Why is nanoparticulate CeO_2 toxic to aquatic algae ?

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The growing use of manufactured nanomaterials in consumer products is raising questions as to whether nanosized materials should be regulated differently to macroscopic forms of the same compounds in terms of the risks they pose both to human and ecosystem health. Nanoparticulate CeO_2 has wide potential usage, particularly as an additive to diesel fuels where it improves the combustion efficiency of engine carbon deposits, reducing particulate emissions and improving fuel efficiency.

In this study, the toxicity of nanoparticulate CeO_2 (nominally 10 - 20 nm) to the freshwater alga *Pseudokirchneriella subcapitata* was investigated. Growth inhibition experiments revealed that the nanoparticulate form was significantly more toxic than micron sized CeO_2 with 72-h IC50 values of 10.3 ± 1.7 and 66 ± 22 mg/L for the nanoparticles and bulk materials respectively. The IC50 for dissolved cerium (III) was 0.63 mg/L.

Solubility measurements showed that the dissolved cerium concentration in algal growth medium was very low (< 3 μg/L) indicating that dissolved cerium was not responsible for the observed toxicity. Algal cells exposed to CeO_2 particles were permeable to the DNA-binding dye SYTOX® Green in a concentration-dependent manner. The effect was observed for both the nanoparticulate and bulk forms of CeO_2. These data indicate that damage to the cell membrane contributes to the toxic mechanism of action of the particles.

Screening assays to assess the oxidative activity of the particles showed that the light illumination conditions used during standard algal bioassays are sufficient to stimulate photocatalytic activity of CeO_2 particles, causing the generation of hydroxyl radicals and peroxidation of a model plant fatty acid. No oxidative activity or lipid peroxidation was observed in the dark. Subsequent experiments investigated the role of free radical production in toxicity. These experiments indicated that algal growth inhibition is most likely caused by unidentified cell-particle interactions which cause membrane damage rather than free radical damage.

Salinity increase with depth in fractured aquifers

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Fractured aquifers constitute an interesting water resource. Due to anthropogenic activities, the upper part of these aquifers [0-30 m] is often highly polluted. (nitrate concentrations above 50 mgL^{-1} in French Brittany). However, the deeper part of these aquifers [30-150 m] may constitute an alternative for water exploitation and present unpolluted water due to long residence times.

We investigated a site exploited for drinking water at a depth of 100 m. A clear reactivity has developed close to the pumping well, pumping inducing autotrophic denitrification reactions with pyrite. The site also presents higher salinities than surface waters with Cl concentrations ranging from 50 to 100 mgL^{-1}. Salinity increases with depth and also increases with time in the abstraction well in relation to pumping. Temperature anomalies indicate that the more saline waters originate from at least 300 m depth.

Chemical (major, traces, Br/Cl ratios) and isotopic analyses (O, D, Sr, B) indicate that the saline waters present a marine signature. Noble gases present an argon enrichment which indicates either an argon production or a recharge temperature of 5°C which would require a large regional recharge following the last glacial maximum.

This example indicates that French Brittany may present saline waters at shallow depth and require a coupled investigation of biogeochemical and mixing processes.