Nanomaterials as an emerging category of environmental pollutants

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Nanomaterials are so tiny that ten thousand of them side-by-side would approximate to the thickness of a human hair. Such materials occur naturally in the environment (for example in volcanic ash or as a product of combustion such as cigarette smoke) but there has been increasing interest in recent decades in synthesising artificially engineered nanomaterials to have applications in areas as diverse as microelectronics, drug delivery and as components of creams and lotions. Nanoparticles are nanomaterials with all three dimensions less than 1nm, nanotubes have two dimensions less than 1nm while nanofilms have only one dimension less than 1nm. Good examples of nanomaterials are metal oxide nanoparticles such as TiO_2, a common component of sun creams, and carbon nanotubes.

Up to now, nanomaterials have tended to be used in low-volume high-value applications but there is an increasing move nowadays towards their use in all kinds of common household applications such as food packagings, paints, car windscreens etc. It is projected that the worldwide commercial market for nanomaterials will increase to $2.4 trillion by 2014.

Notwithstanding their applications in a host of contexts, there is growing concern that nanomaterials may present a novel risk from the perspective of toxicology. This is partly because nanomaterials have very large proportional surface areas compared to the same weight of the same material as a macromaterial. Thus, even chemically inert materials may have extensive surface catalysis properties on the nano scale.

Nanomaterials can also coat themselves with a "corona" of proteins with the potential to confer biological functionality such as the ability to bind to receptors on cell surfaces. In addition, because of their small size significantly smaller than cells, nanomaterials can be swallowed up by cells and be internalised. Thus nanomaterials are able to cross skin, intestine, lung, cell and other crucial bio-barriers and can enter cells and even organelles where they are capable of causing toxicity leading to triggering of stress-response pathways. These pathways can have toxic consequences such as cancer or neurodegenerative diseases. Toxicologists are now actively investigating whether enough is known about the toxicity of nanomaterials to justify their ever-increasing use in ever-increasing quantities with no or little testing.

There is also no explicit system of regulatory approval for new nanomaterials, for environmental risk assessment or for their classification in terms of potential toxicity. Key questions are: What is a "dose" for a nanomaterial? What properties may contribute to nanomaterial toxicity? How can we perform rational risk-assessments? Who will pay for ecological consequences of widespread distribution of nanomaterials in the environment?

There is a precedent for these concerns in our experience with asbestos, a natural mineral material used widely in construction during the 19th and 20th Centuries. This is now known to cause mesothelioma, a form of fatal occupational cancer in lung currently responsible for 4,000

deaths *per annum* in the UK alone. This is due to asbestos' high "aspect ratio" (ratio of length to width) and it has been found that mesothelioma can be caused in mice by carbon nanotubes which also have a high aspect ratio. How would we deal with thousands of different types of nanomaterials if even some of them have long-term toxicity to humans similar to asbestos? Should a regulatory or licensing system be put in place before this situation occurs rather than after it?

All citizens are now exposed to nanomaterials whether they know it or not. There is a need for greater awareness of these unique materials and a dialogue on the potential health-risks they may pose. They will be used in high-volume low-value applications so long as they are cheap but this is only possible in the absence of environmental regulation. This presentation will outline the problem posed by nanomaterials as emerging environmental threats and suggest how we might consider the unique problems they may pose to environmental toxicologists, regulators, governments and ordinary citizens.