



Source: Clemson University

Nano-Ecotoxicology – Assessment of Potential Effects of Engineered Nanomaterials in the Environment

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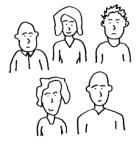
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Toxicology

... is a branch of biology, chemistry, and medicine studying adverse effects of **chemicals** on living organisms.

(Human)Toxicology

Ecotoxicology



human beings





all other organisms, populations and ecosystems





Fundamentals

EFFECT

- Organisms (Algae, fish, water flea...)
- Endpoints (growth, survival, mobility, reproduction,...)

EXPOSURE

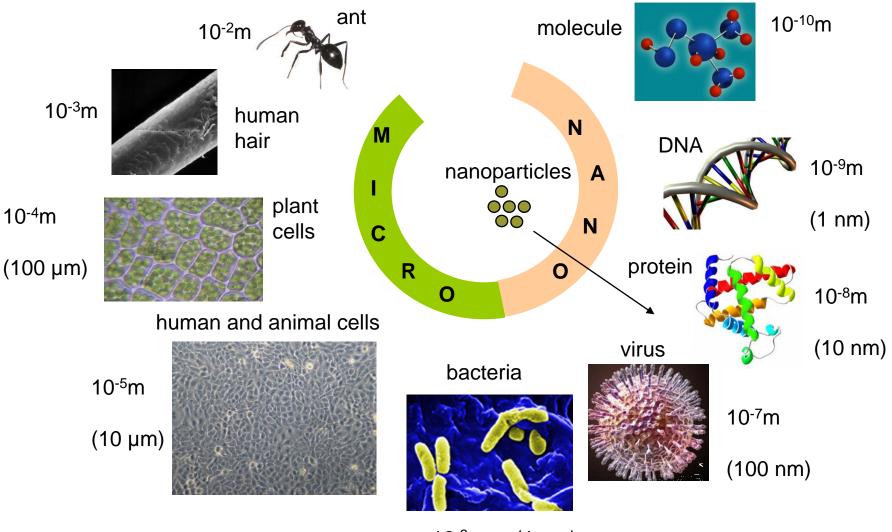
- Dose
- Distribution
- Bioavailability
- Fate

RISK

Degradation

- Probability
 - **Protection/Management**
- **Cost-benefit**

Biological size scale



10⁻⁶m (1 µm)

Relevant properties of nanomaterials for testing of nanomaterials

Properties

Reactivity

Sorption

Size / Shape

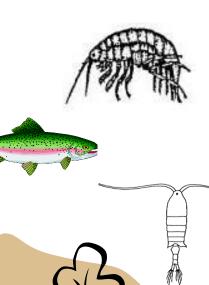
Solubility

Aggregation / Agglomeration

Coating

Others

Organisms in the Environment



Effects

Reactive oxygen species (ROS)

Carrier of toxic substances

Dissolved compounds (Me²⁺)

Bioaccumulation

Molecular interaction

Indirect effects

Others

Nanomaterials for Groundwater Decontamination

Injection of

In-situ Generation of an Reactive Barrier by Injection and Sedimentation of Small Particles

reactive particles Sedimentation and formation of reaction barrier

Groundwater Flow



Carbo-Iron ®



Activated Carbon + Fe⁰

 $RCI + 2e^{-} + H^{+}$

 $R-H + CI^{-}$

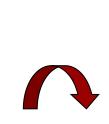
In the lab...

Chemical / Nanomaterials

Add to test media (e.g. water, soil)

Exposure of organisms











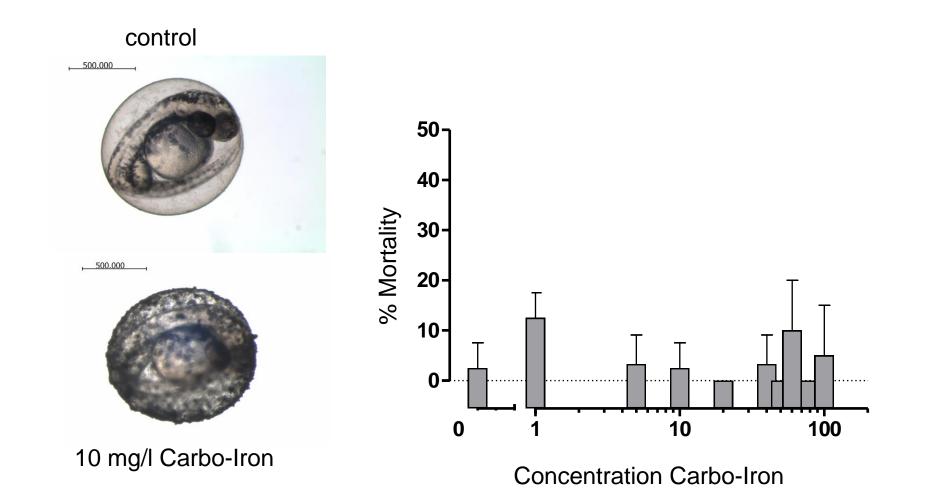


Acute / chronic



Effect / Observation / Measurement of endpoints

NMs for Groundwater Decontamination



No particle uptake into tissue, no toxic effects on organisms

Nanoparticles can reach different organs





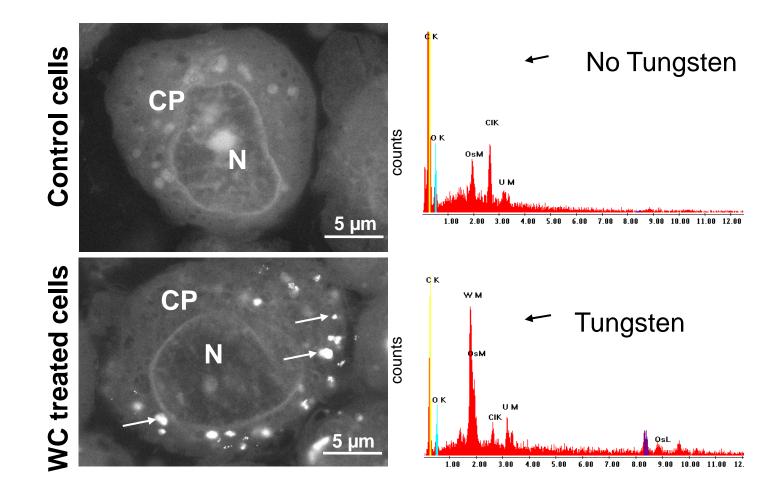
See-through medaka (*Oryzias latipes*) Uptake of fluorescent polystyrene particles (40 nm)

Distribution of particles after 7 days:

Organs (no.)	Control ^a (mean ± SE)	Exposure ^a (mean ± SE)
Brain (16)	28.2 ± 5.6	57.1 ± 8.7
Gills (16)	28.3 ± 4.2	113 ± 10
Liver (16)	48.7 ± 6.2	93.9 ± 19
Kidney (16)	62.6 ±14	103 ± 16
Gallbladder (16)	183 ± 30	246 ± 3.1
Intestine (16)	25.8 ± 3.7	147 ± 20
Spleen	NM	NM
Lungs	NA	NA
Testis (8)	47.1 ±18	112 ± 15
Ovary (8)	118 ± 67	129 ± 36

Kashiwada (2006) EHP 114 (11): 1697-1702

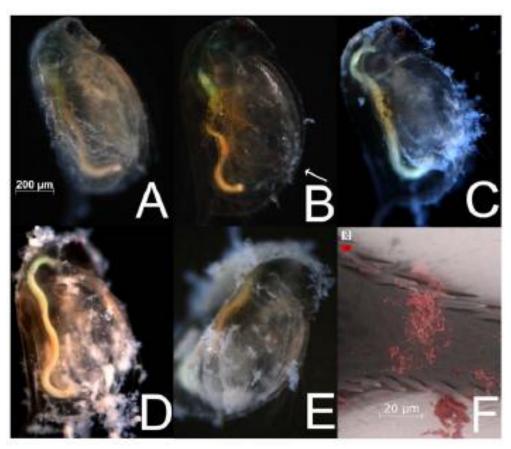
Nanoparticle uptake into cells



Exposure occurs, effect?

Kühnel et al. 2009 Aquatic Toxicology 93 (2009) 91-99.

Effect on molting and reproduction – daphnids exposed to TiO₂

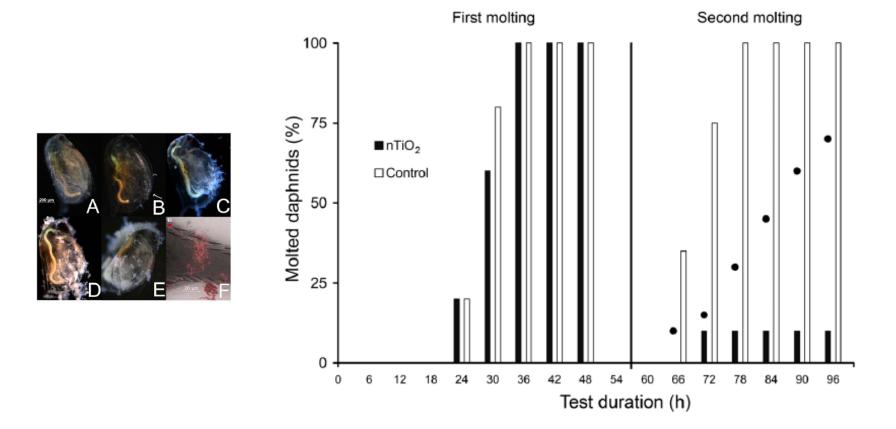


Particles adhere to exoskeleton Particles present in the gut

No effect on mobility and molt after 48 h

Dabrunz et al. (2011) PLoS ONE, 6, e20112.

Effect on molting and reproduction – daphnids exposed to TiO₂

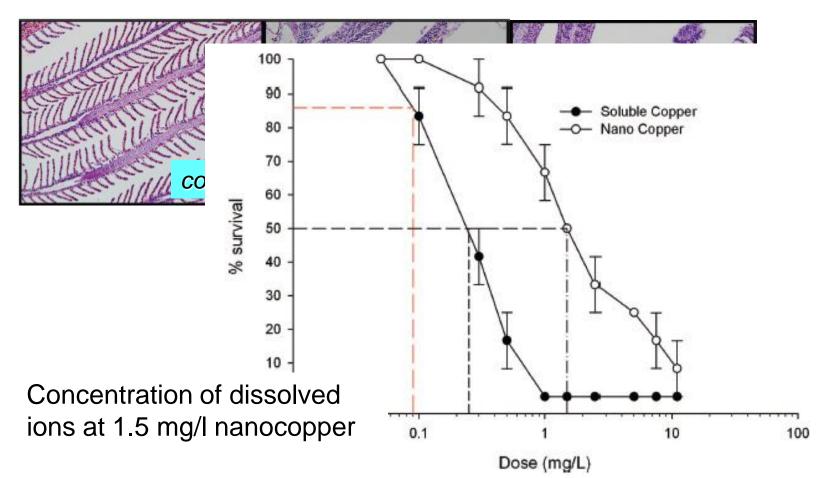


Indirect and mechanical effects

Dabrunz et al. (2011) PLoS ONE, 6, e20112.

Effects of dissolved ions?



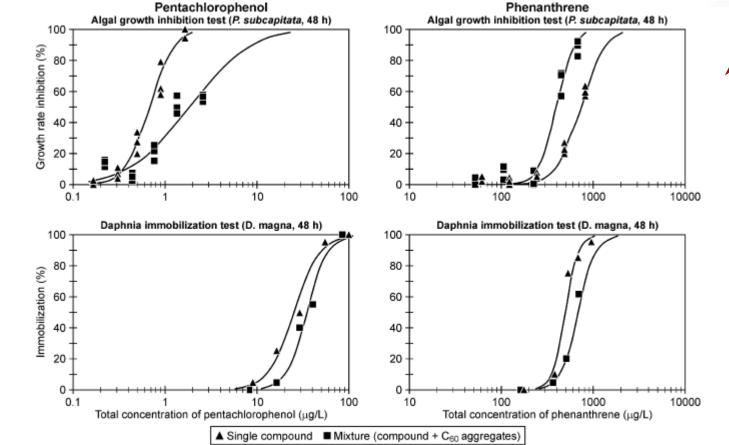


Griffitt et al. (2009) Environ. Sci. & Technol. 41: 8178-8186.



Particles as carrier

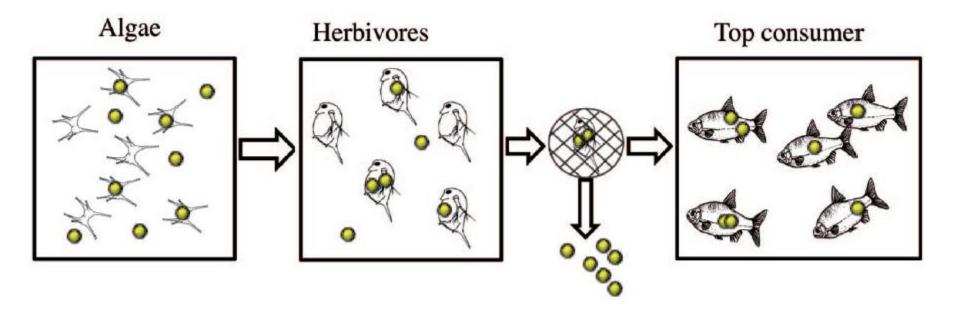




Particles can carry toxicants (Trojan horse effect)

Baun et al. (2008) Auqatic Toxicology, 86, 379-387.

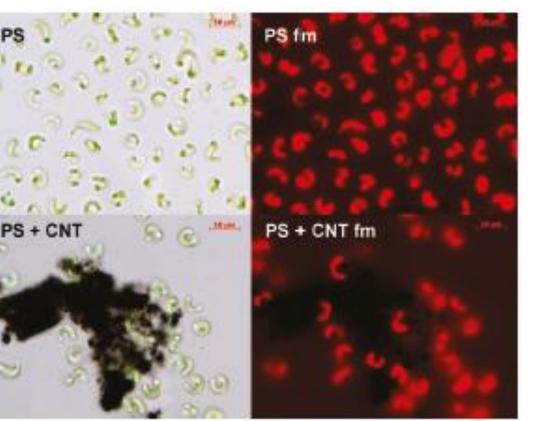
Food chain transport

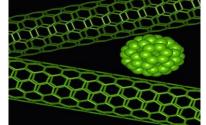


Polystyrene Nanoparticles Affect Behaviour and Fat Metabolism in Fish

Cedervall T et al. (2012) *PLoS ONE*, 7, e32254.

Green algae exposed to CNT





Growth inhibition as an effect of shading, interference of NM with test system

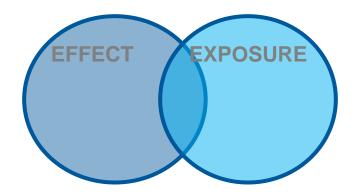
Schwab et al. (2011) ES&T, 45, 6136-6144.

Summary – Exposure

- Uptake into animals, tissues and cells
- Environmental exposure with some ENM shown

Summary – Effects

- Nanomaterials have effects
- Mechanical effects
- Indirect effects
- Dissolution of ions
- Carrier of substances
- Food chain effects



Conclusions – Implications for future testing

- Knowledge on physical-chemical properties
- Suitability of standard tests (duration, application, exposure conditions, shading), realistic exposure scenarios
- Long term tests, mixtures (NM+NM, NM+Chemical)
- Environmental concentrations needed, suitable methods
- More knowledge on behaviour and fate in the environment (e.g. degradation)

Thank you for you attention!

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HOME PROJECTS	KNOWLEDGE BASE	GLO	DSSARY	FAQ	DIA	LOGUE	
 Materials Aluminium oxides Barium sulphate Carbon Black 	Knowledgebase Nanom Knowledge		ise			la fa ma ati a a	Your questions to our experts Knowledge Base
 Carbon Nanotubes Cellulose Cerium dioxide Diamond Fullerenes Gold Iron and iron oxides ITO Platinum Quantum dots Silicon dioxide 	Application Lacquer and plastic additive Suncream Textiles Abrasive and polishin agents Anti-fogging agents Black pigments	m	Indium tin Iron and i Platinum	carbide-	• •	Information Exposure - Human Exposure - Environment Uptake - Skin Uptake - Environment Behaviour - Human Behaviour - Environment	Nanomaterials DaNa Flyer for download → English Version → Japanese Version → Company of the second seco
 <u>Silver</u> <u>Strontium carbonate</u> <u>Titanium dioxide</u> 	Brief Information Our database contains information about products and applications with nanomaterials.						
 <u>Titanium nitride</u> <u>Tungsten carbide</u> <u>Tungsten carbide-Cobalt</u> <u>Zeolite</u> 	Navigation						Health-related Aspects of Synthetic Nanomaterials The NanoCare Brochure for download:
 Zinc oxide Zirconium dioxide 	Please take a choice from "application" and you get the corresponding "material" with brief information about exposure, uptake and behaviour.						
 Basics <u>Overview</u> <u>Exposure</u> 	Please select a material and you will get information about its behaviour in the body and in the environment. The corresponding applications are highlighted in red.						
Uptake	You can get detailed information by following the link "For more information, click here".						

What are the concentrations in the environment?

Exposure Modelling



Predicted Environmental Concentrations

Predictions are based on:

- production volumes
- categories of products containing nanomaterials
- paths of particle release

		nano-Ag		nano	-TiO ₂	CNT	
	<u>unit</u>	Real.	High	Real.	High	Real.	<u>High</u>
Air	µg m ⁻³	0.0017	0.0044	0.0015	0.042	0.0015	0.0023
Water	µg L⁻¹	0.03	0.08	0.7	16	0.0005	0.0008
Soil	µg kg⁻¹	0.02	0.1	0.4	4.8	0.01	0.02
		Mueller and Nowack (2008) Environ. Sci. Technol. 42: 4447-4453					4447-4453

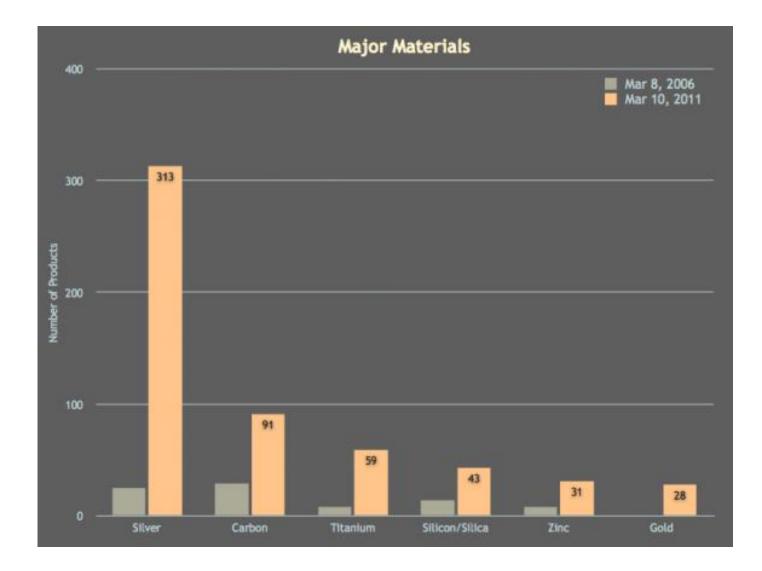
Risk assessment

Risk Quotients (PEC/PNEC) for all ENM and Regions nano TiO2

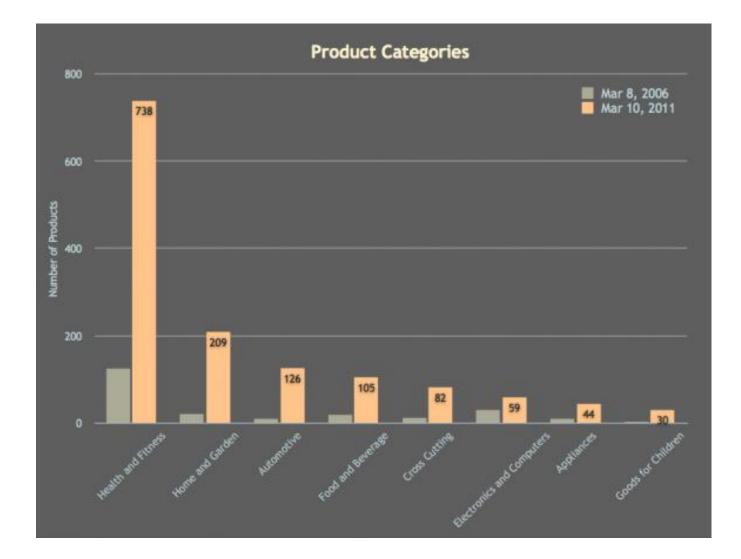
compartment	Europe	U.S.	Switzerland
surface water	0.015	0.002	0.02
STP effluent	3.5	1.8	4.3
air	<0.0005	<0.0005	<0.0005
soil	0.004	0.002	0.001
sludge treated soi	0.3	0.14	

predicted no effect concentration (PNEC) Predicted environmental concentrations (PEC) sewage treatment plant (STP)

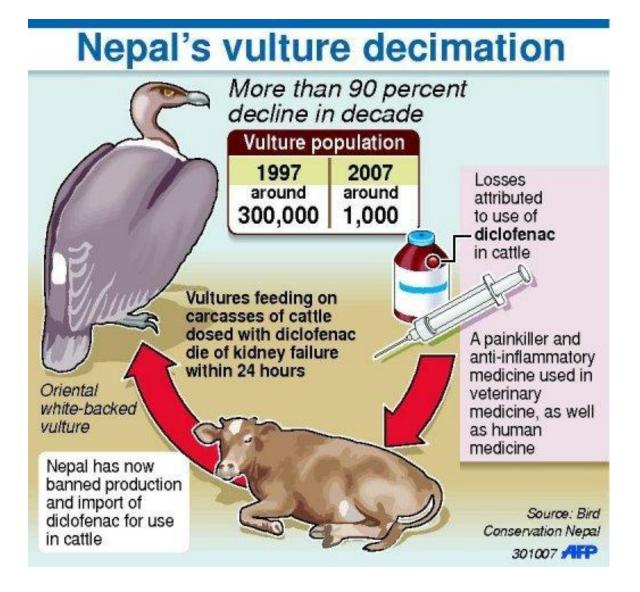
www.nanoproject.org



www.nanoproject.org



Example: Diclophenac



Chemicals and REACh

283,382 (~ 0.5%) listed or regulated

CAS Registry, as of 10 Oct 2011

63,203,091 organic and inorganic substances recorded

53,773,985

commercially available

Registration, Evaluation, Authorisation and Restriction of Chemical substances.

Nanoparticles are not yet considered within REACh!

But might be implemented in the future.