Friends of the Earth

Nanotechnology and the environment: Challenging the nano industry "green wash"

Issue Summary

What are the key environmental problems associated with nanotechnology?

Nanotechnology is a powerful new technology for taking apart and reconstructing nature at the atomic and molecular level. It is being touted as the basis of the next industrial revolution and will be used to transform and construct a wide range of new materials, devices, technological systems and even living organisms.

The nanotechnology industry is keen to promote nano as an essentially 'green' technology. Their promise – that nano will deliver smarter, faster, cleaner, cheaper industrial production, effectively enabling us to "decouple economic growth from resource use" - is proving to be very seductive for the corporate sector and governments world-wide. The world is already battling with the all too obvious ecological limits to growth – climate chaos, water shortages, pollution and desertification. The consequences of huge inequities in wealth, power and quality of environment are also starkly evident – poverty, disease and social unrest grip a large proportion of the world's population. The idea that a new technology could enable endless environmentally benign economic expansion and material abundance for all is understandably very powerful. However the current trajectory of nanotechnology's development indicates that such a nano-utopia is unlikely to be realised.

The reality is that nanotechnology is more likely to facilitate the radical expansion of resource and energy consumption, and pollution and waste emission, while introducing a whole new range of serious ecological risks associated with nanopollution and the introduction of atomically engineered organisms. The goal of nanotechnology to achieve the deep integration of the natural world within the machinery of industry raises serious ethical problems, as does nanobiotechnology's quest to engineer organisms that contain both biological and human made components.

Challenging the nano industry green wash: why nanotechnology will exacerbate existing unsustainable levels of resource use and pollution, rather than offering any alternatives

Nanotechnology is promoted by its proponents as an essentially 'green' technology that will improve the environmental performance of existing industries, reduce our consumption of resources and energy, and allow us to shift to an environmentally sustainable economy and way of life. Nano optimists see nanotechnology providing: improved water and air filtering technology to deliver universal clean drinking water and reduce air pollution emissions; greater productivity in agriculture and nutritionally enhanced foods; cheap and powerful solar energy generation and the more efficient use of fossil fuels; clean and highly efficient manufacturing; 'smarter' energy-saving building materials; biosensors for the detection of pollutants and pathogens; and environmental remediation applications such as products for cleaning up contaminated water and soils.

In other words, nanotechnology will provide a panacea to existing resource constraints and environmental pollution – we will be able to continue a 'business as usual' path of economic expansion, but minimise our ecological impact. However this very optimistic vision of what a nano world could look like is based on three very flawed assumptions. The first flawed assumption is that nanotechnology will enable us to accurately predict, control and manage the outcomes of atomic-level engineering of materials, systems and organisms. The second flawed assumption is that efficiencies gained by nanotechnology will somehow translate into environmental savings. The third and perhaps most significant flawed assumption is that the development, application and use of nanotechnology will be driven by altruistic motivations rather than commercial and military interests.

It would be foolhardy to think that we could predict accurately the outcomes of atomic level engineering of the natural world. Unpredictability and uncertainty are inherent characteristics of the science and technology of manipulating nature at the level of atoms, molecules, genes, cells and organisms. The use of nanobiotechnology to atomically engineer organisms for use in agriculture, warfare or environmental remediation is a source of real concern. History is littered with examples of unpredicted consequences of human attempts to control complex biological systems, for example the ecological damage that followed the introduction of biological control species such as cane toads.

The use of nanomaterials in a wide range of manufactured products, their accidental release in waste streams and their large-scale intentional release for environmental remediation, in pesticides etc., is also very concerning. Innumerable substances that were originally perceived to be 'wonder' materials have now been demonstrated to cause serious harm to human health or the environment, for example DDT, CFCs and asbestos. The United Kingdom's Royal Society has warned that nanoparticles which are released en masse into the environment, for example for remediation purposes, may simply introduce their own set of environmental pollutants and hazards[1]. It recommended that the release of nanoparticles be "avoided as far as possible" and that their use for remediation "be prohibited until appropriate research has been undertaken and it can be demonstrated that the potential benefits outweigh the potential risks"[2]. However, literally dozens of sites in the United States have already been injected with nanoparticles for remediation purposes[3], despite no study having being carried out to assess the safety of these nanoparticles for environmentally relevant species[4]. This is of serious concern given early indications that nanoparticles presents a whole new range of serious ecological threats[5] (see discussion below).

The bold claim by nanotechnology proponents that efficiency gains achieved by nanotechnology will somehow translate into conservation outcomes similarly flies in the face of all previous experience; in a growth economy, efficiency gains inevitably result in expanded production, rather than environmental savings. In the last 100 years, efficiency gains in producing energy, materials and agricultural crops, rather than leading to benefits for the environment, have instead resulted in cheaper materials and cheaper end-products, while overall production and consumption has expanded. There is no reason to think that the introduction of nanotechnology will result in more conservation-minded behaviour.

Perhaps the most compelling illustration of the fact that nanotechnology's development is being driven by 'business as usual' commercial and military interests is provided by a quick analysis of investment and commercialisation trends. Nanotechnology research is dominated by the military and the first non-military nanoproducts to be released commercially are targeted squarely at wealthy consumers in the Global North. In 2006, the US government, which is the world's biggest funder of nano research, allocated a third of its US$1.3billion nanotechnology research budget to the US defence program, which was a greater share than that received by the entire National Science Foundation[6]. In stark contrast, research into the environmental and health impacts of nanotechnology received less than 4% of the budget. The first non-military nanoproducts to be released commercially include: anti-ageing cosmetics; odour-eating socks; superior display screens for computers, televisions and mobile phones; premium coatings for luxury cars; and self-cleaning windows and bathrooms. In 2004, the United Kingdom's Royal Society noted that of the engineered nanomaterials in commercial production, the majority were being produced for use in the cosmetics industry[7].

Experience tells us that technological innovation in and of itself will not be enough to deliver environmentally positive and socially just outcomes. Industrial-technological solutions alone cannot fix problems stemming from flawed economic ideologies, a failure to value the natural world, socio-economic inequity or the unequal distribution of power.

New environmental hazards and the threat of nanopollution

Nanoparticles and other nano-structures will be released into the air, soil and water in the form of environmental remediation products; through waste streams from factories and research laboratories; as fixed or unfixed nanoparticles in composite products and particularly after nanoproducts have been disposed of; in the form of nano-chemical pesticides and fertilisers; accidental releases during handling or transport; as components of military weapons; and through the explosion of nano-powders. Domestic nano waste discharge will also expand as ever greater quantities of cosmetics, sunscreens and personal care products containing nanomaterials are washed off in the shower and join water waste streams, or are washed off swimmers and sunbathers directly into oceans and lakes.

Nanoparticles and devices may constitute a whole new class of non-biodegradable pollutants. Like chemical pollution, the concerns over nano-pollution are based on the persistence, bioaccumulation and toxicity of nanoparticles and other nano-structures and products. Remarkably little information exists on the potential of nanomaterials to cause environmental harm. There is no body of literature equivalent to that which exists for the potential of nanomaterials to cause harm to humans that examine the impacts of nanotoxicity on non-human animals, micro-organisms and plants[8]. Preliminary study in this area has begun, however it has received even less funding than the relatively small amount available for the examination of nanotoxicity's implications for human health[9].

The little research completed cautions against broad extrapolation of results. However the preliminary findings indicate the potential for serious environmental impacts and point to the urgent need for further study. Carbon fullerenes (buckyballs), already used in several face creams and moisturisers, have been found to cause brain damage in largemouth bass[10], a species accepted by regulatory agencies as a model for defining ecotoxicological effects. Fullerenes have also been found to kill water fleas and have bactericidal properties[11].

Early studies suggest that microorganisms and plants may be able to produce, modify and concentrate nanoparticles that can then bioaccumulate (or even biomagnify) along the food chain[12]. Scientists have noted that although most people are concerned with the impacts of nanoparticles on large wildlife, the basis of many food chains depends on soil flora and fauna which could be dramatically affected by nanoparticle exposure through waste streams or deliberate release (eg for environmental remediation)[13]. The antimicrobial properties of nanoparticles have led to concerns that they may shift into microbial populations and disrupt signalling between nitrogen-fixing bacteria and their plant hosts[14]. Any significant disruption of nitrogen fixing could halt plant growth and have serious negative impacts for the functioning of entire ecosystems. This would have significant ecologic and economic impacts. High levels of exposure to nanoscale aluminium (currently used in face powders and sunscreen) have been found to stunt root growth in five commercial crop species[15].

Nanoparticles also have a demonstrated ability to bind to sediments and soil particles. Rice University's Center for Biological and Environmental Nanotechnology has pointed out the tendency for nanoparticles to bind to contaminating substances already pervasive in the environment like cadmium and petrochemicals. This tendency would make nanoparticles a potential mechanism for long range and wide-spread transport of pollutants in groundwater[16]. Substances such as nano-formulated pesticides and fertilisers that may be applied regularly and widely are therefore a concern. Nano-formulated pesticides are already on the market[17]. These pesticides have been developed precisely because they are more toxic to their target pests, and their effects are longer lasting, but they may also potentially become more toxic to all other living organisms as well.

Nanoparticles and devices which are non-biodegradable and are released en masse for 'environmental' purposes - such as nano-scale sensors, or nanoparticle iron oxide used already in the US for remediation - may also simply introduce their own set of environmental pollutants and hazards that cannot be cleaned up.

Beyond the specific hazards of nanoparticles, the use of nanobiotechnology (or 'synthetic biology') poses more far-reaching environmental threats. Nanobiotechnology involves the integration of living and non-living materials, such that nano-bio modified organisms will be able to be constructed from a tool-box of interchangeable parts. The smallest units of nature - including cells and viruses - will be transformed into tiny production units or nano-factories for producing commercially useful materials. One of the inherent dangers associated with nanobiotechnology and the atomic engineering of organisms - such as modified viruses - is not only that they reproduce, but that they may also mutate and evolve and unpredictable and uncontrollable ways. The ETC Group has referred to the danger posed by the release of nano-biotechnologically engineered living organisms as 'green goo'[18].

Nano-Industrial Expansion: The Deep Integration of Nature into the Economy

In essence, nanotechnology represents the most powerful attempt to date to deconstruct the world into the most basic elements or units and to reshape it to meet our requirements. In these various ways, nanotechnology opens up new avenues for the exploitation of the earth's resources, as ever more parts of the earth become mere putty to be reconstructed and harnessed to the goals of commodity production. Rather than *decoupling* resource consumption from economic growth — or simply decoupling nature from the economy — nanotechnology represents the deepest *integration* of nature into the economy yet attained.

Ultimately, nanotechnology is the technological platform that may enable the next wave of expansion of the corporate-industrial economy. Far from leading us towards more environmentally sustainable and benign systems of production and consumption, nanotechnology will more likely facilitate the radical expansion of current levels of resource and energy consumption as well as pollution and waste emissions. While some nano-materials and nano-products may require less resources and energy for their manufacture, other nano-materials may be very energy intensive and polluting. Early evidence suggests that the production of nanoparticles and other nanomaterials will introduce serious new risks to environmental systems and human health.

The urgent need for a moratorium on the commercial research, development, production and release of nanoproducts

Nanotechnology is likely to facilitate the radical expansion of resource and energy consumption, pollution and waste emission, while introducing a whole new range of serious ecological risks associated with nanopollution and the introduction of atomically engineered organisms. There is an urgent need for a moratorium on the commercial research, development, production and release of nanoproducts while regulations are developed to manage these serious environmental risks. For further information about Friends of the Earth's nanotechnology policy, visit http://nano.foe.org.au

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