Discovering how nanoparticles affect the environment

**Although nanotechnology remains** at an early stage of development, engineered nanoparticles are already interacting with fungi, bacteria and algae in natural ecosystems. A recent paper identifies gaps in our knowledge about this interaction which require intensive attention.

**Engineered nanoparticles (ENPs)** are of a more regular shape and composition than those formed naturally (e.g. by volcanoes) or by combustion engines, the main source of atmospheric nanoparticles. Annual production of ENPs is expected to reach one hundred thousand tonnes and be worth more than $1 trillion (about EUR 800 billion) within 5 years. Despite this rapid proliferation, the study indicates five key properties of ENPs which remain unknown:

- **At which concentrations do ENPs become problematic in terrestrial, aquatic and atmospheric environments?** Environmental nanoparticle quantities and concentrations are unknown, as are the concentrations at which ENPs actually become toxic to organisms.
- **Which physical and chemical characteristics of ENPs determine their behaviour?** The high surface area to volume ratio of ENPs increases their reactivity and chances of binding to other molecules or ENPs, but their behaviour will change according to their surroundings. For some uses, ENPs are treated to prevent them from clustering with other particles, which can cause them to settle in sediments and reduce their availability to organisms. However, some ENPs are deliberately treated to maintain their separated status, for example, in uses such as environmental remediation of water or land.
- **How do ENPs enter cells?** Some small molecules can pass through the cell walls of fungi, algae and bacteria. Airborne ENPs can accumulate on leaves, where they may be able to penetrate cells. Experiments have revealed that fungi can incorporate ENPs from soil, via their roots.
- **Which properties of ENPs cause toxic effects?** The increased reactivity of ENPs may affect photosynthesis and respiration. Studies have revealed relationships between high concentrations of some ENPs and reduced plant growth, or increased permeability of bacterial cells. Indirect toxic effects due to ENP accumulations include increased cell weight (affecting algae’s ability to float) and reduced fertility of seaweeds. They may also prevent photosynthesis by reducing nutrient absorption. The toxicity of other pollutants may also be affected.
- **Do ENPs accumulate in the food chain?** ENPs have been observed to remain within bacterial cells for long periods and so may accumulate in larger organisms. Various environments may cause several different toxic behaviours at different levels of the food chain.

Although possible positive effects of ENPs are discussed, the authors expect negative effects on algae, bacteria and fungi. European Commission communications on nanotechnology recognise knowledge gaps and the need for continued scientific investigation of health and environmental risks. Current expectations are that regulation can be achieved under existing legislation, but implementation will have to continually adapt to new information arising from research.


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**Themes:** Biodiversity, Chemicals