.com/recetas/sopa-de-albondigas-con-arroz-y-cilantro>

- *Coriandrum sativum*  
– (cilantro)
- Cu into food chain – spices
- Herb, culinary spice
- Eaten fresh
- Antioxidant properties



<http://jessfuel.com/wp-content/uploads/2013/04/RoastedTomatilloSalsaVerde13.jpg>



<https://kathleeniscookinginmexico.files.wordpress.com/2010/03/chipotle-fish-soup-3.jpg>



<http://ajillofalltrades.blogspot.com/2011/09/best-salsa-recipe.html>

# Cilantro exposed to copper soil



Suspension preparation

*Cu Concentration in soil:*  
0 ppm (control)  
20 ppm  
80 ppm



Suspension sonication



Soil + Cu

Procedure – plant growth & tissue harvest



30 days growth



Harvest

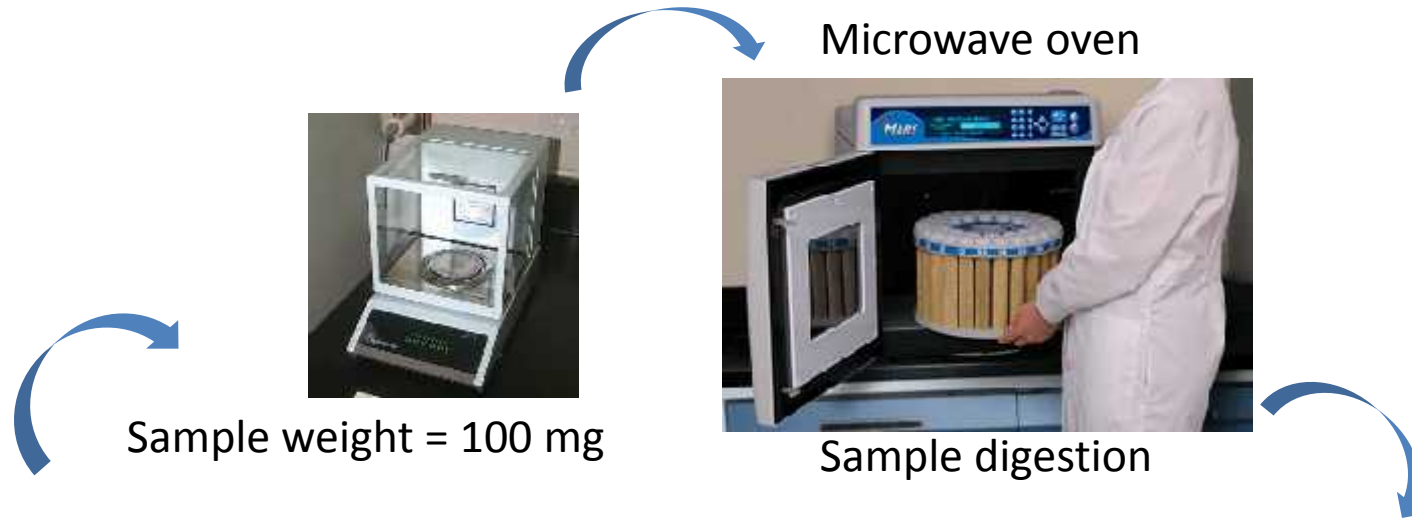


Tissue washing



Measurement

# Sample analysis

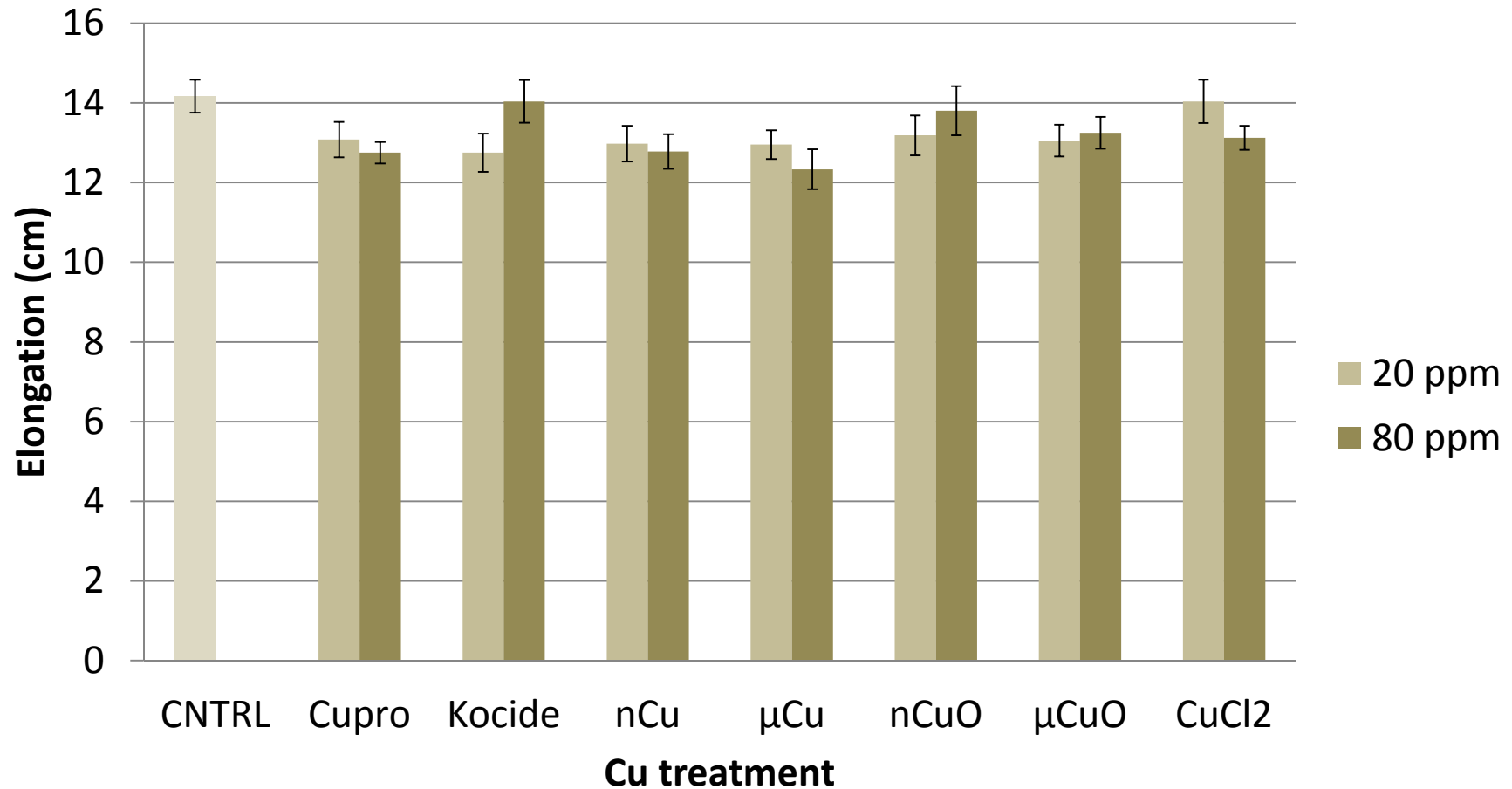


Samples dried at 70 °C

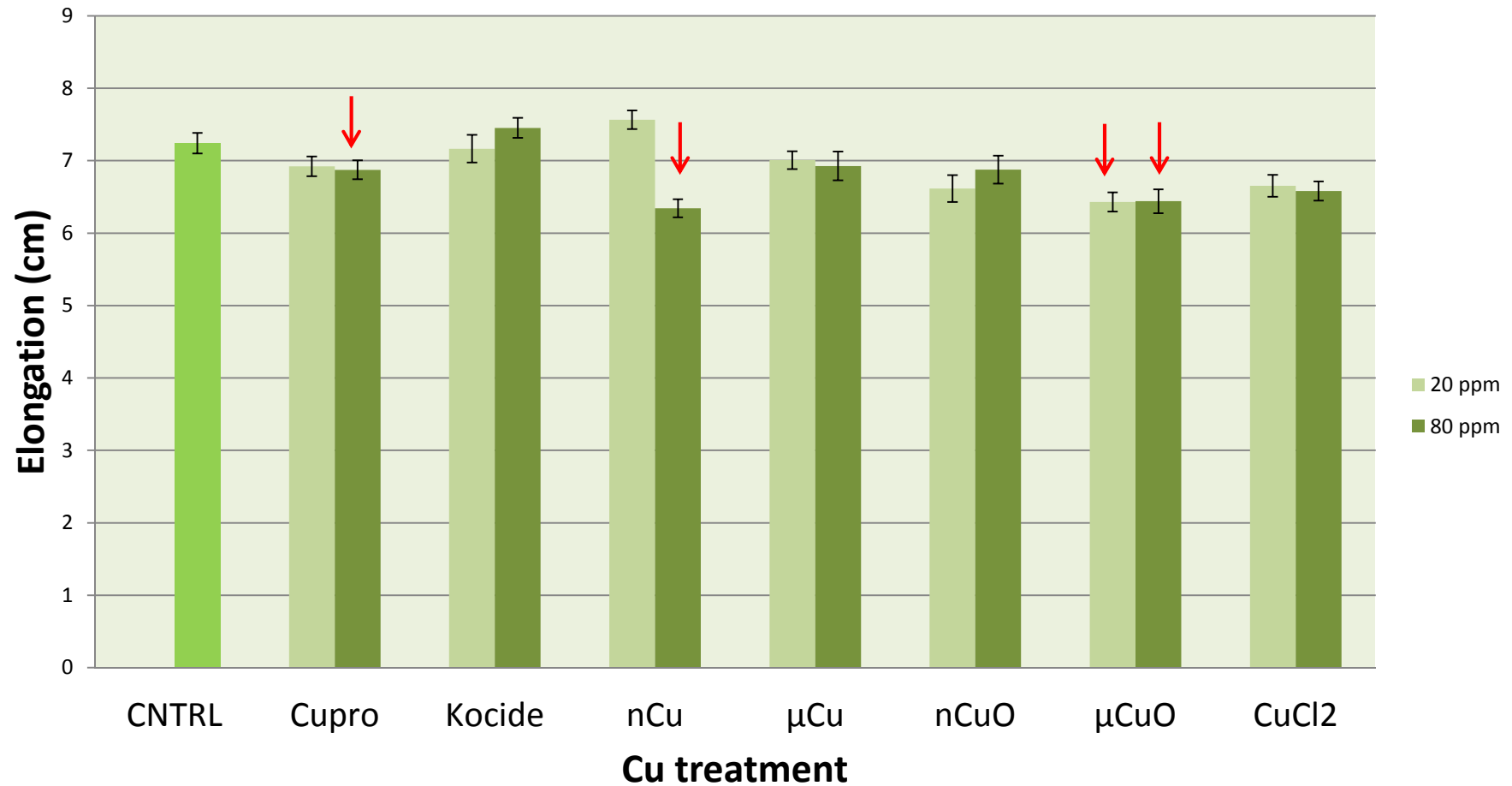


ICP-OES analysis

### Cu Effects on Coriander Roots Elongation



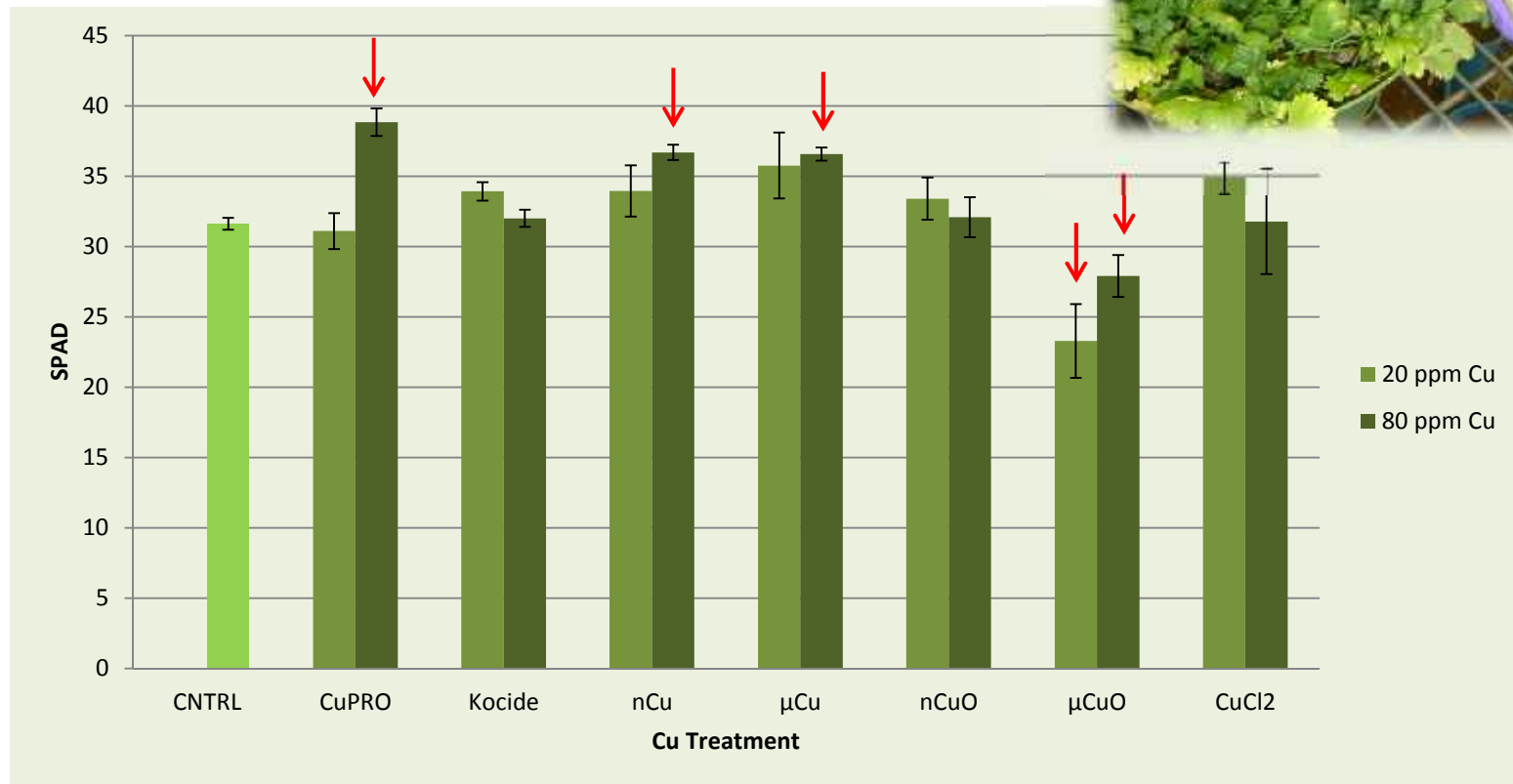
## Cu Effects on Cilantro Shoot Elongation



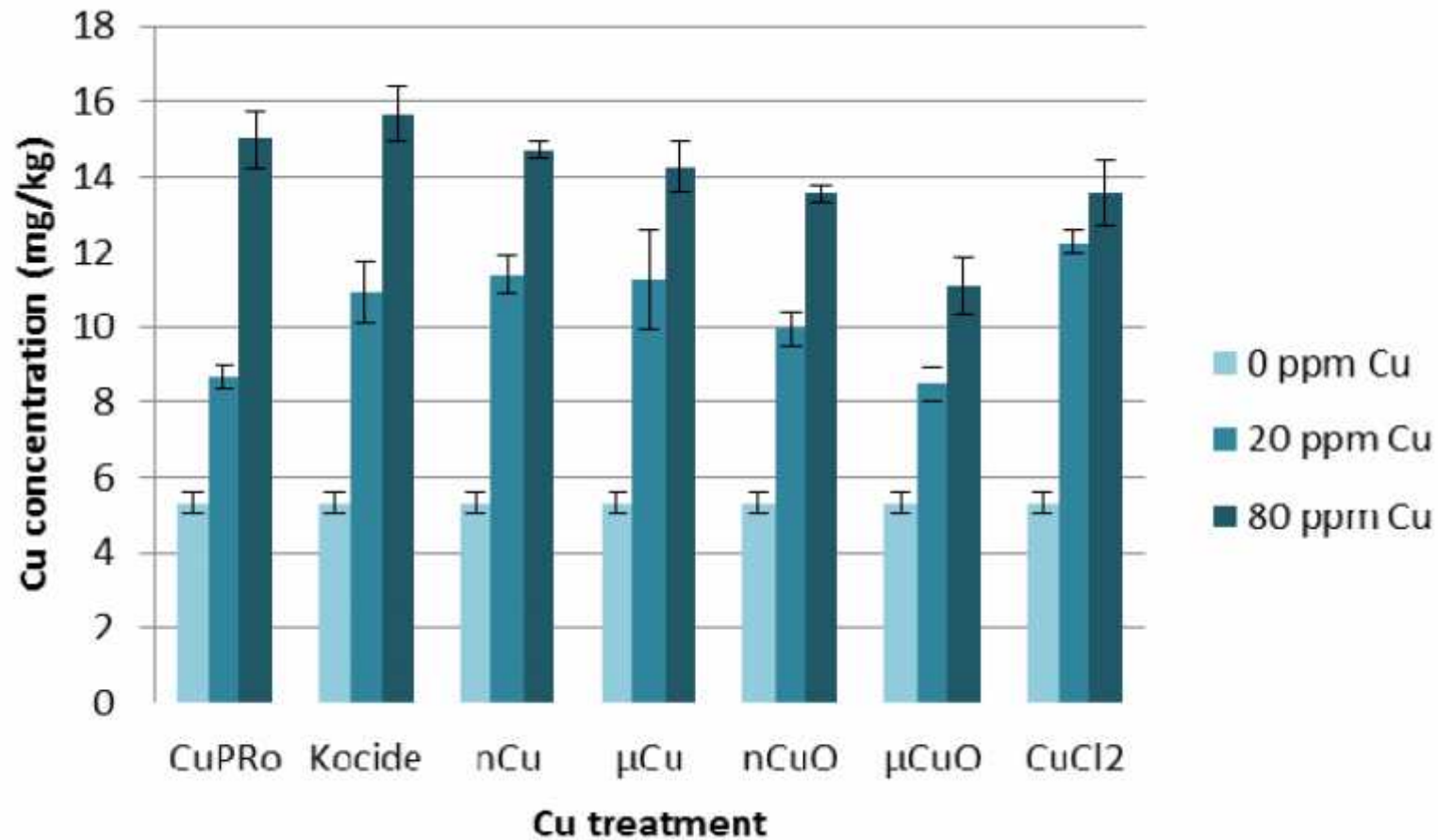


# Results

## Cu Effects on Cilantro Chlorophyll



## Copper concentration in cilantro shoots



## 20ppm Cu effects in cilantro shoots nutritional value

	B	Zn	Mn	Ca	P	S	Mg
CuPRO			+	+	-		
Kocide				-	-	+	-
nCu			+	+	-	-	
$\mu$ Cu		-			-		-
nCuO	+				-	-	-
$\mu$ CuO				-	-	+	-
CuCl <sub>2</sub>			+	+	-		

## 80ppm Cu effects in cilantro shoots nutritional value

	B	Zn	Mn	Ca	P	S	Mg
CuPRO			+	+	-		
Kocide				-	-		-
nCu	+				-		
$\mu$ Cu	+	-		-	-		
nCuO	+				-	-	-
$\mu$ CuO		+		-	-		-
CuCl <sub>2</sub>			+		-	-	-

# Summary

		CuPRO		Kocide		nCu		μCu		nCuO		μCuO		CuCl <sub>2</sub>	
		20	80	20	80	20	80	20	80	20	80	20	80	20	80
Shoot length							↓					↓	↓		
Chlorophyll content			↑				↑					↓	↓		
Nutrients	Mg	↑		↓	↓			↓		↓			↓		↓
	P	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	S			↑						↓		↑			↓
	Ca	↑	↑	↓	↓	↑			↓				↓	↑	
	B						↑	↑		↑		↑			
	Mn		↑			↑								↑	↑
	Zn								↓				↓		

- Agronomic parameters in cilantro were mostly affected by 80 ppm nCu and both 20 and 80 ppm bulk CuO
- Chlorophyll content was increased by 80ppm CuPRO and nCu; decreased by both concentrations of bulk CuO
- Nutritional value was affected by all copper compounds

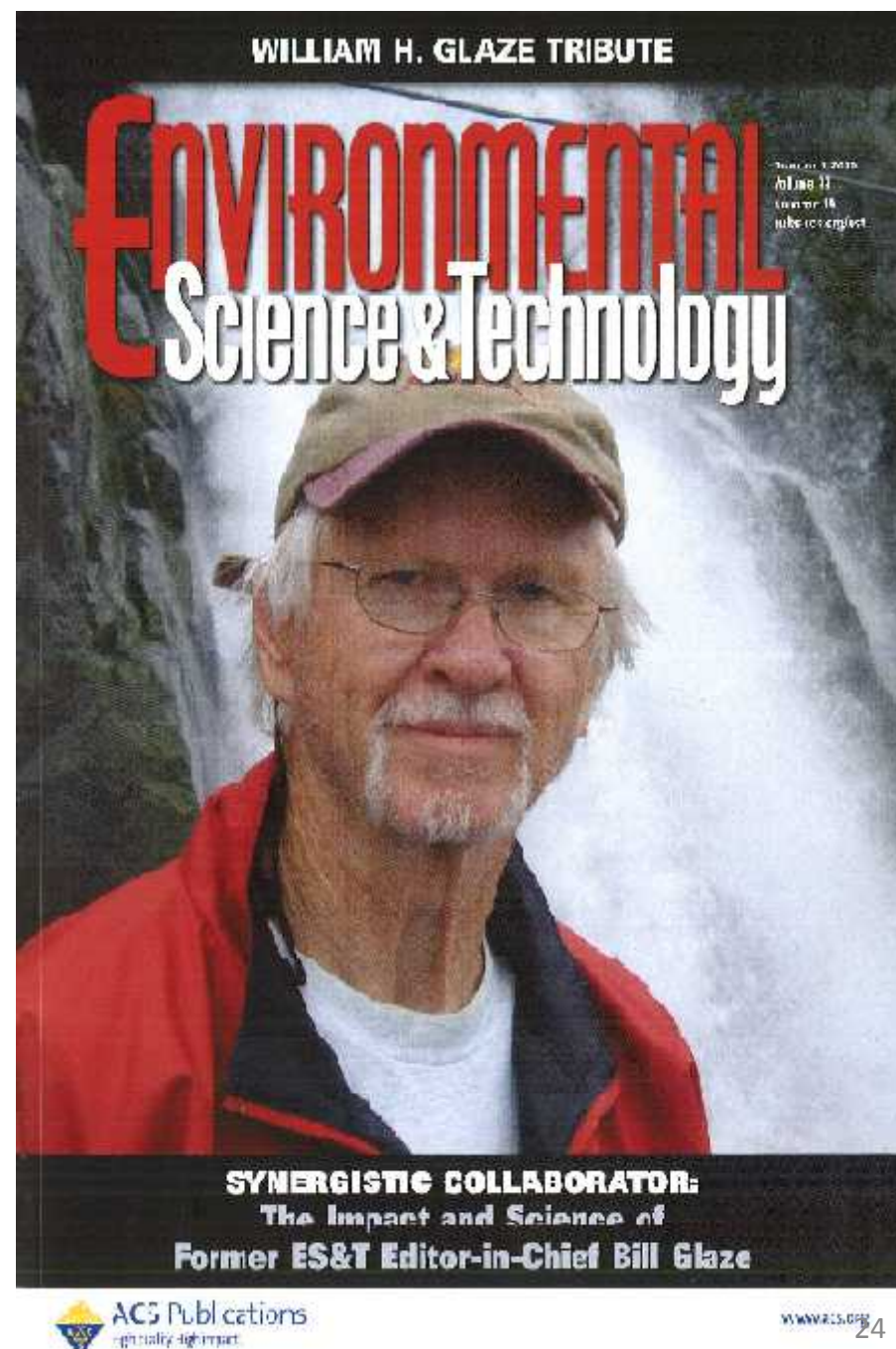
# Acknowledgements

- CEIN NSF-EPA # EF0830117.
- USDA-UPRM grant # 2008-38422-19138.
- National Science Foundation (NSF) CHE-0840525.
- Dudley Family for Endowed Chair.
- LERR and STAR Grants of the University of Texas System.
- NIH BBRC 2G12MD007592
- Science and Technology Mexican National Council (CONACyT)

**Gardea-Torresdey's Research Group (Fall 2014)**  
<http://www.ssslogic.com/gardea>



In Memory  
Prof. William "Bill" Glaze  
ES&T Editor-in-Chief  
1988-2002  
"A Mentor, and a Friend"  
Passed away December 17, 2014  
"A 21st century pioneer in environmental  
science and technology."





Thank you!

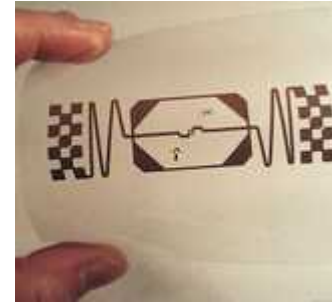
Questions?



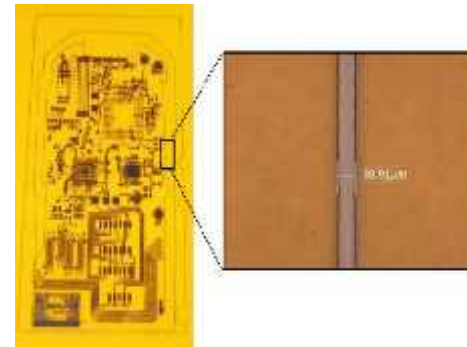
SNO 2014 student awardees

# Nanomaterials and the environment

- NMs widely used
- Diverse fields applications
  - Medicine, electronics, cosmetics, agriculture, etc.
- Unknown effects/lack of regulations
- Cu
  - conductivity
  - biocidal properties
  - cheaper than Au Ag



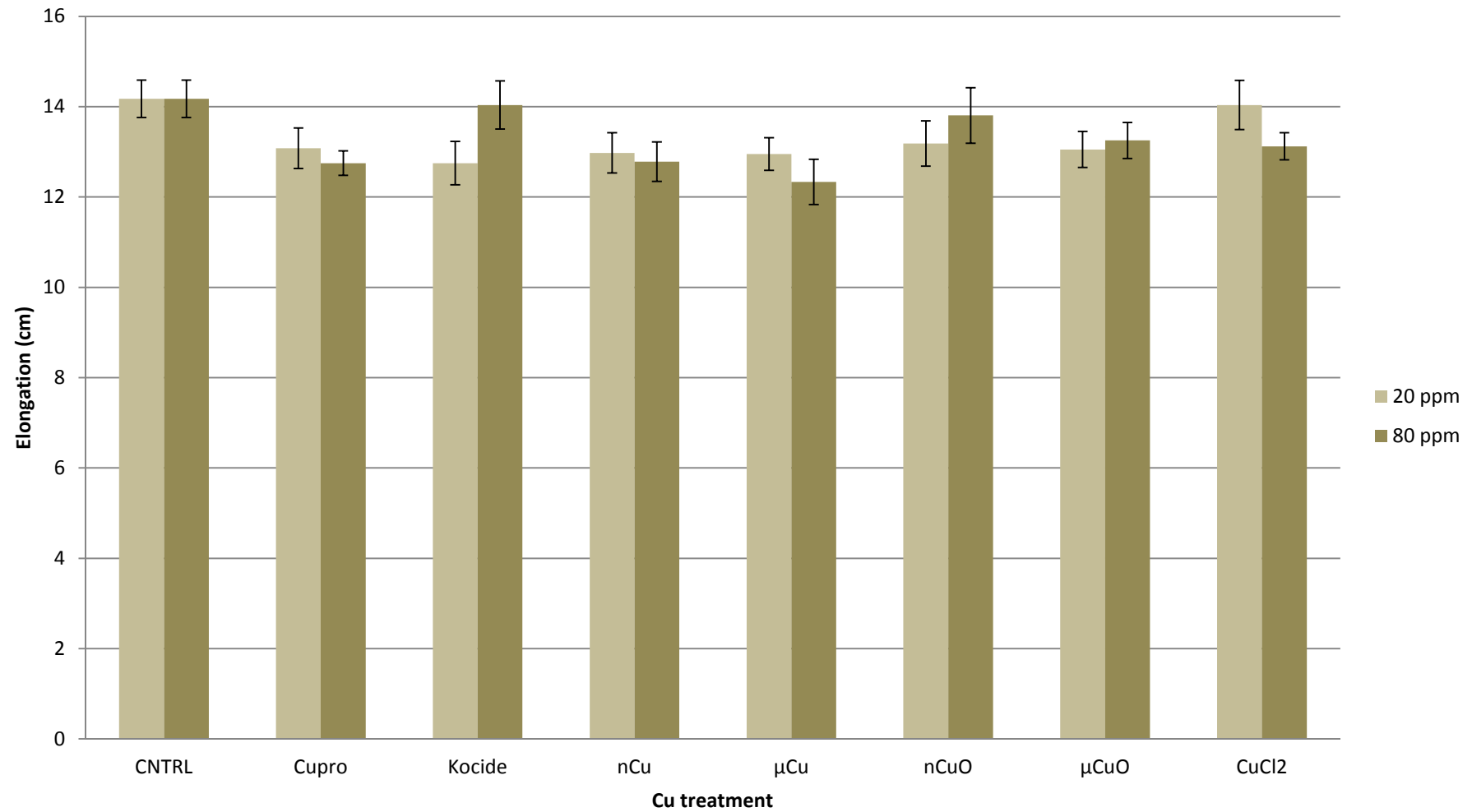
[http://www.gwent.org/gem\\_low\\_temp\\_copper.html](http://www.gwent.org/gem_low_temp_copper.html)



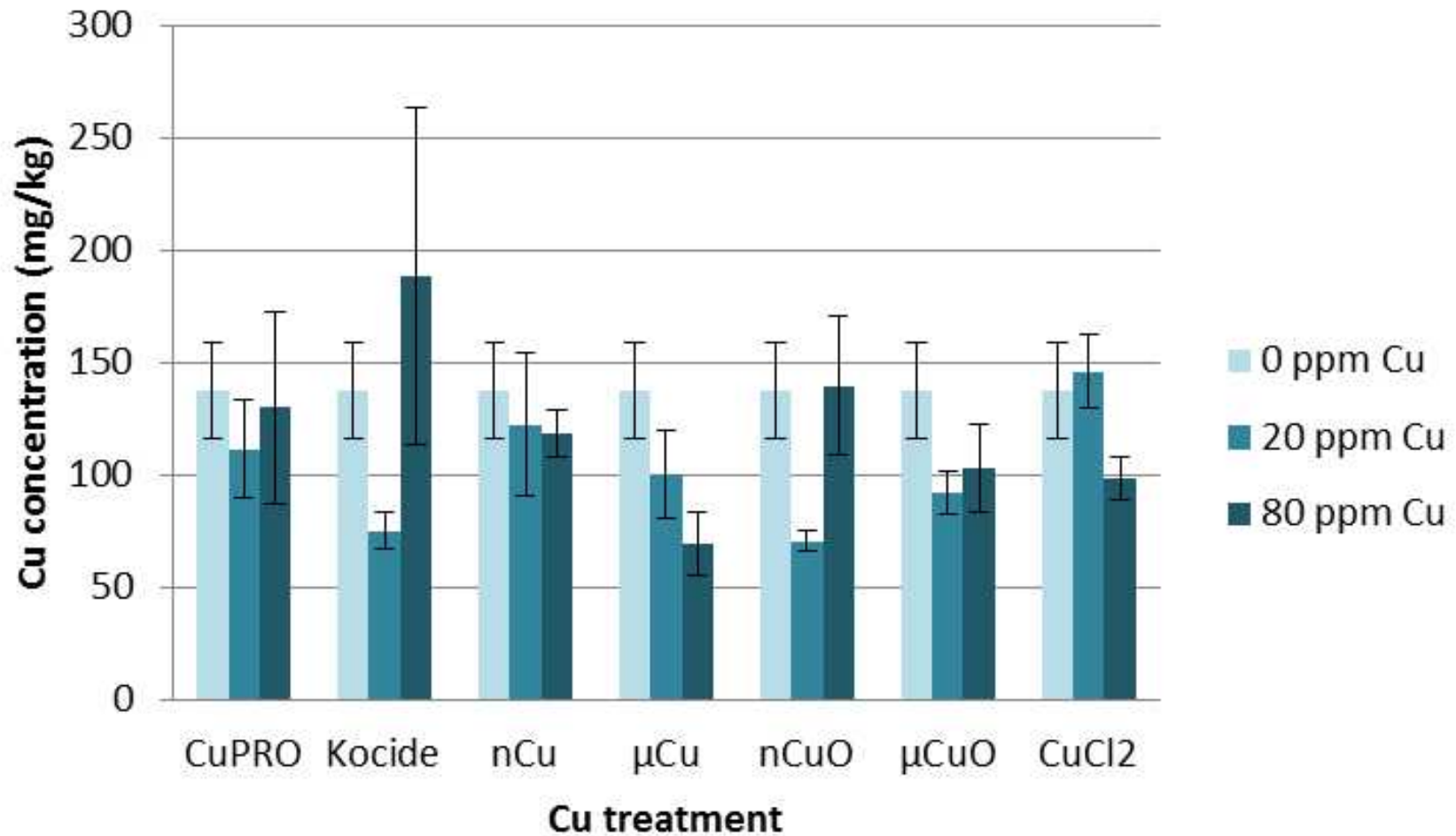
<http://nanotechweb.org/cws/article/tech/36737>

## Physiological results

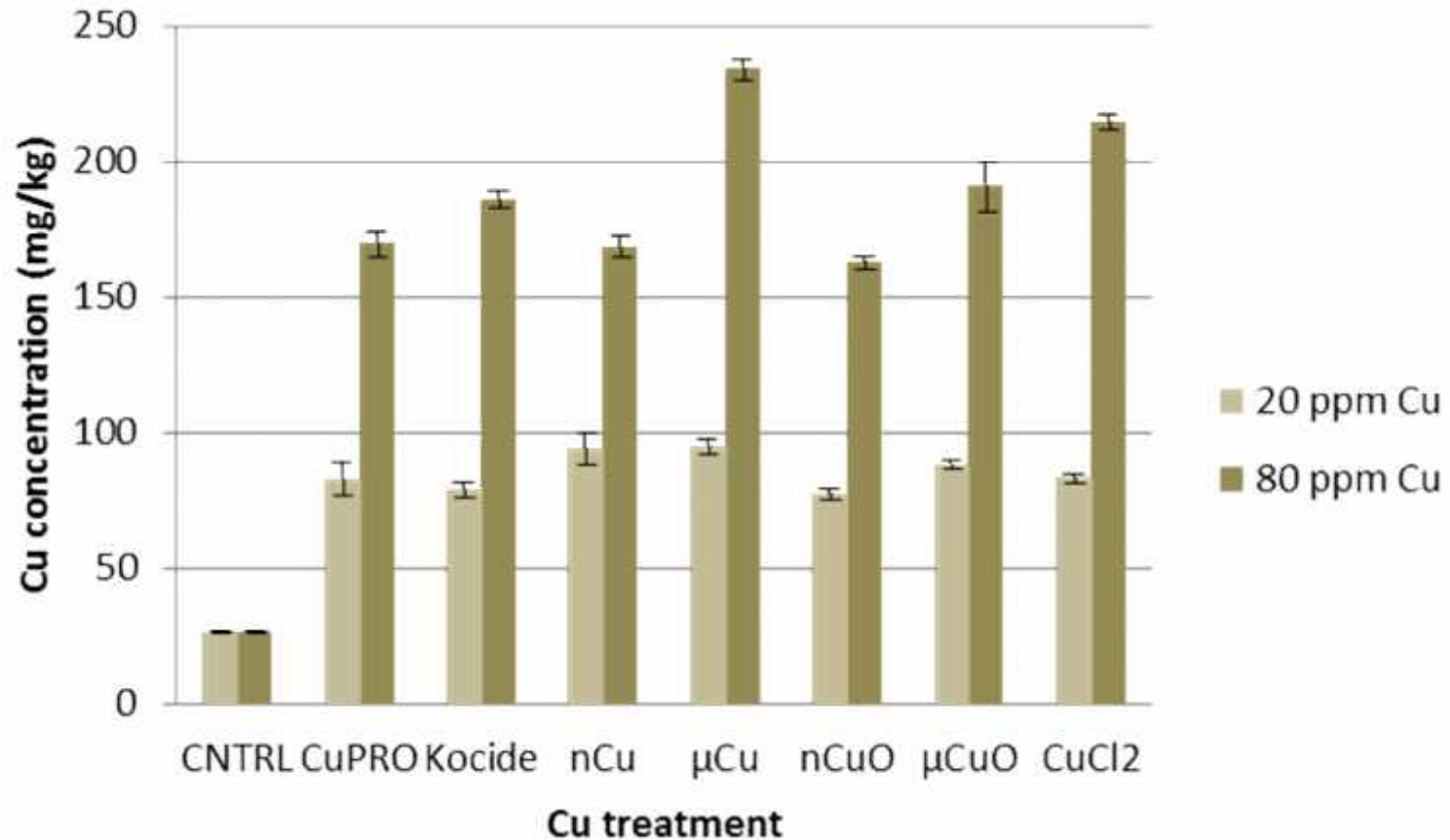
### Cu Effects on Cilantro Roots Elongation



# Copper uptake by cilantro roots

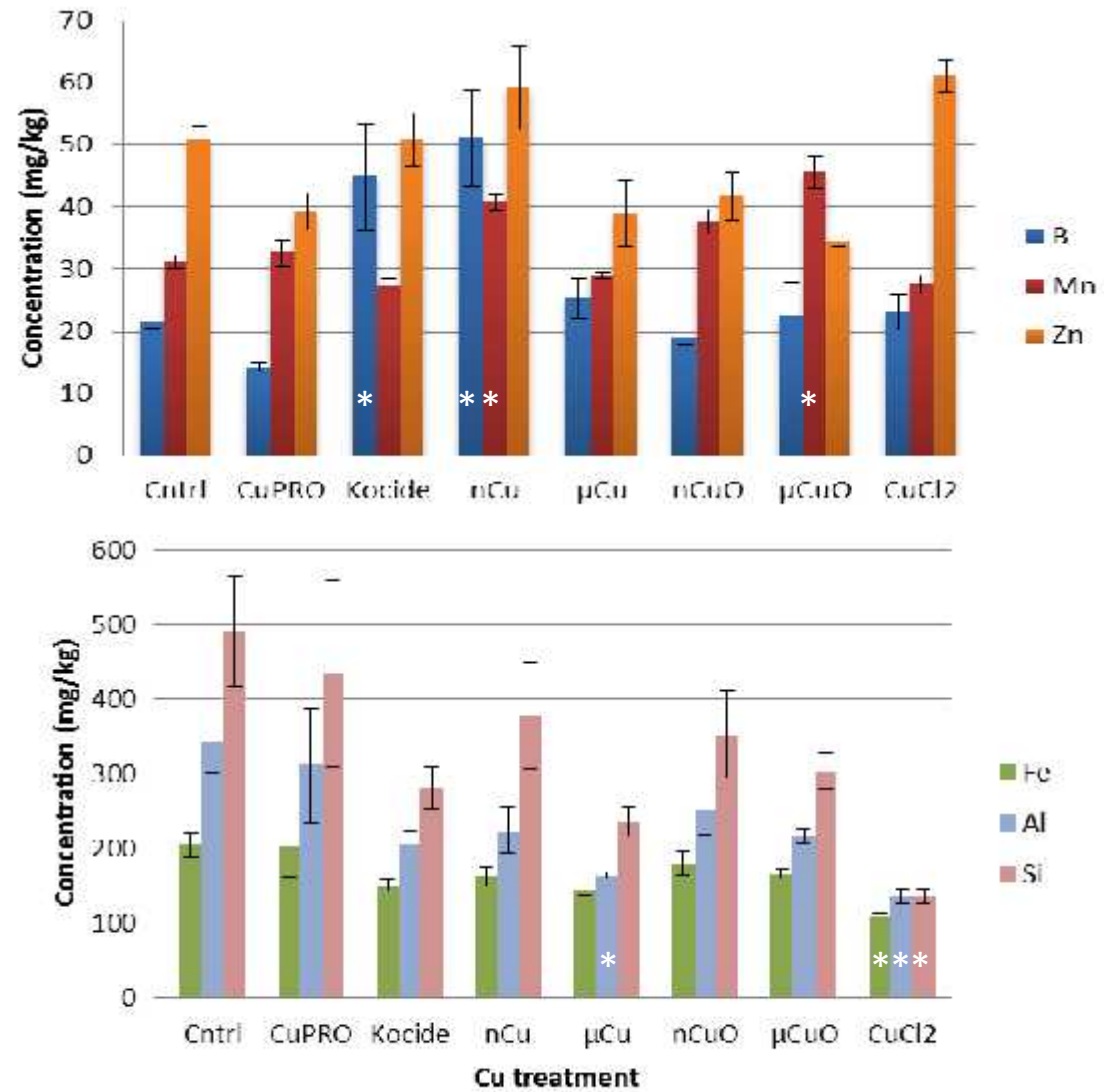


# Copper concentration in soil



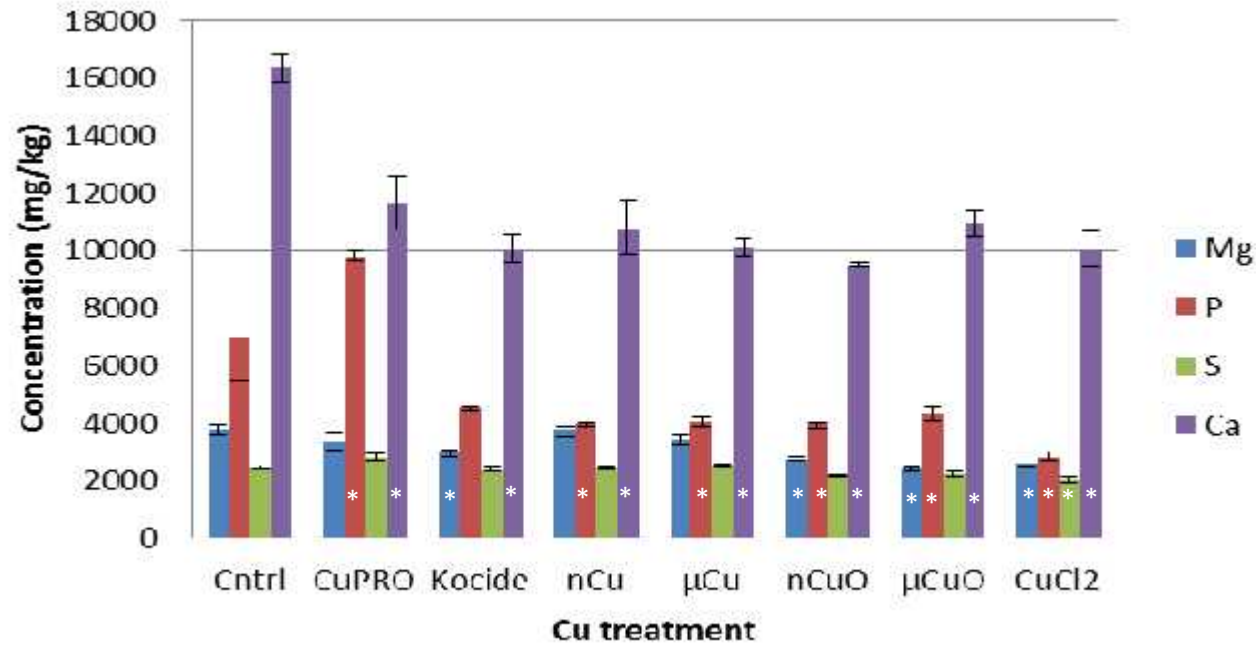
## Agronomical results

### Nutrients concentration in cilantro roots exposed to 20ppm copper compounds



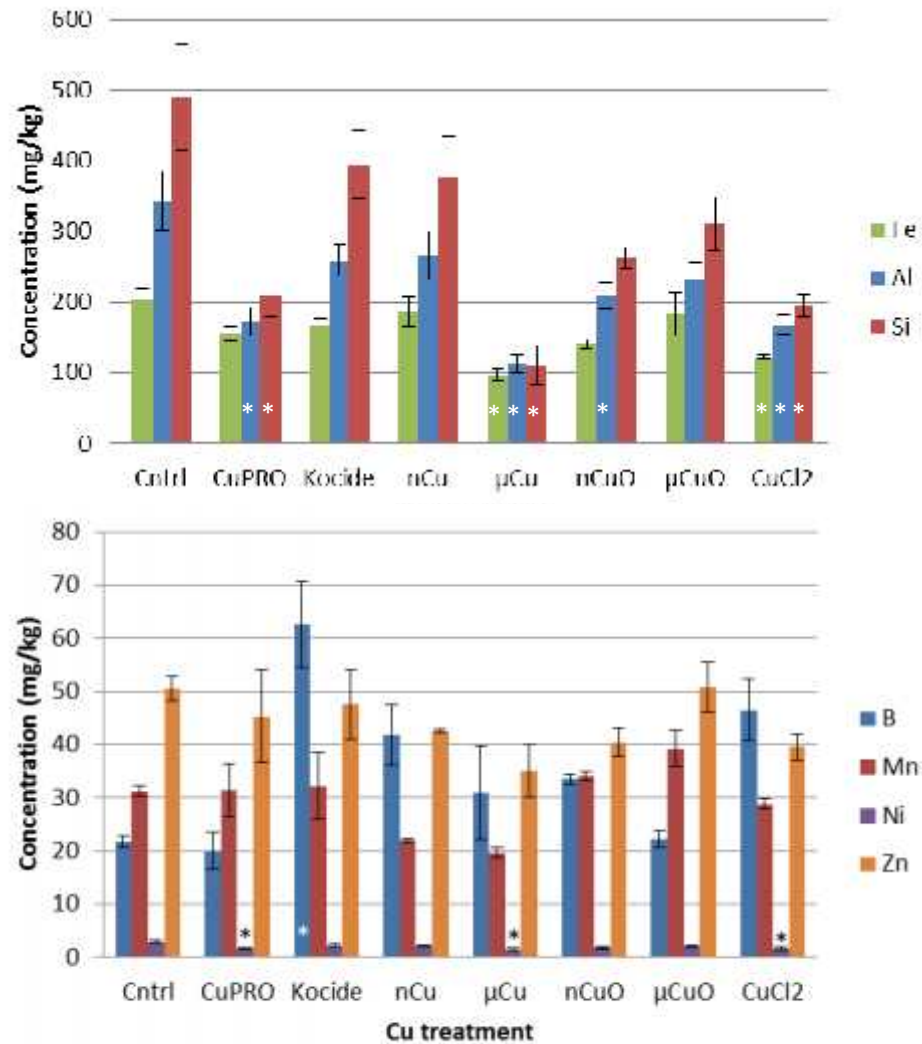
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### Nutrient concentrations in cilantro roots exposed to 20ppm copper compounds



## Agronomical results

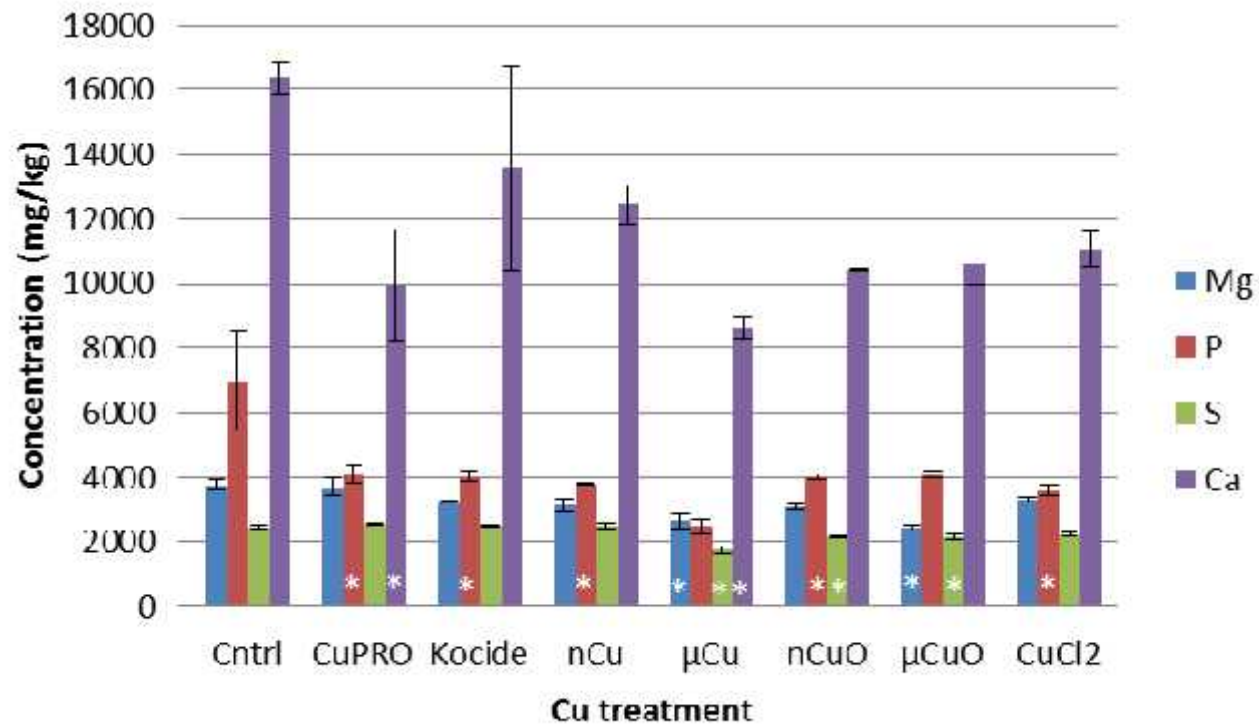
### Nutrients concentration in cilantro roots exposed to 80ppm copper compounds



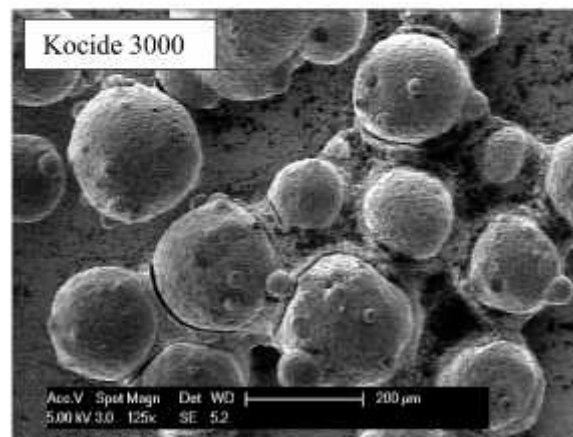
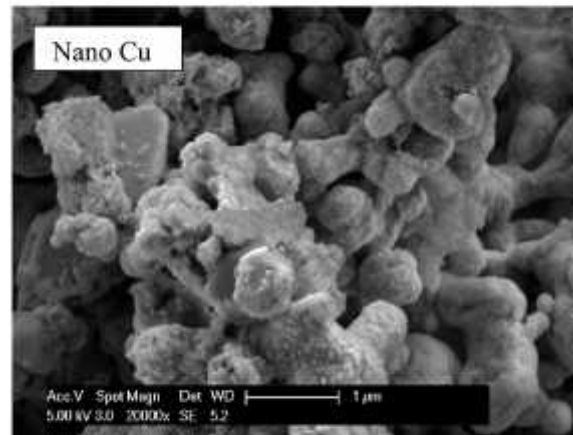
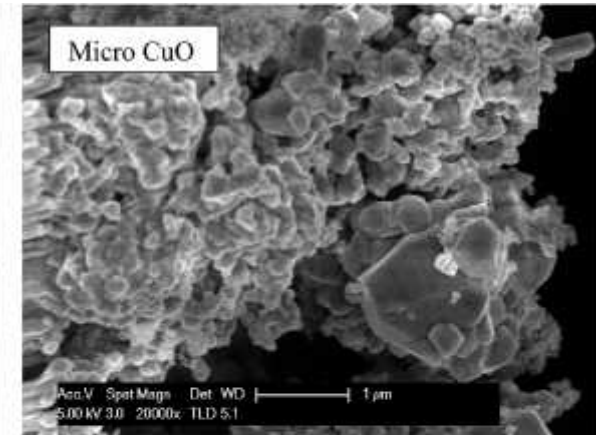
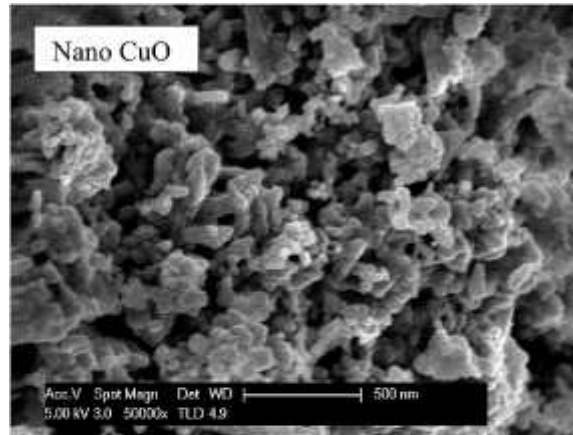


## Agronomical results

### Nutrient concentrations in cilantro roots exposed to 80ppm copper compounds

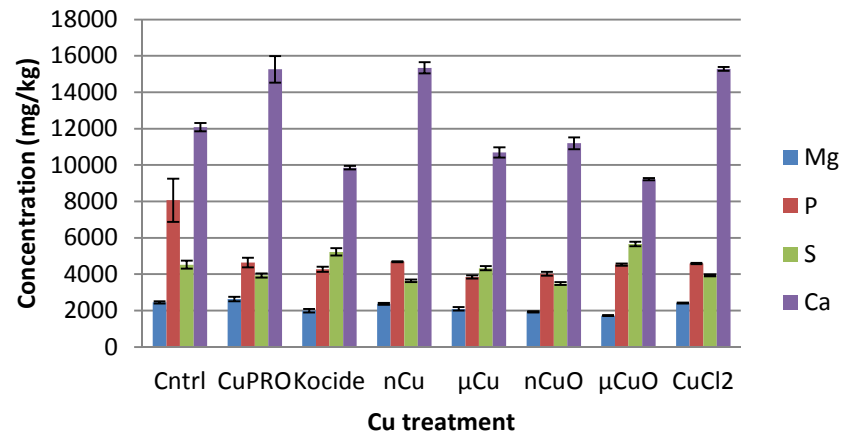
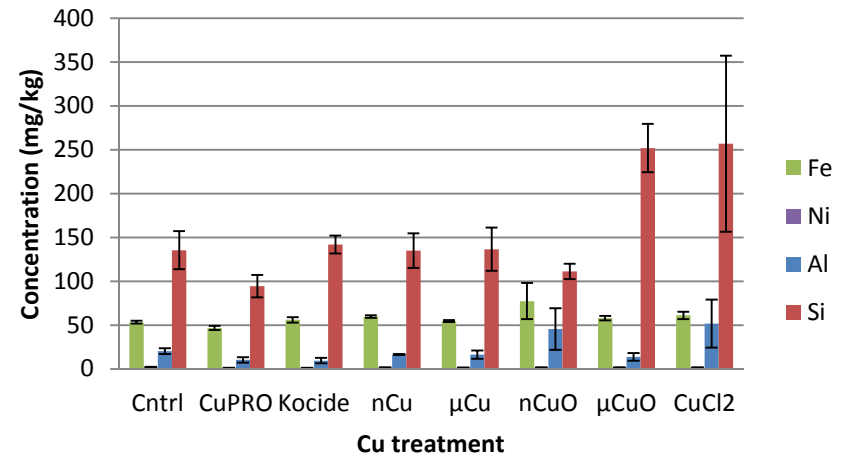
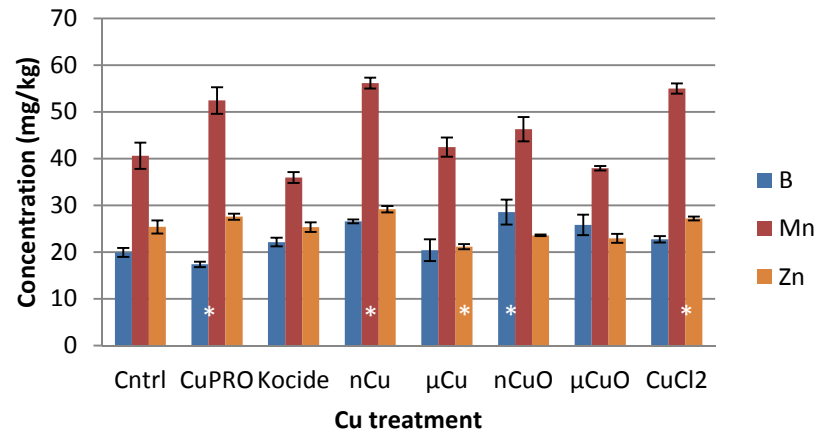


Jie Hong, Cyren M. Rico, Lijuan Zhao, Adeyemi S. Adeleye, Arturo A. Keller, Jose R. Peralta-Videa and Jorge L. Gardea-Torresdey. 2015. Toxic effects of copper-based nanoparticles or compounds to lettuce (*Lactuca sativa*) and alfalfa (*Medicago sativa*). *Environ. Sci.: Processes Impacts*, 23, 17(1), 177-185. 23, 17(1), 177-185



Physiological results

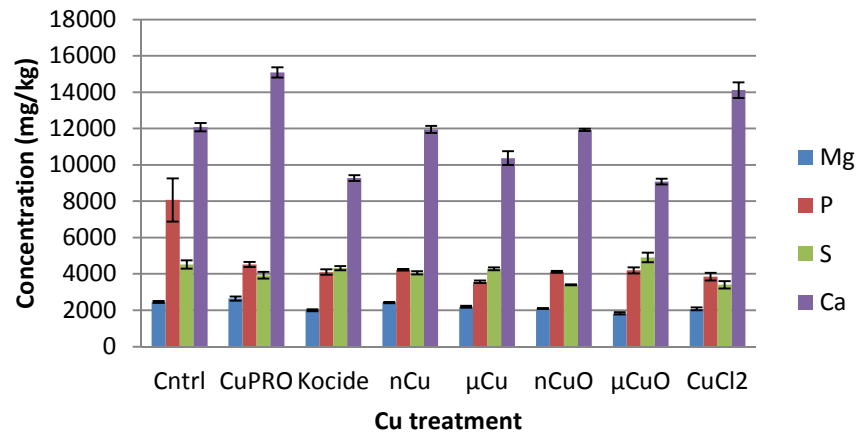
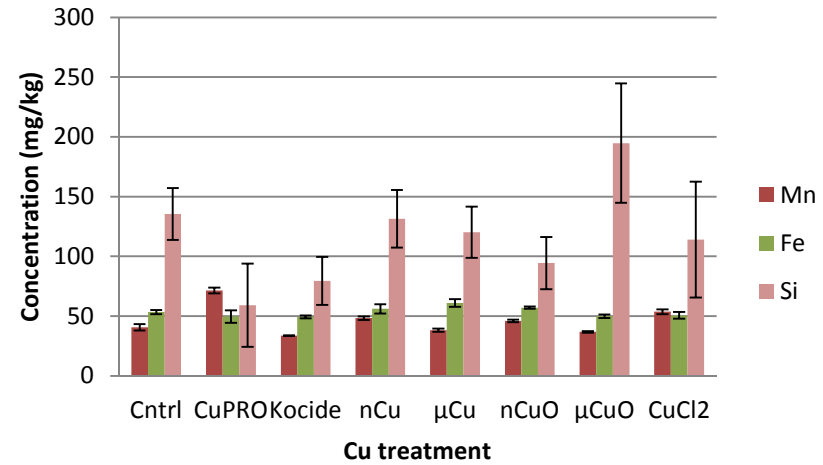
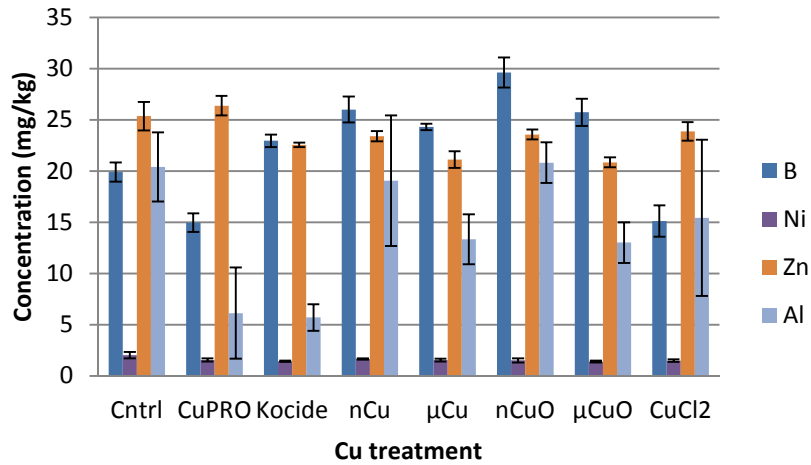
## 20ppm Cu effects in cilantro shoots nutrients



	Increases	Decreases
CuPRO	Mn, Ca	P
Kocide	S	Ca, Mg, P
nCu	Mn, Ca	S, P
μCu		Zn, Mg, P
nCuO	B	S, Mg, P
μCuO	S	Ca, Mg, P
CuCl2	Mn, Ca	P

Physiological results

# 80ppm Cu effects in cilantro shoots nutrients



	Increases	Decreases
CuPRO	Mn, Ca	P
Kocide		Mg, Ca, P
nCu		B
μCu		B, Zn, Ca, P
nCuO		B, Mg, S, P
μCuO		Zn, Mg, Ca, P
CuCl2	Mn	Mg, S, P

