CHALLENGES IN STUDYING THE FATE AND EFFECTS OF NANOPARTICLES IN AQUATIC SYSTEMS.

Valery E. Forbes

School of Biological Sciences

University of Nebraska-Lincoln

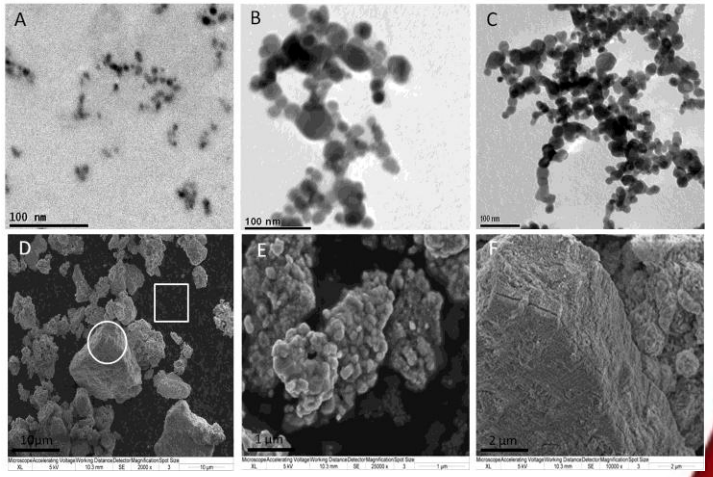
NanoReTox

NanoReTox – Overall Aims

- **The reactivity and toxicity of engineered nanoparticles: risks to the environment and human health (NanoReTox)**
- **EU FP7 Project; Project Leader Eva Valsami-Jones; 12 partners; total budget of 3.2 mil EUR**
- **Work divided into 3 main clusters: synthesis & characterization; human toxicity; ecotoxicity**
- **Key Questions of NanoReTox:**
  - **Are metal-NPs more bioavailable than other forms of metals?**
  - **Are metal-NPs more reactive and/or have different mechanisms of toxicity than other forms of metals?**

Our focus is on sediments

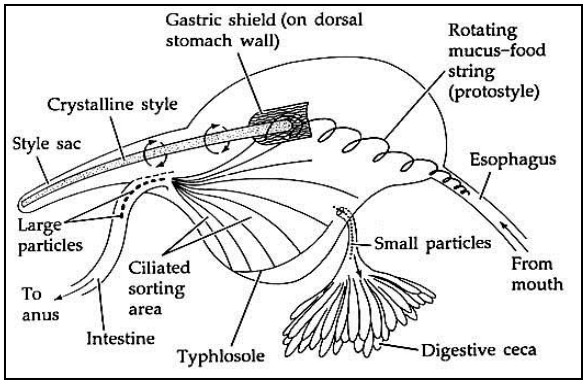
- **Aquatic route of entry will be important for many uses of NPs.**
- **We know that NPs tend to react quickly in complex media through agglomeration.**
- **Though dissolution occurs, we still expect significant accumulation of NPs in sediments.**



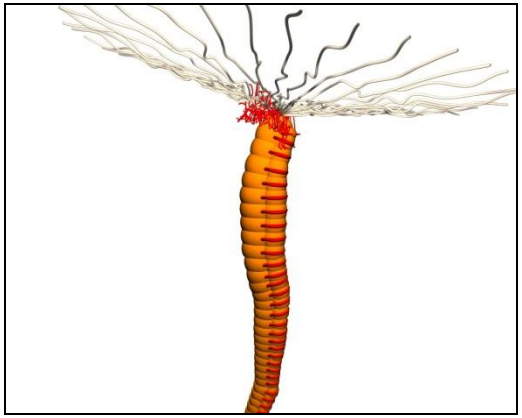
Deposit feeders are particularly at risk

- **Animals that have evolved to live off sediments are extremely good at concentrating and extracting material bound to sediment grains.**

Digestive sorting



Selective ingestion



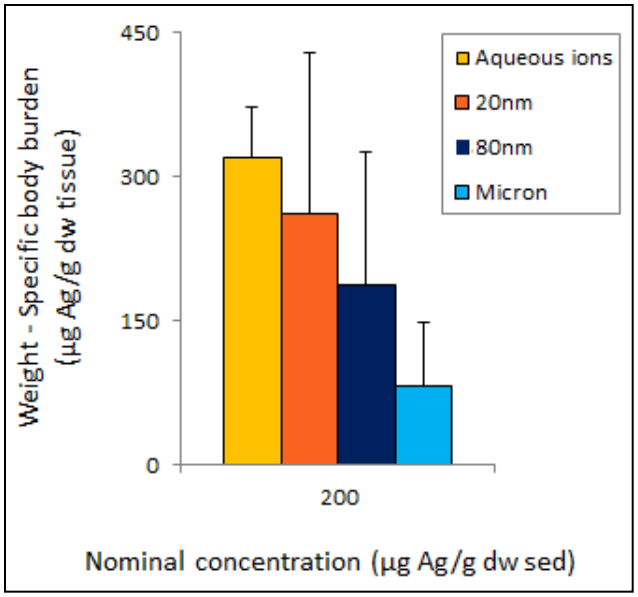
Gut surfactants

Methods overview

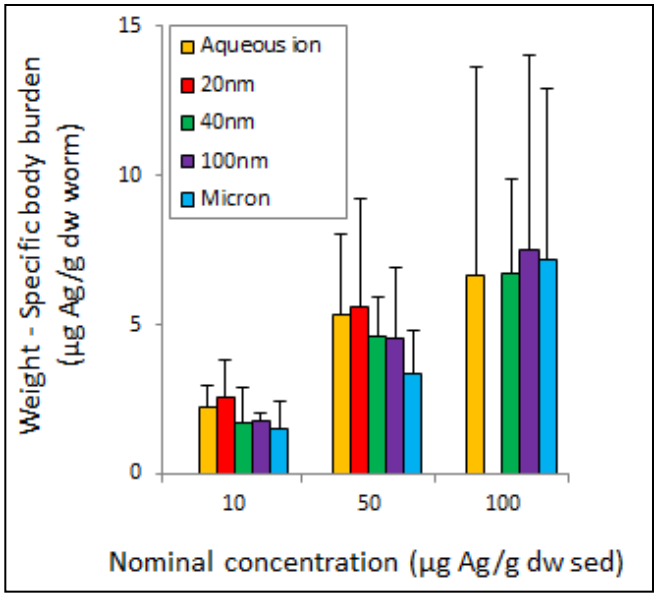
- **Species:**
  - ***Capitella teleta***
  - ***Hediste (Nereis) diversicolor***
  - ***Potamopyrgus antipodarum***
  - ***Macoma balthica***
- **NPs:**
  - **Ag**
  - **Au**
  - **CuO**
- **Endpoints:**
  - **Bioaccumulation**
  - **Mortality**
  - **Growth, reproduction**
  - **Burrowing, feeding rate**
  - **Lysosome stability, DNA damage**

In some (but not all) cases metal-NPs show higher bioaccumulation.

Macoma balthica



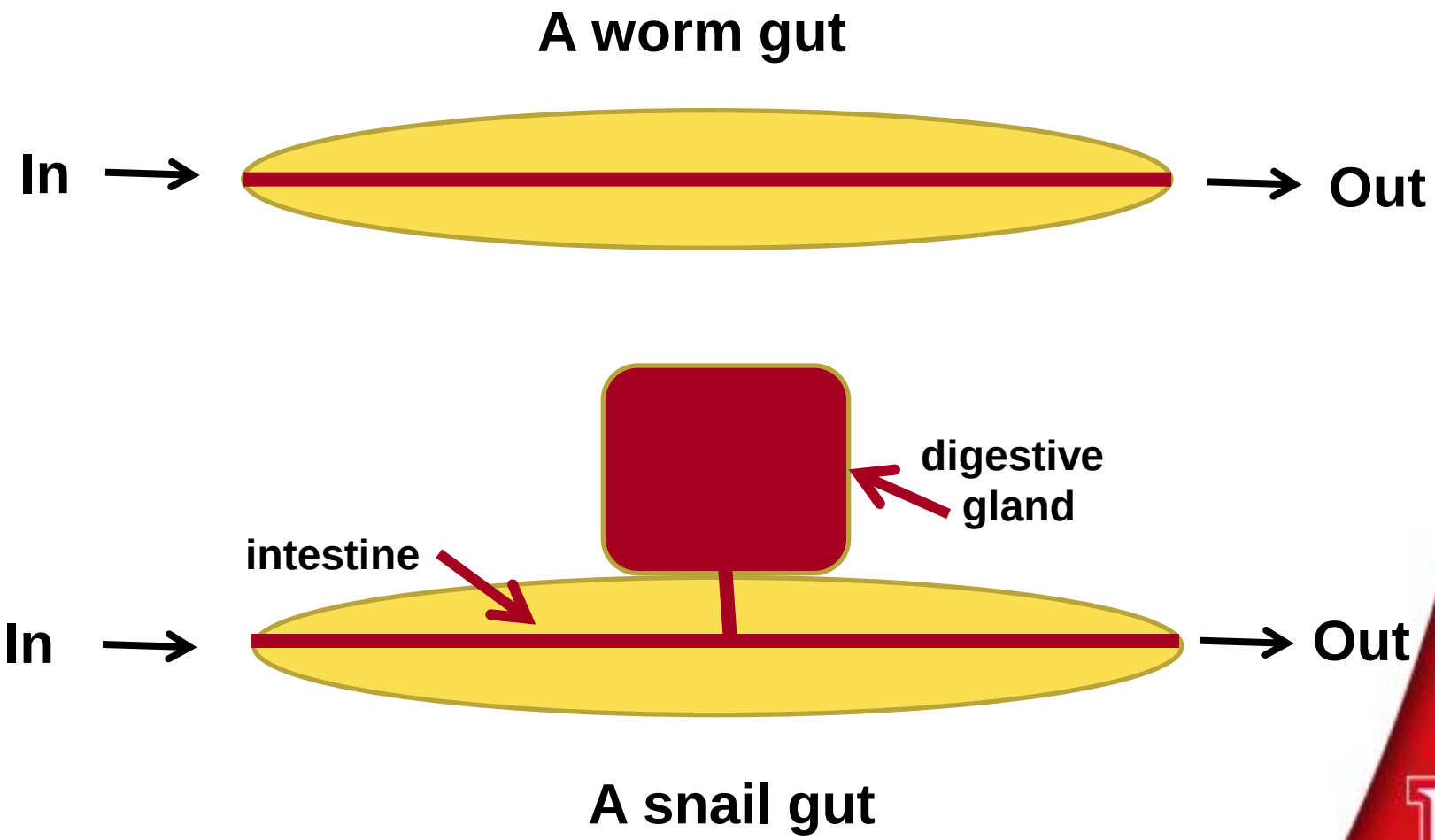
Capitella teleta



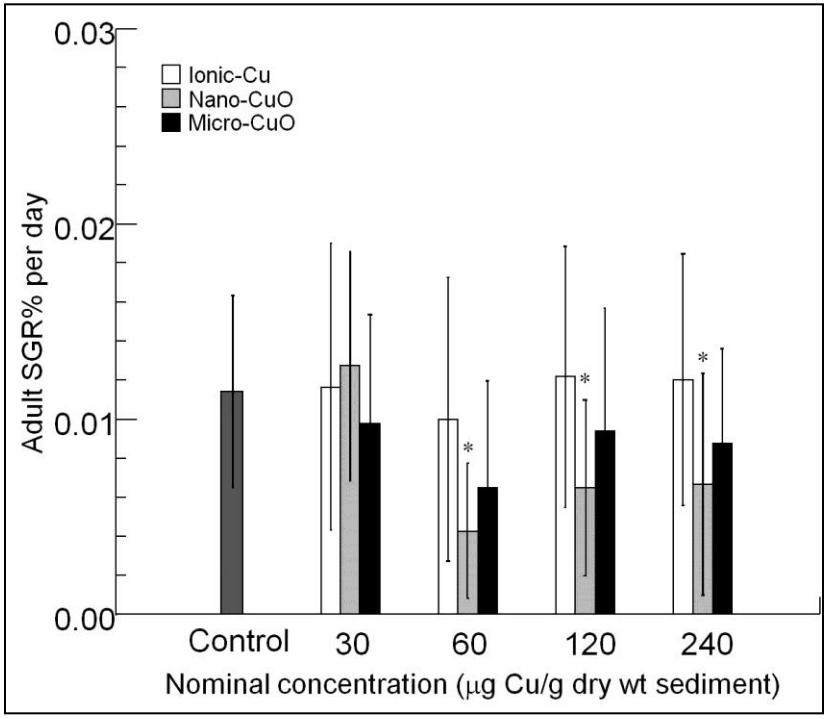
From: Dai, et al. in preparation

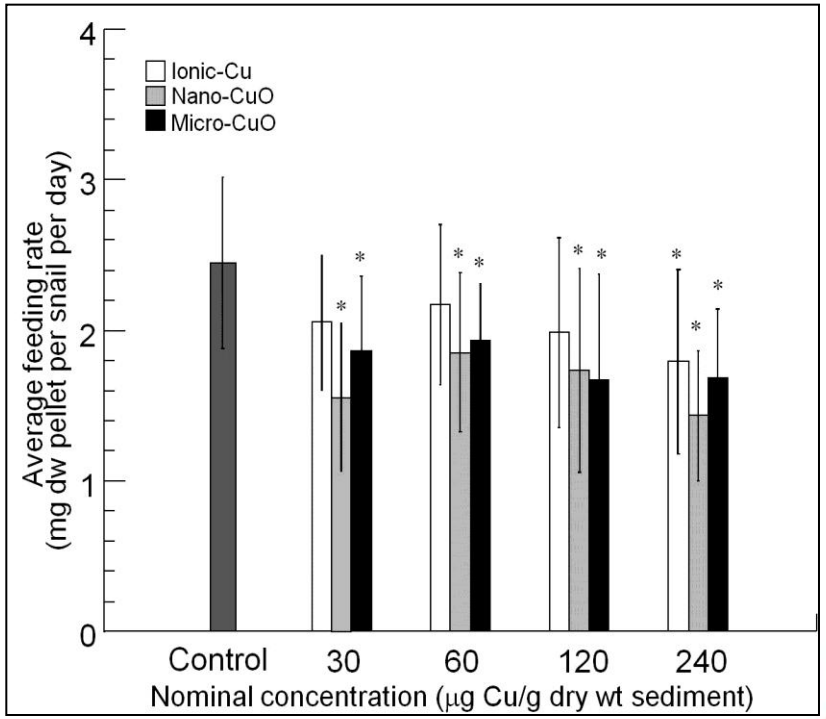
In general, it seems that NP size matters for molluscs but not polychaetes

We can explain this by differences in digestive physiology.



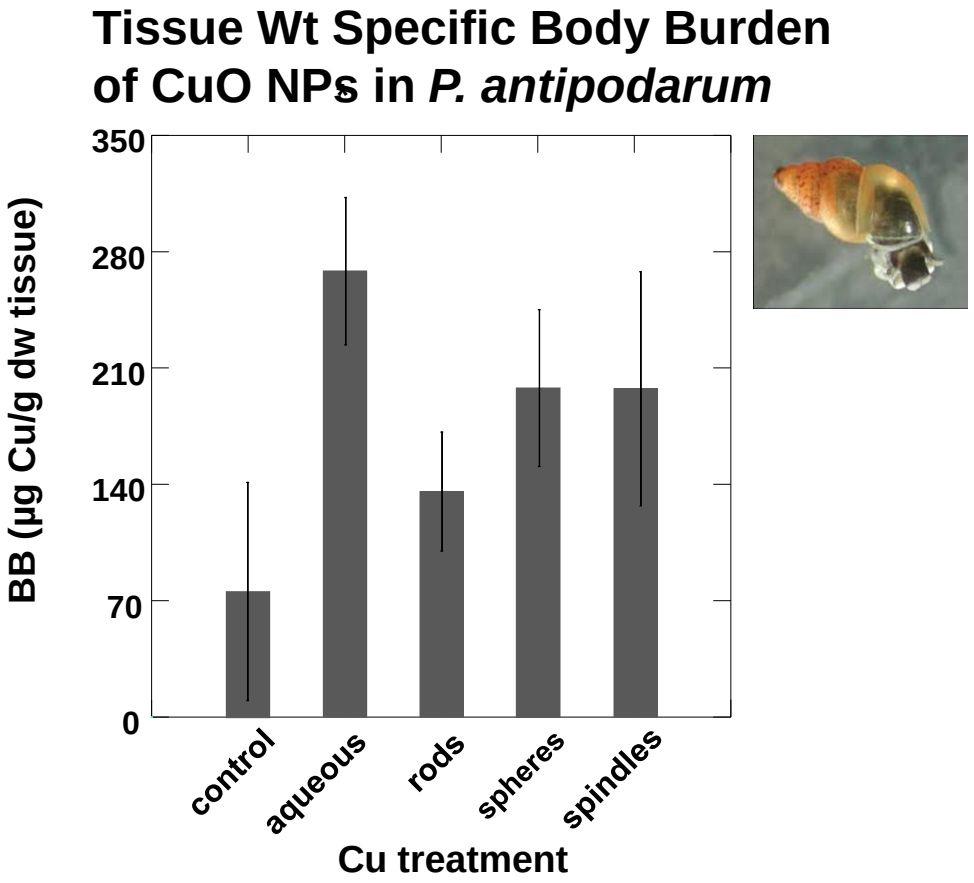
In most cases metal-NPs are more toxic, but not dramatically so.





From: **Pang C, Selck H, Misra SK, Berhanu D, Dybowska A, Valsami-Jones E, Forbes VE. 2011. Effects of sediment-associated copper to the deposit-feeding snail, *Potamopyrgus antipodarum*: a comparison of Cu added in aqueous form or as nano- and micro-CuO particles. *Aquat Toxicol* 106-107: 114-122.**

NP shape also seems to matter.

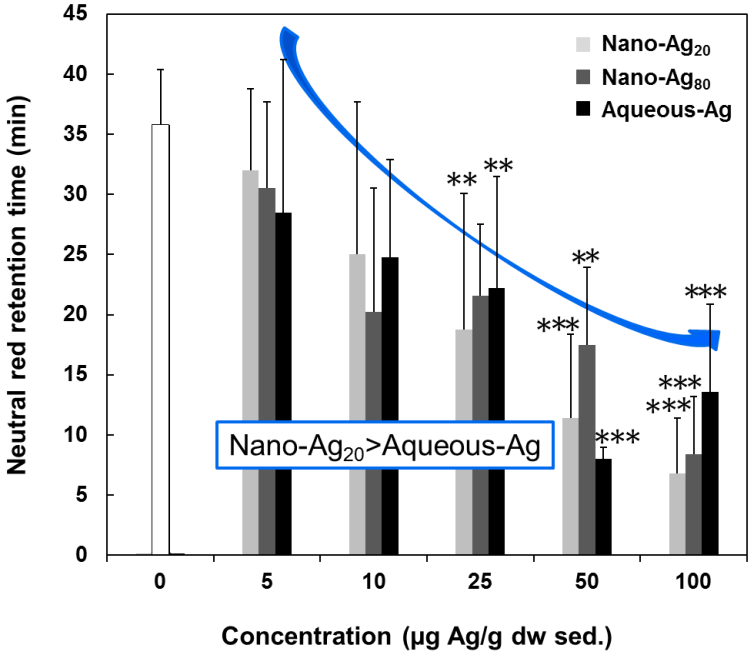


Aqueous, spheres, & spindles significantly taken up, but not rods.

From: Ramskov, et al. in preparation.

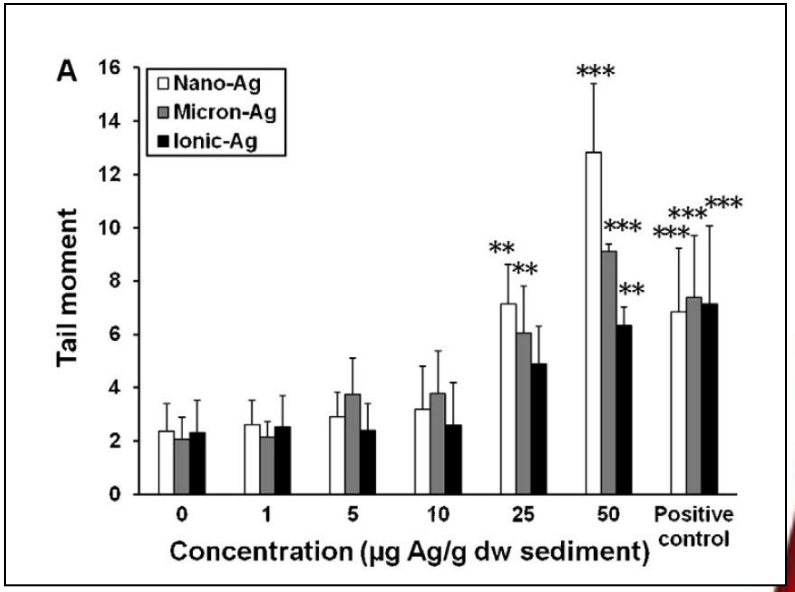
Evidence for sub-organismal effects

Lysosome stability



**p<0.01
***p<0.001

DNA damage

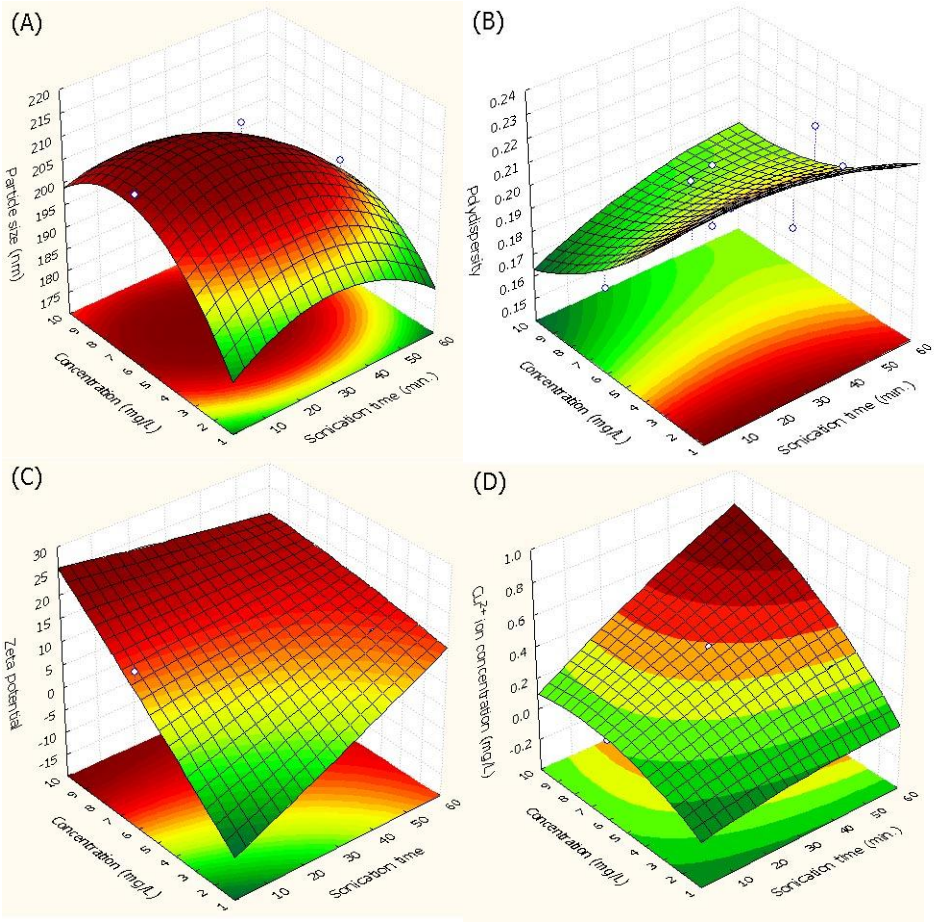


But the meaning of such responses for ecological risk of NPs is not at all clear!

Where to go from here?

- Current studies aimed at
  - developing more predictive models of how water quality parameters (pH, hardness, DOM) affect NP behavior
  - Determining whether such models can predict uptake and toxicity of NPs in intact organisms
    - from water and from sediment
  - Measure/model bioaccumulation and toxicity at environmentally realistic concentrations using stable isotopes (with SN Luoma & M Croteau – USGS)

Ongoing work at UNL (Son et al. in prep)



Response surface model for the response variables (particle size (A), polidispersity (B), zeta potential (C) and Cu ion concentration (D)) as functions of sonication time and CuO NPs stock concentration.

Progress to date

- **Methods of stock solution preparation seem to matter – a lot for certain NPs (i.e., Ag).**
- **Very subtle experiment-to-experiment differences in sonication conditions, timing of measurements, and other difficult-to-identify variables limit reproducibility.**
- **For sediments – we are working in a black box.**
  - **Need realistic exposure estimates.**
  - **Need better methods to track and characterize NPs in sediments.**

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