TiO_2 and Ag Nanoparticles in a River Environment

Transformation in the organism and in the environment:

What do we measure and how do we develop testing strategies to measure impacts of transformed particles in the environment

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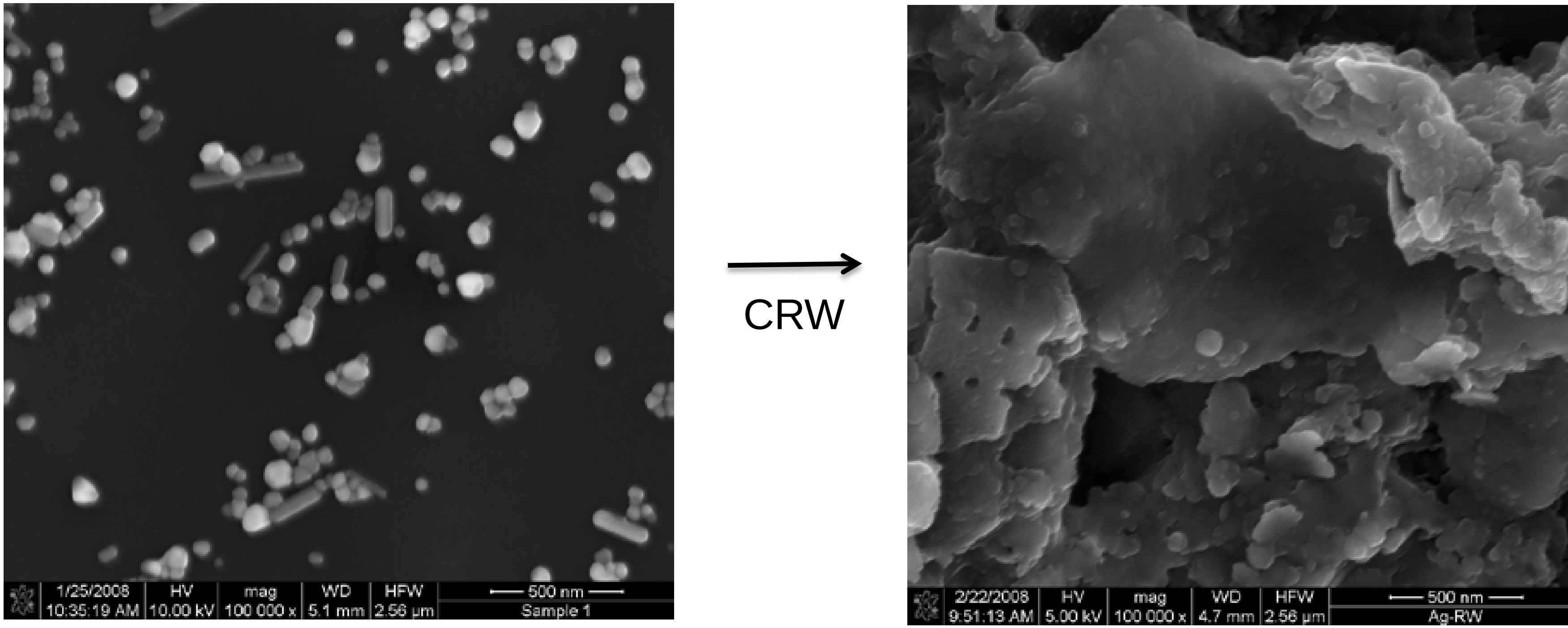
Understand the transformation of nanomaterials under different environmental conditions

- Titania and Silver nanoparticles in a simulated river/sediment system
  - Columbia River water (TSS= 7 mg/L; pH=7.65; hardness=77 mg/L as $CaCO_3$)
  - Sand sediments

- Titania and Silver citrate in static cells and flow through river mesocosms
  - Microbial community changes (static only)
  - Uptake by clams and amphipods
  - Deposition on sediments
  - Aggregation in flowing water

Silver Citrate Materials



30 – 200 nm for spheres

80 – 400 nm x 30 – 50 nm for rods

Microbial Community Silver Exposures

Static Exposure Study

ü Homogenized sediment from surface water mesocosm

ü Exposures (1, 4 and 14 d):

Doses in CRW (detection limit 3 ng/L):

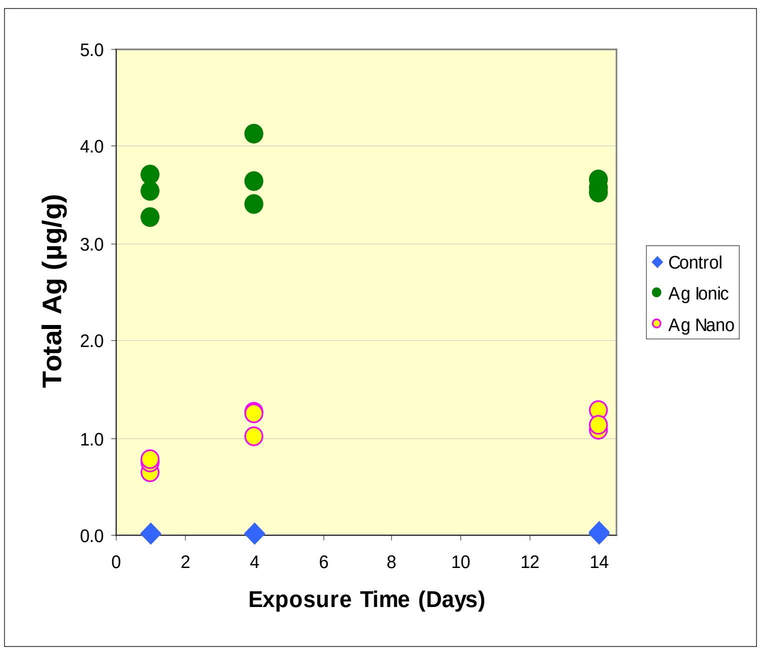
1 ug/g Ag nano

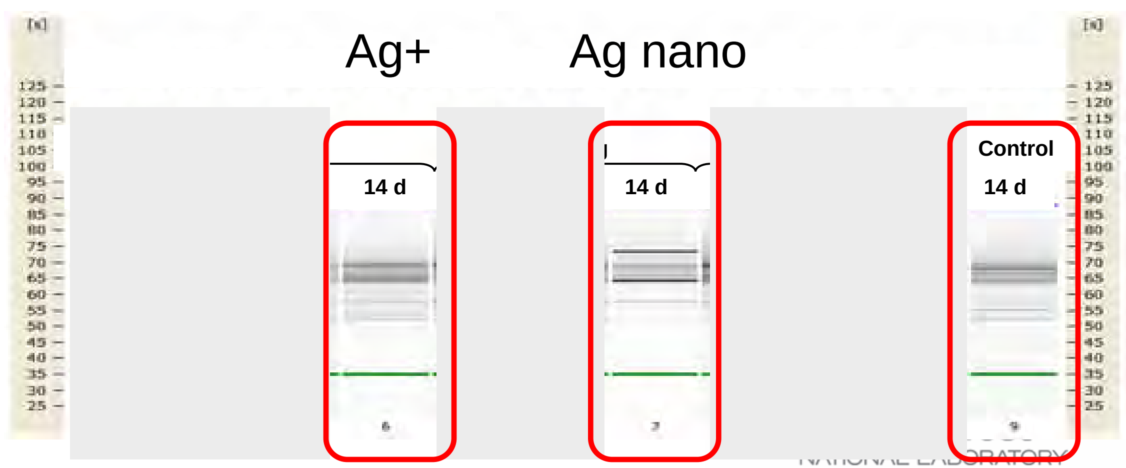
4 ug/g Ag+

Controls

•Shift in dominant microbial species at 14 days

•Ag nano had greater community shift than Ag+

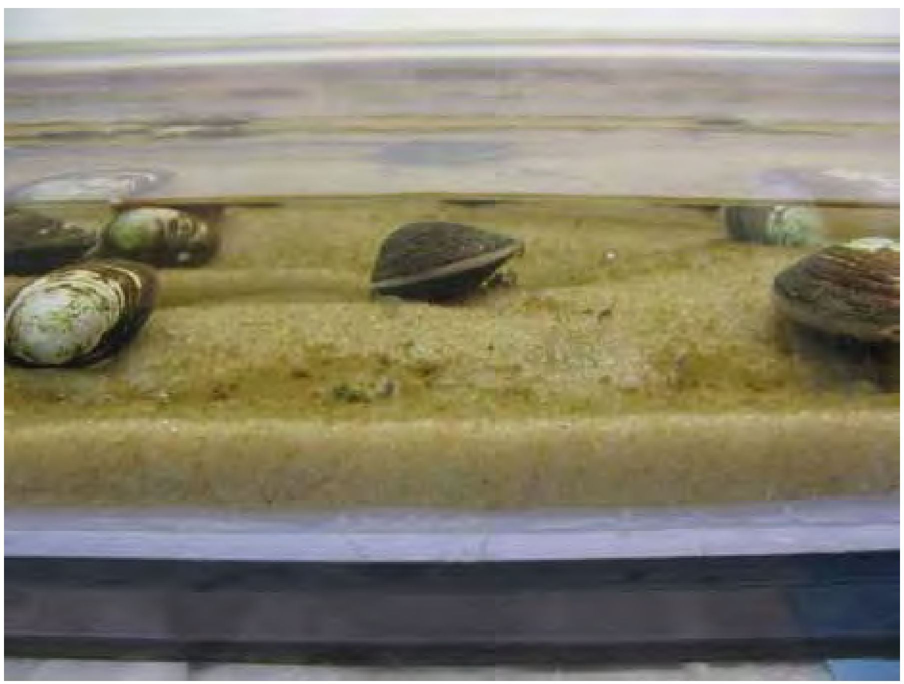




Silver Mesocosm Exposure

24 hr exposure, 24 hr depuration
- Columbia River water (CRW)
- Clams
- Amphipods
- Microbial community in sand sediments

Control,1 µg/L, 10 µg/L, 50 µg/L

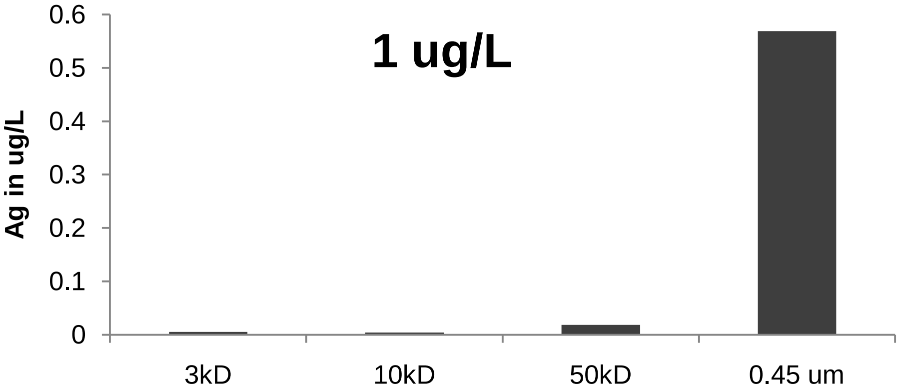


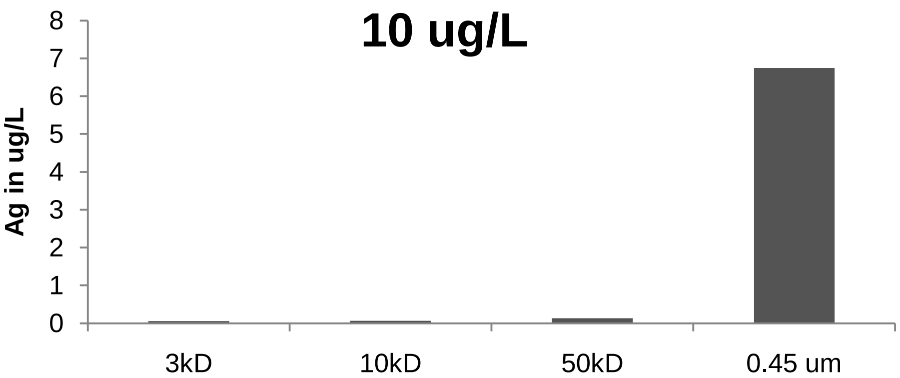
Ag particle size in CRW

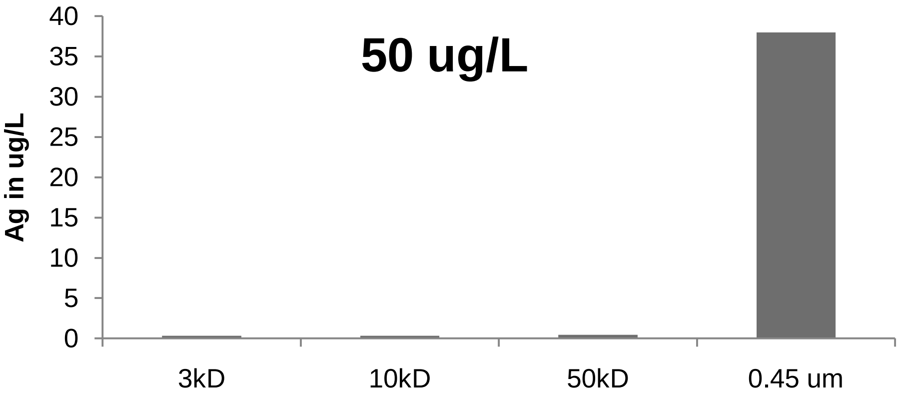
- Low concentrations of dosed Ag nanoparticles fractionated to larger particle sizes

- Degree of fractionation occurs over 24 hours

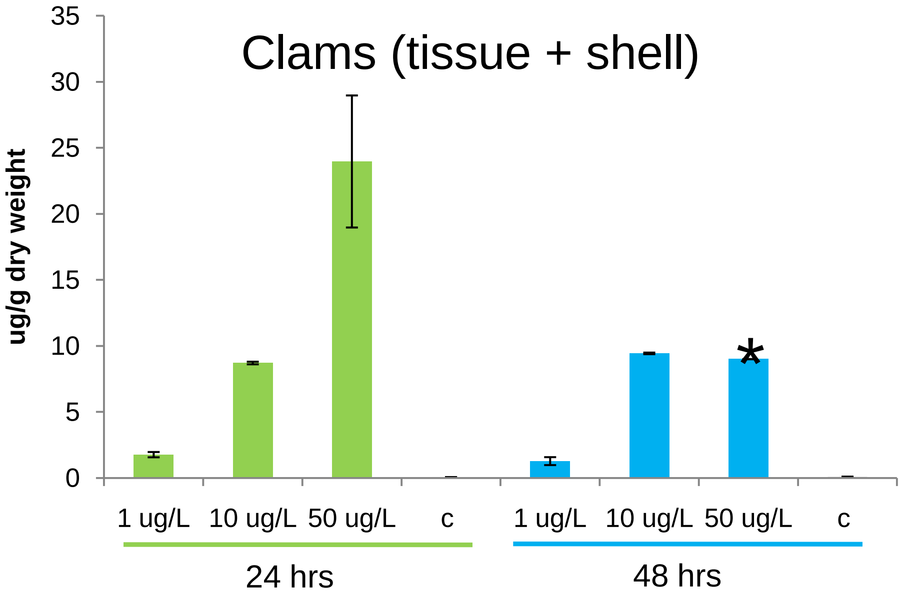
- Prior studies show dissolved fractions at doses > 100 ug/L

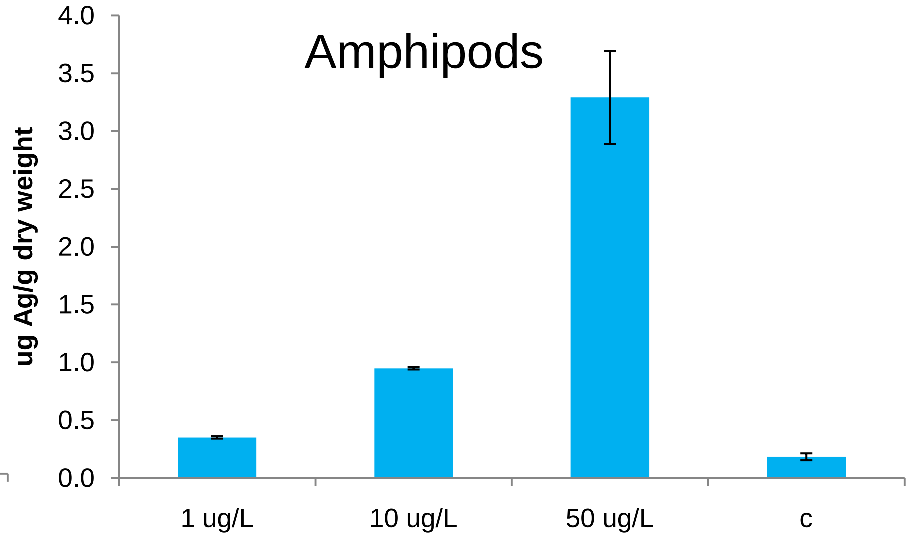


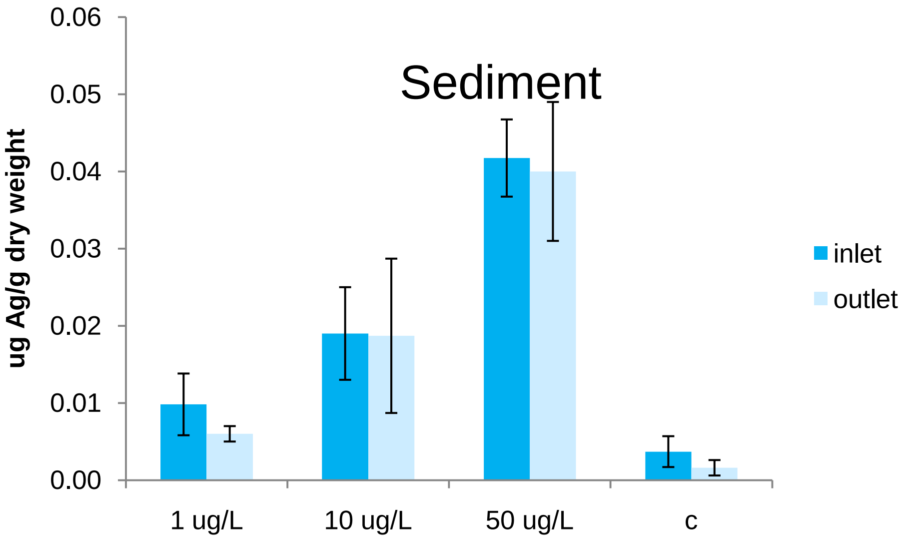


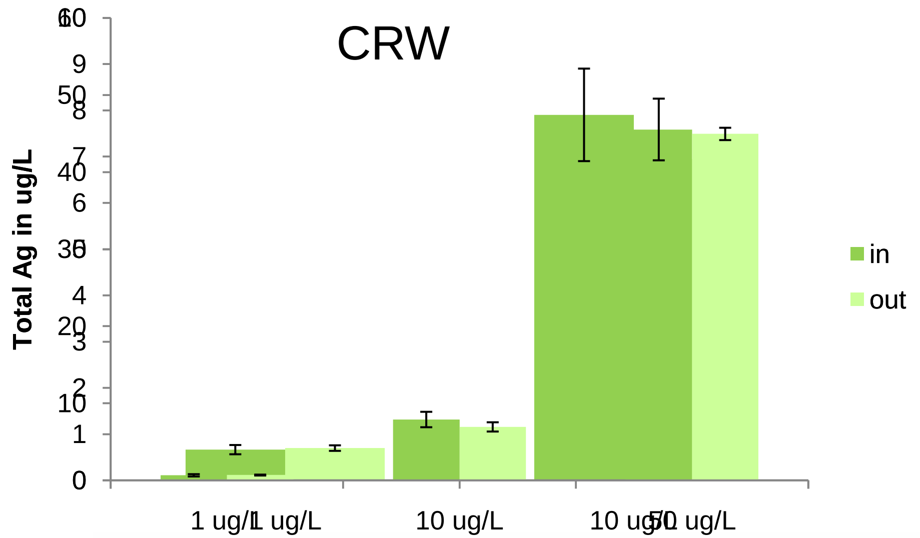


Accumulation of Silver

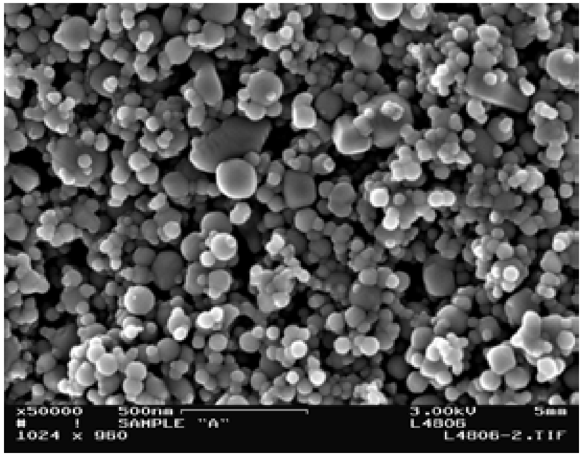






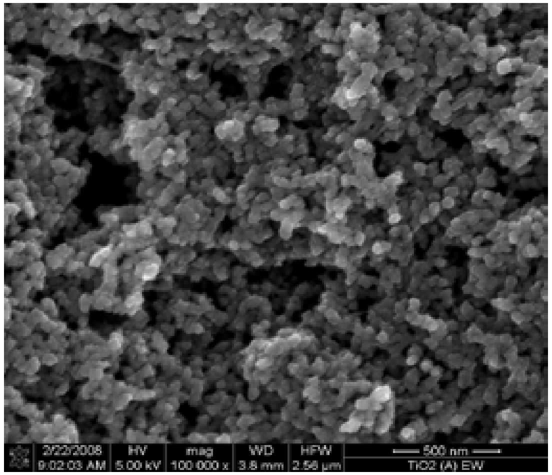


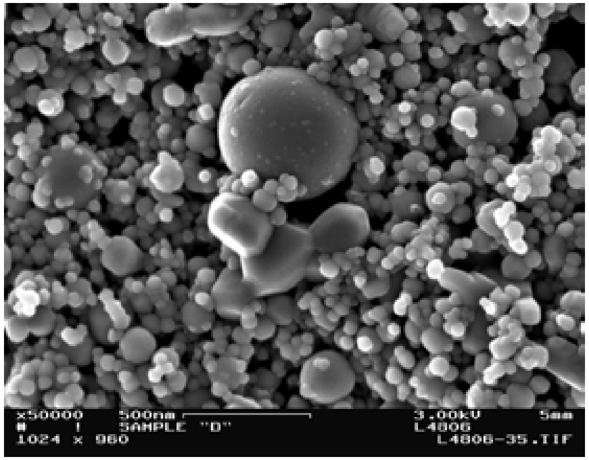
Titanium Oxide Materials



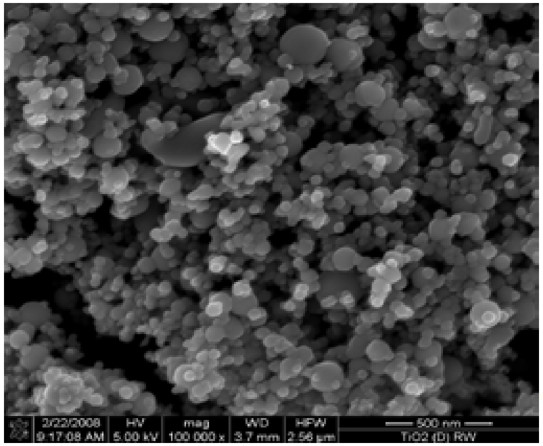
5-30 nm anatase

CRW





CRW



<75 nm rutile/anatase

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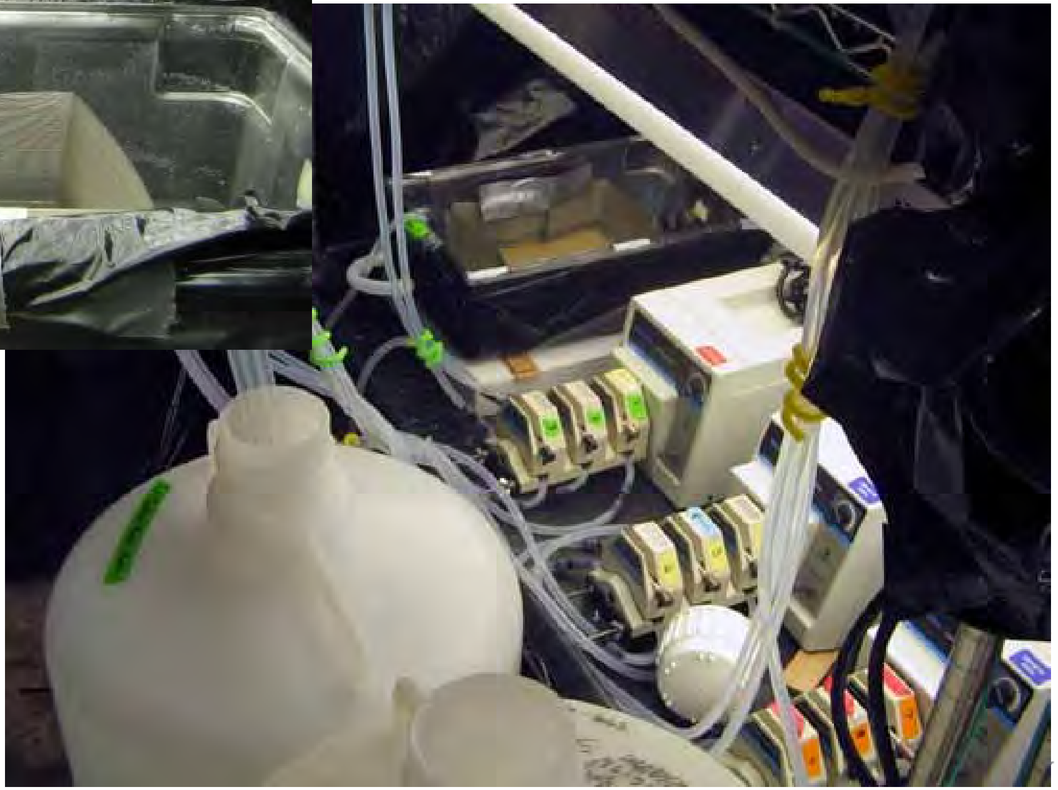
Titania Mesocosm Exposures

-5 mg/L over 12 hour flow-through
-36 hr flow-through depuration



Titania exposures

Variable	TiO_2 (mg/g dry weight) or % total dose (5 mg/L)		
	Flow - Through		**Static***
	A	A/R	A
amphipods	**47.9**	**64.8**	**2.1**
clams	**0.55**	**1.04**	**0.03**
sediment	**66%**	**13%**	**34%**

Clam : Amphipod uptake ratio ~1:70

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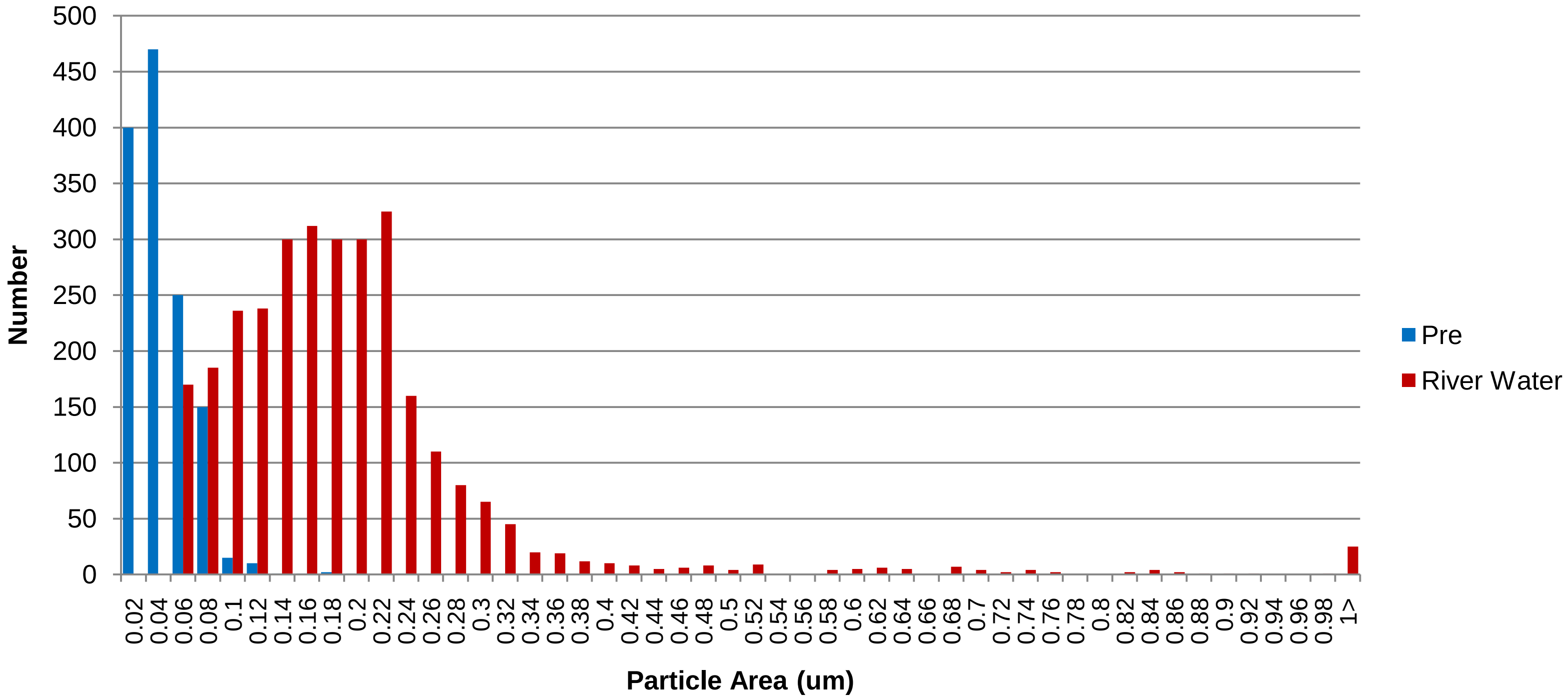
TiO_2 Size Distribution from SEM



- Mean equivalent diameter*
  - Distilled Water – 30 nm
  - CRW – 200 nm

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Two Materials – One Exposure Scenario
Abiotic and Ecosystem-Wide Effects

- NP size affected by environmental characteristics

- Specific properties of NP material may affect bioaccumulation and downstream ecosystem impacts
  - Silver uptake higher in clams; stays in water column
  - Titania uptake higher in amphipods; settling out greater

- Acute toxicity not observed in Columbia River water

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Research Gaps Remain

- NP toxicity/effect may be different in a complex environmental setting compared with single variable/static lab exposures

- Chronic (long-term) studies under complex environmental conditions need to be matched with ability to measure and characterize NPs in complex environmental samples
  - absorption, distribution, metabolism, excretion
  - recycled NPs
  - route(s) of exposure – absorption, dietary

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Case Study

- Seeing changes that reflect ecosystem scale disturbance
  - Birds, fish dead
  - Deformed frogs
  - Selective flora die-offs
- Relevance of materials in complex matrix
  - New paradigm vs. a standard tier-testing approach?
  - Choice of organisms for toxicity endpoints
  - Transformation of materials in complex media

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