

Contents in Context

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Manufactured nanoparticles in the environment

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Nanotechnology is a very important industry which may be socially transformative, but produces nanomaterials (NMs) which have a potential but poorly characterised risk to the environment. This Research Front describes new research investigating NM environmental chemistry, particularly in relation to ecotoxicology. This Research Front shows some of the most exciting research undertaken currently and fits within a dynamic research program, which is global in scope and which attempts to unravel these complex areas.

Bacteria–nanoparticle interactions and their environmental implications

Deborah M. Aruguete and Michael F. Hochella Jr.

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The advent of nanotechnology means that the release of nanomaterials into the environment is very likely, if not inevitable, and knowing the environmental impact of such nanomaterials is important. A key aspect of understanding this impact is to learn how nanomaterials affect microorganisms, a critical part of the environment; this topic is addressed in this review, which specifically concerns nanoparticle–bacteria interactions. Current studies show that nanoparticles have the potential to impact bacterial viability, although a great deal remains to be understood concerning nanoparticle–bacteria interactions.

Assessing the colloidal properties of engineered nanoparticles in water: case studies from fullerene

C₆₀ nanoparticles and carbon nanotubes

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The fate and bioavailability of engineered nanoparticles in natural aquatic systems are strongly influenced by their ability to remain dispersed in water. Consequently, understanding the colloidal properties of engineered nanoparticles through rigorous characterisation of physicochemical properties and measurements of particle stability will allow for a more accurate prediction of their environmental, health, and safety effects in aquatic systems. This review highlights some important techniques suitable for the assessment of the colloidal properties of engineered nanoparticles and discusses some recent findings obtained by using these techniques on two popular carbon-based nanoparticles, fullerene C₆₀ and multi-walled carbon nanotubes.

Interaction of CdSe/CdS core-shell quantum dots and *Pseudomonas aeruginosa*

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The growing use of nanotechnology means that nanomaterials are likely to be released into the environment, and their impact upon microbes, which form the biological foundation of all ecosystems, remains unclear. To understand how nanomaterials might affect bacteria in the environment, the interactions between a commercially-relevant quantum dot and a common soil and water bacterium was investigated. In this case, it was found that these quantum dots are non-toxic to these bacteria, and also that these bacteria do not cause degradation of the quantum dots. This study also has implications related to the environmental fate of quantum dots.

Assessment of cultured fish hepatocytes for studying cellular uptake and (eco)toxicity of nanoparticles

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The production and application of engineered nanoparticles is rapidly increasing, and development of suitable models for screening nanoparticles for possible toxic effects is essential to protect aquatic organisms and support the sustainable development of the nanotechnology industry. Here, the suitability of isolated rainbow trout hepatocytes was assessed for high through-put toxicity screening of nanoparticles and for studying uptake of nanoparticles into cells.

Physico-chemical behaviour and algal toxicity of nanoparticulate CeO₂ in freshwater

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It cannot be assumed that nanomaterials entering aquatic environments will have the same impacts on aquatic biota as their macroscopic particle equivalents. If their toxicities are different, this will have implications for the way in which nanomaterial usage is regulated. Algae, at the bottom of the food chain, are likely to be a sensitive indicator of toxic effects. Understanding the physical and chemical factors controlling nanoparticle toxicity to algae will assist in evaluating their ecological risk.

Aggregation of titanium dioxide nanoparticles: role of calcium and phosphate

Rute F. Domingos, Caroline Peyrot and Kevin J. Wilkinson

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The increasing use of nanomaterials in consumer products has led to increased concerns about their potential environmental and health impacts. TiO₂ is a widely used nanoparticle found in sunscreens and electronic products. In order to understand and predict the mobility of TiO₂ in the natural environment, it is essential to determine its state of aggregation under environmentally relevant conditions of pH, ionic strength, ion and natural organic matter content. Aggregation is likely to lead to both reduced mobility and bioavailability in soils and natural waters.

Measurements of nanoparticle number concentrations and size distributions in contrasting aquatic environments using nanoparticle tracking analysis

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Manufactured and unintentionally produced nanoparticles have been of environmental concern owing to potential harm to humans and ecosystems, but very little is known of the actual concentrations of these owing to limitations of available methods. In order to understand both the potential adverse effects and the underlying natural processes, improved measurement techniques are needed. Here, we explore the feasibility of a novel minimum perturbation method that relates the diffusive movement of nanoparticles in a light field to their size distributions.

Using FIFFF and aTEM to determine trace metal–nanoparticle associations in riverbed sediment

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Determining associations between trace metals and nanoparticles in contaminated systems is important in order to make decisions regarding remediation. This study analysed contaminated sediment from the Clark Fork River Superfund Site and discovered that in the <1-μm fraction the trace metals were almost exclusively associated with nanoparticulate Fe and Ti oxides. This information is relevant because nanoparticles are often more reactive and show altered properties compared with their bulk equivalents, therefore affecting metal toxicity and bioavailability.

Roles of dissolved organic matter in the speciation of mercury and methylmercury in a contaminated ecosystem in Oak Ridge, Tennessee

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Mercury (Hg) presents an environmental concern owing to its transformation to the potent neurotoxin methylmercury (CH₃Hg⁺). The environmental factors that control bacterial methylation of mercury are poorly understood, but we know that methylmercury is bioaccumulated and biomagnified in aquatic food webs. We show that, even at low concentrations (~3 mg L⁻¹), natural dissolved organic matter strongly complexes with ionic Hg²⁺ and CH₃Hg⁺, thereby influencing biological uptake, and methylation of Hg in aquatic environments.

Effect of ash from forest fires on phosphorus availability, transport, chemical forms, and content in volcanic soils

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Intensive fertilisation and the availability of phosphorus species (less than 10%) in cultivable soils of volcanic origin are causing the accumulation of P in these soils. Phosphorus is a macronutrient that severely limits good agricultural development, so knowledge of the distribution and the different forms of P present in soils is fundamental for sustainable agricultural practice. This novel study reports the existence of increased available P in all the soils that received a load of plant ash from different tree species.

Phase II pharmaceutical metabolites acetaminophen glucuronide and acetaminophen sulfate in wastewater

Manjula Sunkara and Martha J. M. Wells

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Excretion of pharmaceuticals and their metabolites by humans and animals, flushing unused pharmaceuticals and inadequate water treatment result in the occurrence of these chemicals as pollutants in wastewater, surface water and drinking water. In this research, the pharmaceutical agent acetaminophen (paracetamol, Tylenol) and its glucuronide and sulfate metabolites were examined as a model system for monitoring wastewater influent and effluent. The true risk to ecosystems and humans from the occurrence of pharmaceuticals in our water supply can only be estimated if accurate concentrations of parent pharmaceutical chemicals as well as their metabolites are measured.

In-situ sampling of soil pore water: evaluation of linear-type microdialysis probes and suction cups at varied moisture contents

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There is a need for slightly invasive techniques capable of in-situ probing of target analytes in environmental compartments. Owing to its passive sampling mode and small probe dimensions, microdialysis-based dosimetry is an appealing tool for monitoring of solute concentrations in both water bodies and pore soil waters with minimum disturbance of natural equilibrium. The development of field applications is challenging but will provide novel insights as to the speciation and bioaccessibility of environmental pollutants, e.g. trace metals, at high spatial resolution.