UNIVERSITY OF WYOMING
COLLEGE OF AGRICULTURE
department of renewable resources

Adsorption of Arsenic Species from Groundwater onto Cupric Oxide (CuO) Nanoparticles Across a Wide Range of Natural Conditions

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Presentation Overview

1. Introduction

2. Materials and Methods

3. Results

What is arsenic?

- Naturally occurring element in the Earth's crust
  - Arsenite (trivalent) H_3AsO_3
  - Arsenate (pentavalent) $H_2AsO_4^-$ and $HAsO_4^{2-}$
- Natural sources
  - Weathering of arsenic-bearing minerals
- Anthropogenic sources
  - Product manufacturing
  - Mining
  - Pesticide application

What are the effects of exposure?

- Cancers
  - Skin, lung, liver, kidney, bladder
- Vomiting and diarrhea
- Gangrene, numbness, and paralysis
- Skin thickening and discoloration
- Blindness
- Diabetes

WHO Org.

Who is affected by arsenic?

- Arsenic is a global issue
  - 150 million people worldwide[1]
  - 70 million in Bangladesh and India[2]
  - 13 million in the US[3]

1. J. Toxicol. Clin. Toxicol.
2. Science
3. EPA

What treatment options are there?

- Precipitation
- Adsorption
- Membrane

- Require pre-treatment
- Require post-treatment
- Suitable for municipal water treatment

Previous research at U. of Wyoming

- CuO effectively removed arsenic
  - *Both* arsenate and arsenite
- Not affected by competing anions
- Does not require pre- or post-treatment

- Long processes to make CuO
- Questionable purity of CuO
- Particles very large and not uniform

Why use nanoparticles?

- Highly reactive
- Faster synthesis of CuO
- Smaller particles = larger surface area
- Higher overall efficiency

Materials and Methods

- **Preparation of CuO Nanoparticles**
- **Sample Collection**
- **Batch Experiments**

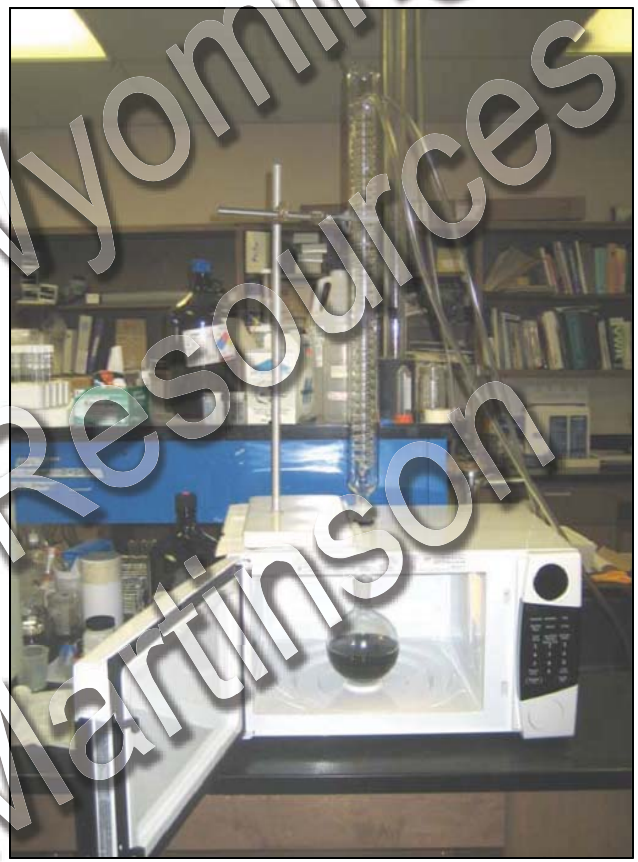
Materials and Methods

- **Preparation of CuO Nanoparticles**

  Ethanolic Solution
  Copper chloride (0.2M)
  Sodium hydroxide (0.4M)
  Polyethylene glycol
  Microwave for 10 minutes

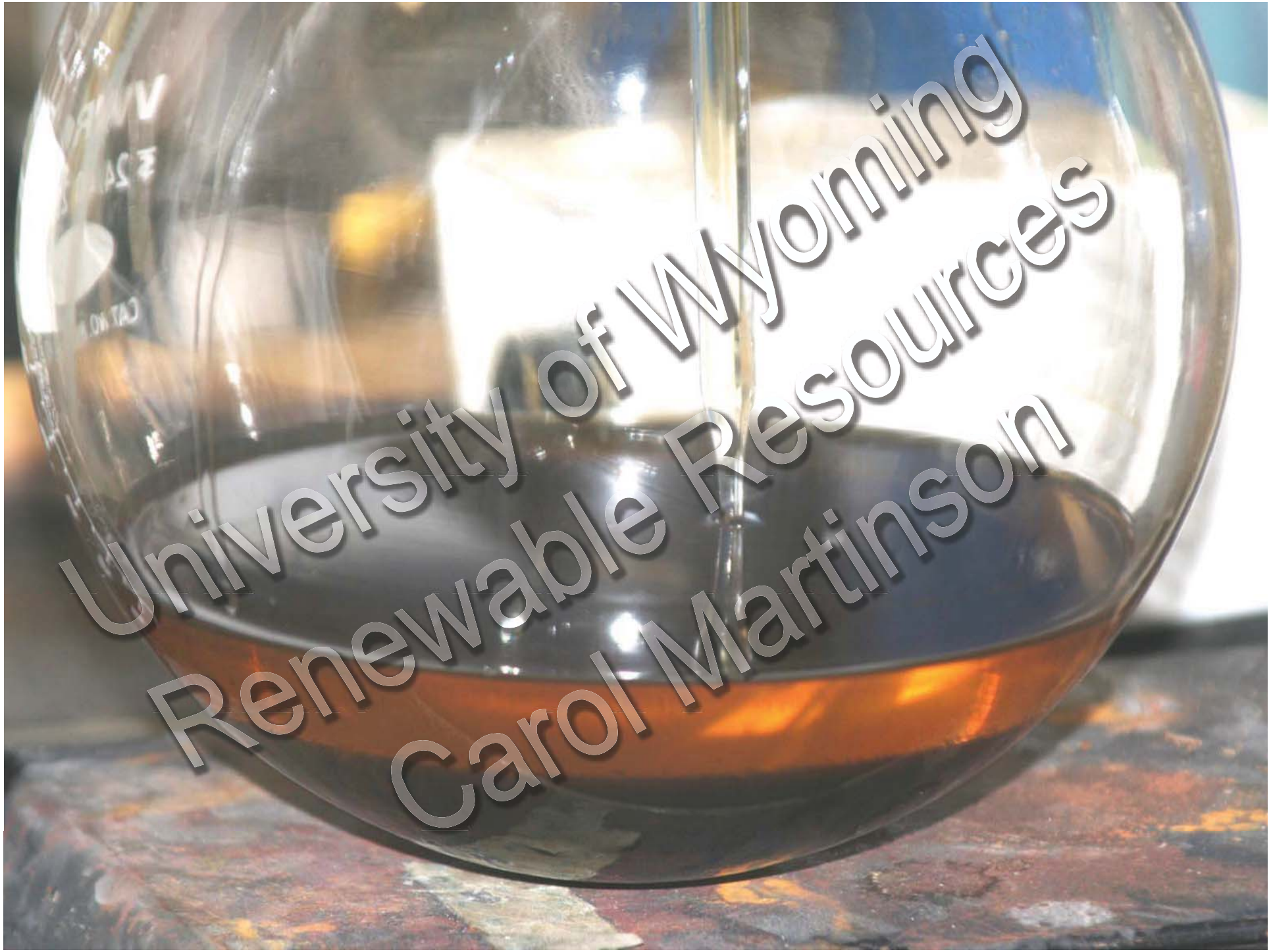
Laboratory vs. Modified

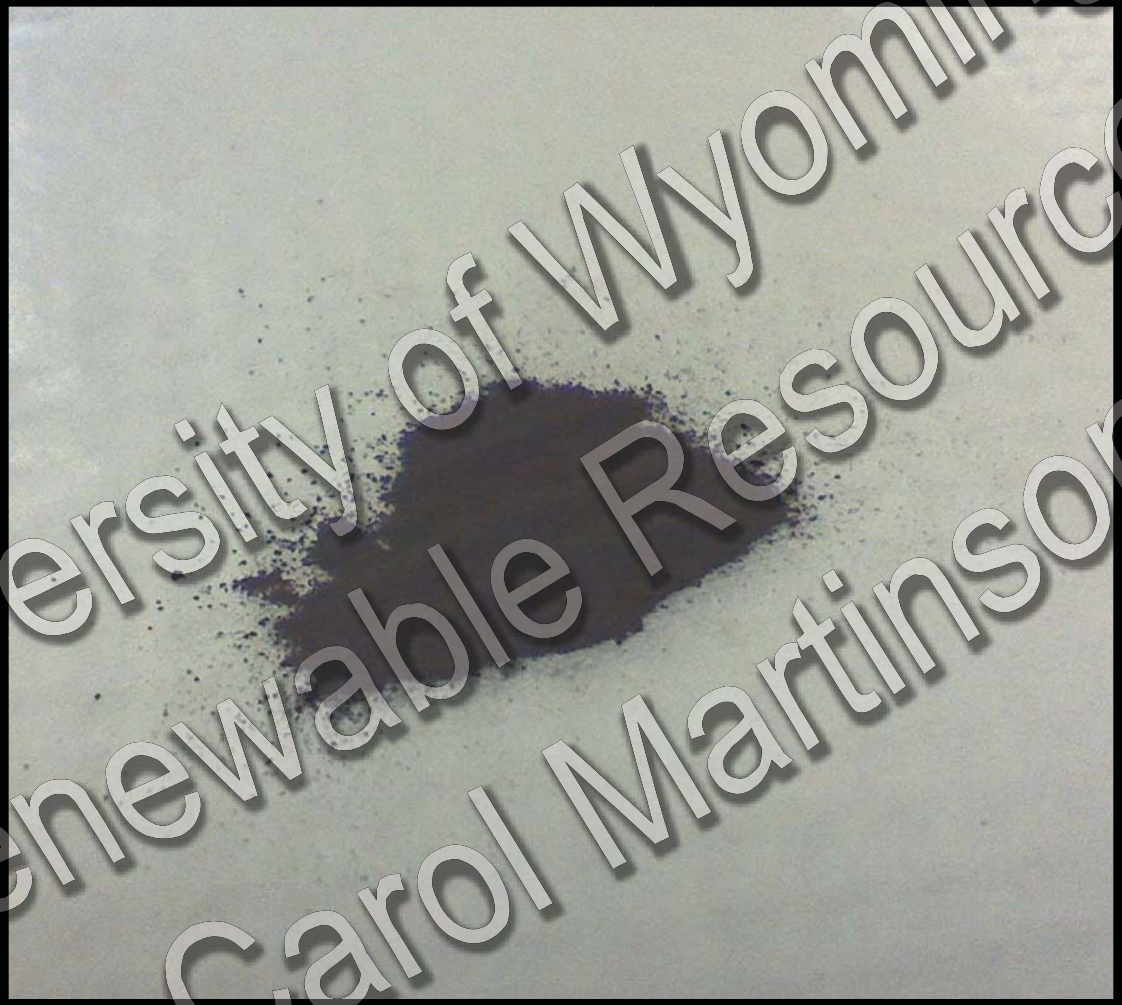
4th int. Electronic Conference on Synthetic Organic Chem



~$50,000 ~$300

Difference: Options, Price


University of Wyoming
Renewable Resources
Carol Martinson



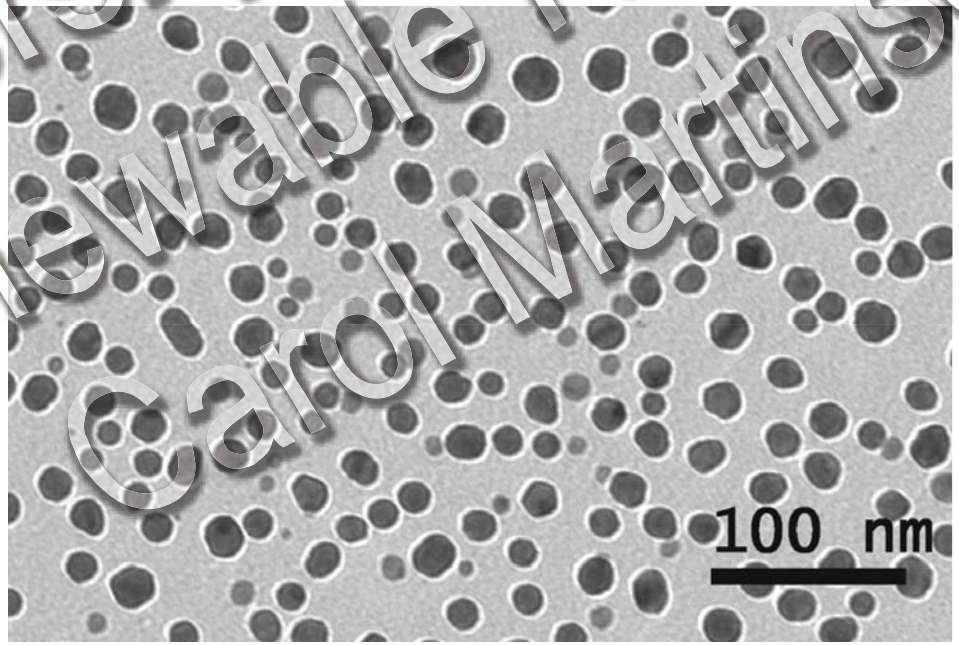
Materials and Methods

- Preparation of CuO nanoparticles
  - **Characterize nanoparticles**
  - Physical Properties
  - Chemical Properties

Materials and Methods

- Prepare CuO nanoparticles
  - **Characterize nanoparticles**
  - Physical Properties – size, shape

    Transmission Electron Microscope



Materials and Methods

- Prepare CuO nanoparticles
  - **Characterize nanoparticles**
  - Physical Properties – surface area

    BET Surface Area Analysis

    85 m^2/g

Materials and Methods

- Prepare CuO nanoparticles
  - **Characterize nanoparticles**
  - Physical Properties – size, shape
  - Chemical Properties – composition, purity

    XRD – X-Ray Diffraction

Materials and Methods

- Preparation of CuO Nanoparticles
- **Sample Collection**
  - Worked with USGS and CSREES
  - Chose ground water sites with highest arsenic
  - Followed Wyoming DEQ Sampling Procedure

Sampling Locations

Materials and Methods

- Preparation of CuO Nanoparticles
- Sample Collection
- **Batch Experiments**

  Use laboratory reagent grade salts

  Reaction volume = 50 mL

  Reaction time = 30 minutes

  Adsorbent concentration = 2 g CuO/L

  ICP-MS and IC to analyze supernatant

Materials and Methods

- Preparation of CuO Nanoparticles
- Sample Collection
- **Batch Experiments**

  Adsorption capacity

  Reaction kinetics

  Effects of oxidation state, competing anions, pH

  Groundwater samples

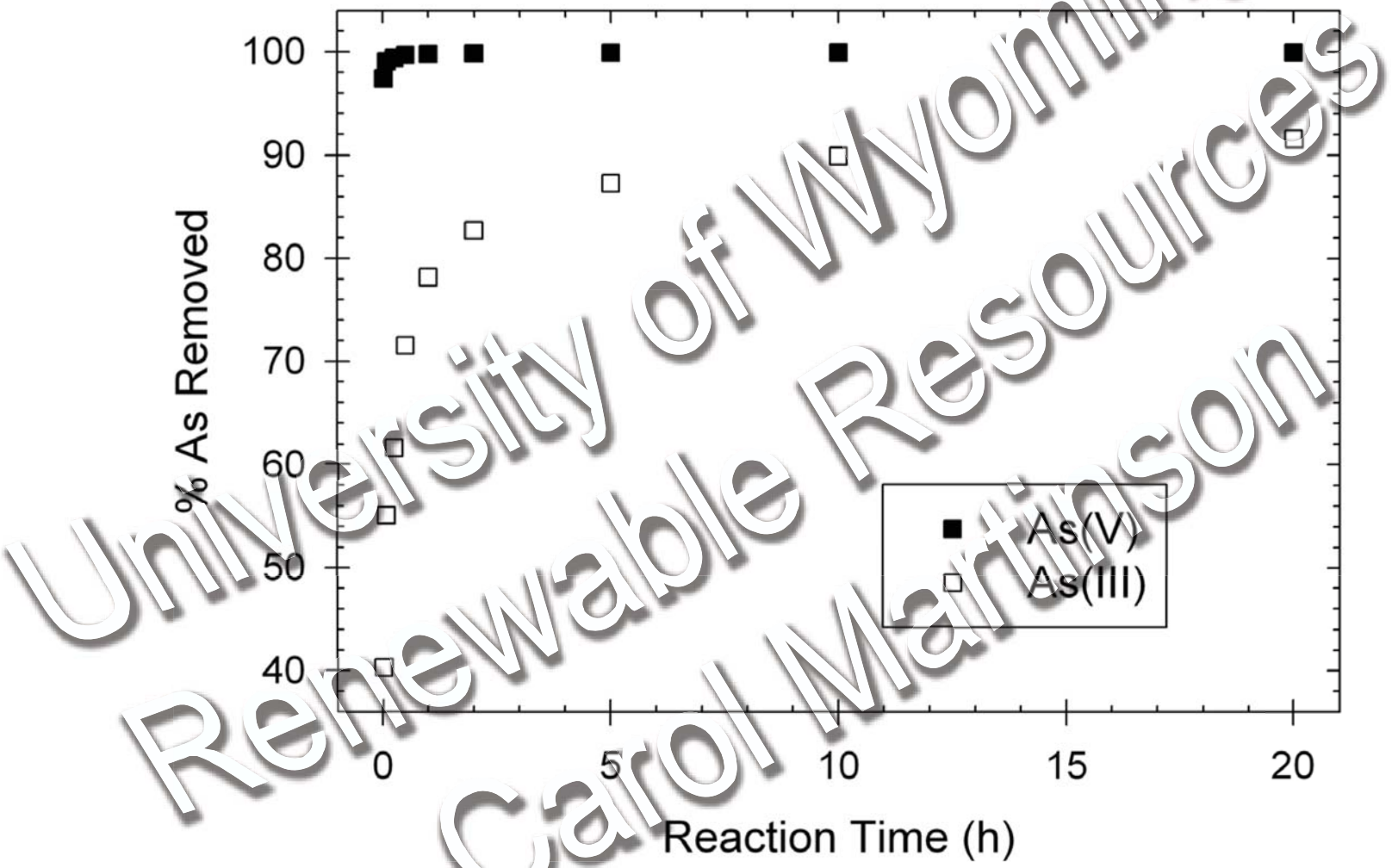
Results

- Adsorption capacity
  - Langmuir isotherm
  - Maximum adsorption capacity at pH = 8.0
    - 26.9 mg Arsenite / g CuO nanoparticles
    - 22.6 mg Arsenate / g CuO nanoparticles

Results

- Adsorption capacity
- Reaction kinetics
  - 1 mg/L arsenic
  - 2.5 minutes – 20 hours
  - pH = 8.0

Reaction Time



Results

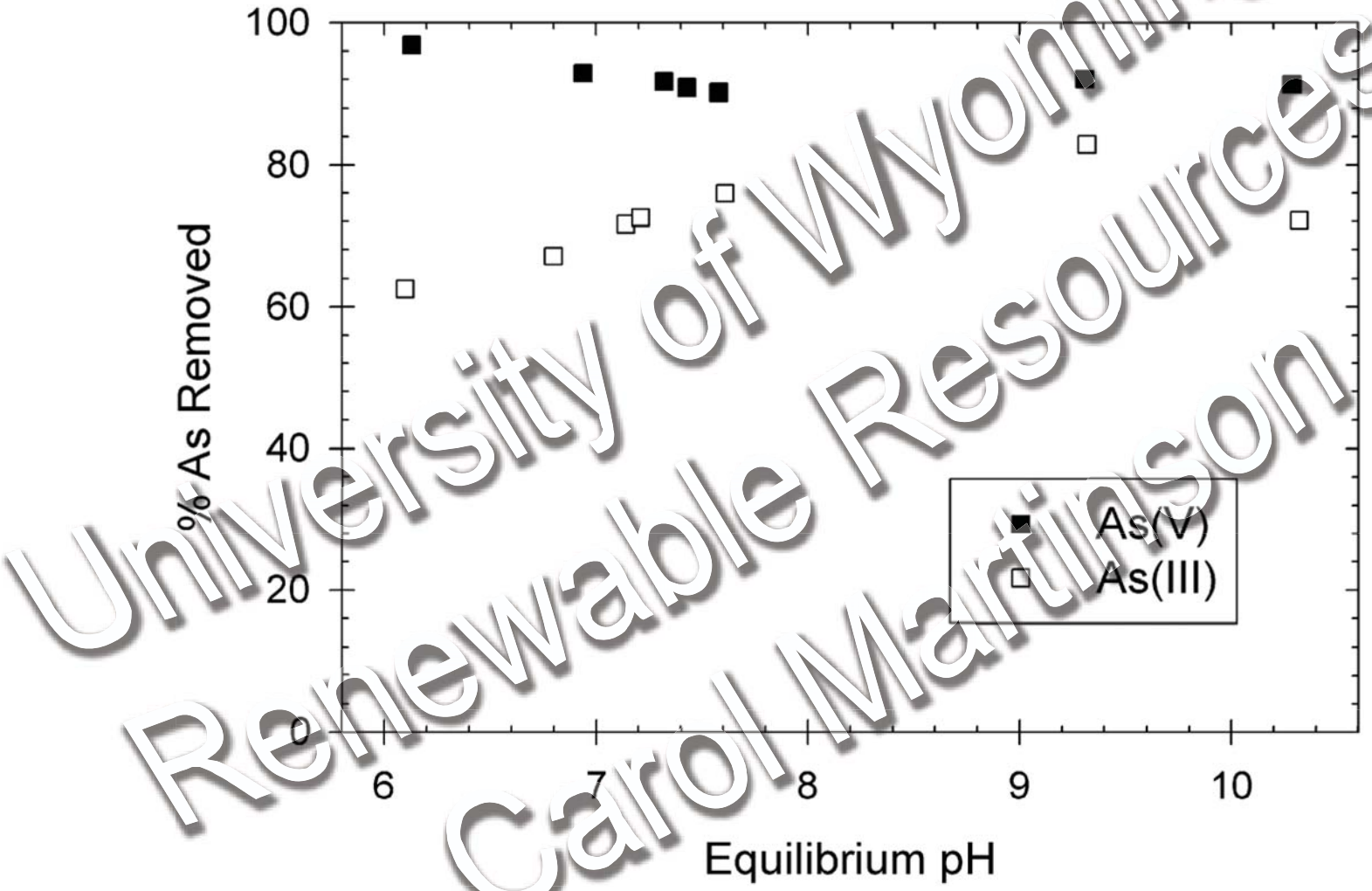
- Adsorption capacity
- Reaction kinetics
- Effect of competing anions
  - 1 mg/L arsenic
  - Various sulfate, phosphate, silicate concentrations
  - pH = 7.0

Form of Arsenic	Competing Anion Concentration (mM)	% As Removed in the presence of:		
		Sulfate	Phosphate	Silicate as Si
As(III)	0		72.0	72.0
	0.2	72.0	59.3	71.9
	1	69.4	31.3	71.3
	5	65.1	28.5	66.1
As(V)	0		99.7	99.7
	0.2	99.7	98.7	99.7
	1	99.7	61.7	99.6
	5	99.6	49.2	99.3

Results

- Adsorption capacity
- Reaction kinetics
- Effect of competing anions
- Effect of pH
  - pH between 6 and 11
    - Initial arsenic concentration = 4.5 mg/L

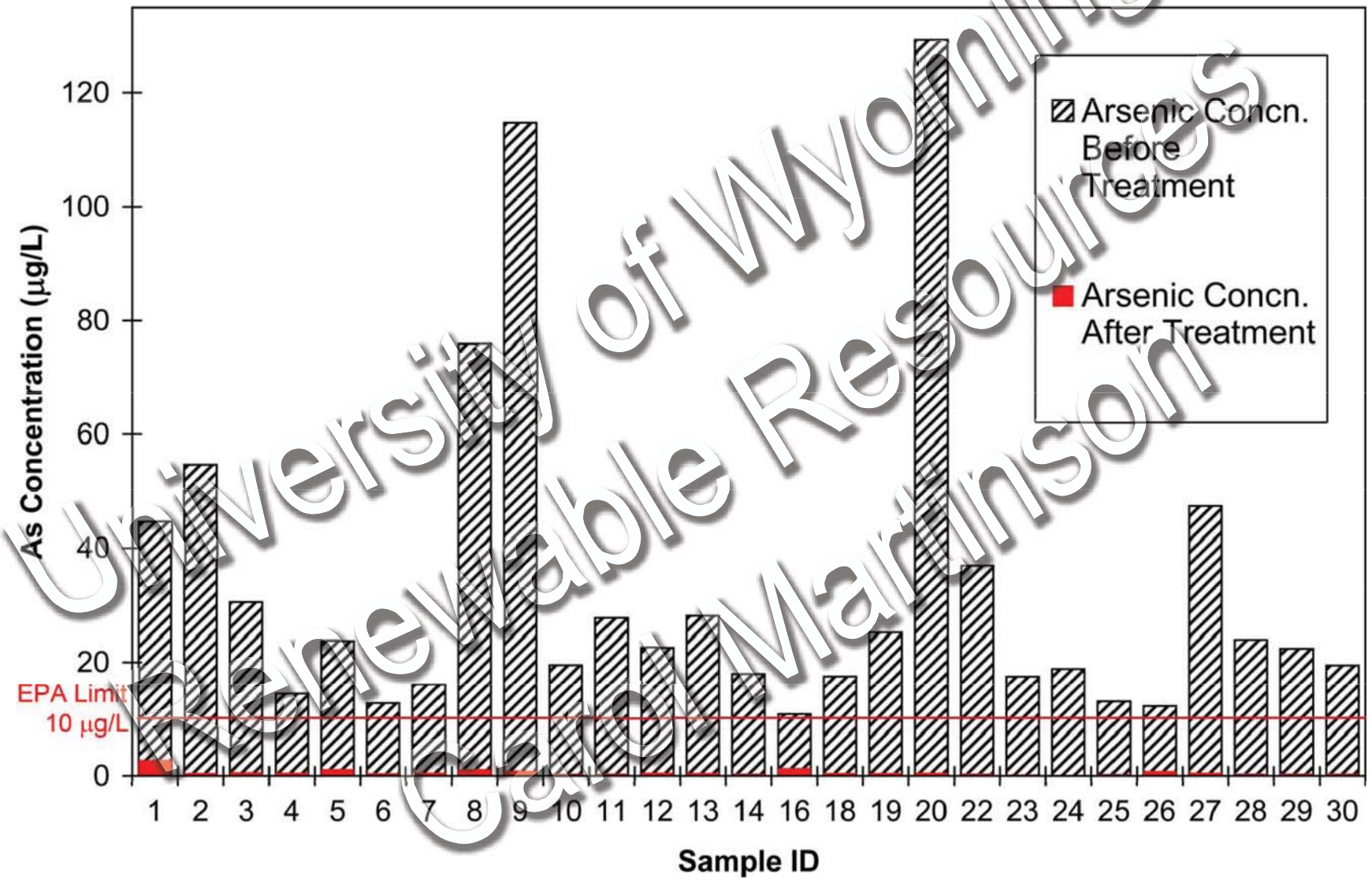
Effect of pH



Results

- Adsorption capacity
- Reaction kinetics
- Effect of competing anions
- Effect of pH
- Groundwater samples

Collected Groundwater Samples



Questions?

Acknowledgments

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