Nanotechnology is an exciting branch of science concerned with the very small. It has the potential, however, to have a big impact on our efforts to live more sustainably.

THE POWER of very small things

Some of the most significant challenges facing global society in the 21st century involve the sustainability of the environment (water, soil and air quality), energy, health and food. Existing technologies have had a profound effect on the environment, releasing formidable pollutants and depleting natural resources. The situation continues to be aggravated by contaminants from pesticide and fertiliser runoff, gas emissions from industries and vehicles, and runoffs from chemical industries, abandoned industrial sites and mines. In addressing environmental sustainability, it is important to attend to the past, present and future by cleaning up previous damage, tackling current problems and preventing future impacts.

Nanotechnology, the science of the extremely small, has the potential to have an extremely large impact on many aspects of society. Unlike many other technologies, it could have applications in almost all areas of human life, including health and medicine, energy, information technology, material and manufacturing, and the environment. It is this cross-cutting nature that gives nanotechnology its potential to impact greatly on the quality and sustainability of our natural resources.

What is nanotechnology?

Nanotechnology is the science of manipulating material at an atomic and molecular scale. At this level, the normal rules of physics and chemistry no longer apply, and materials often display unique and surprising properties. The ability of scientists to create and manipulate matter at the nanoscale offers previously unenvisaged possibilities for research and applications. Nanotechnology has been hailed as the 'leading technology of the 21st century' and is recognised as an important tool for both innovative development and improving the lives of ordinary people.

The past two decades have seen rapid global advances in nanoscience and nanotechnology in all spheres of science, engineering and technology. Around the world, chemists, biologists, physicists and engineers continue to explore the positive – and negative – potential of nanotechnology-based materials and devices. South Africa is no exception. Leading South African universities, the Department of Science and Technology's (DST) Nanotechnology Innovation Centres and the industrial and private sectors are engaged in research and the development of new materials that will contribute to a more sustainable way of living.

How can nanotechnology contribute to environmental sustainability?

Climate change South Africa, like most countries, faces serious challenges from climate change. As a developing nation pursuing sustainable economic growth, changes to the environment are likely to impede progress. Greenhouse-gas (GHG) emissions such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are major contributors to climate change, so reducing and mitigating their effects is crucial. Adaptation is also an important component of the response to climate change. All strategies require viable innovative solutions.

A report by the United Nations University Institute of Advanced Studies in 2008 identified nanotechnology as one of three innovative technology solutions to climate change. To date, the science has applications in hydrogen storage and the development of efficient hydrogen-powered vehicles, enhanced and cheaper photovoltaics or solar power technology, the development of new batteries and supercapacitors, and fuel efficiency. In South Africa, a number of research activities to develop these nanotechnologies are being carried out at universities and Nanotechnology Innovation Centres, namely CSIR and Mintek.

Depletion of natural resources Access to clean, safe water is a challenge faced by most countries. The properties offered by nanomaterials make them well suited to treating water, provide an opportunity to refine and optimise current techniques and introduce novel methods for dealing with domestic, industrial and mine wastewater. The depletion of petroleum can also be addressed by nanotechnology through its contribution to alternative energy sources such as solar power and hydrogen fuel.

Preventing environmental degradation Nanotechnology products and nanomaterials can have a low impact on the environment. Lightweight nanomaterials used in the production of cars and other means of transportation could reduce the resources required to make them, and save fuel as well. Nanotechnology could lessen pollution from energy production and help to limit our reliance on fossil fuels through its application in renewable energy systems. By enhancing battery life, it could lead to the use of fewer materials and less waste.

This technology can also be used to develop products that specifically target the improvement of the environment, such as cleaning waste sites and water, or treating and monitoring pollutants.

In addition, nanotechnology can make current manufacturing processes for other (non-nano) materials and products more environmentally friendly. Nanoscale catalysts, for example, can make chemical reactions more efficient and less wasteful.

Is nanotechnology environmentally friendly?

Nanotechnology may have its drawbacks. Concerns have been raised that the same properties (size, shape, reactivity, etc.) that make nanoparticles so useful could also make them harmful to the enviroment and toxic to humans. What if they accumulate in drinking water supplies and the food chain, for example? These concerns are exacerbated by the current poor understanding of the behaviour of nanoparticles in humans and the environment. Risk assessment research is crucial for establishing their potential effects on people and the natural world – the technology's benefits must be balanced against any unintended consequences.

This is a massive challenge because it is very difficult to monitor the possible impact of the huge volume of diverse nanoparticles being produced. Although there are currently no regulations in South Africa specific to nanotechnology because of its relative infancy, the government, through the DST, is funding a research platform to investigate the environmental, safety and health aspects of this new science. ■

The Nanotechnology Public Engagement Programme (NPEP) is an initiative funded by the Department of Science and Technology (DST) and implemented by the South African Agency for Science and Technology Advancement (SAASTA), a business unit of the National Research Foundation (NRF). Launched in early 2008, the NPEP aims to promote credible, fact-based understanding of nanotechnology through awareness, dialogue and education so that informed decisions may be made on innovations it brings to improve our quality of life.

The objectives of the NPEP are to:

- Create awareness around nanotechnology
- Educate the public about and improve understanding of nanotechnology
- Enable and stimulate meaningful public debate around nanotechnology
- Stimulate interest in nanotechnology and nanoscience as a career in order to ensure long-term capacity building in the field
- Get industry involved in the development of nanotechnology and take the lead in its innovation.

For more information about the NPEP, visit www.saasta.ac.za *or e-mail* info@saasta.ac.za

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NRF SAASTA National Research Foundation South African Agency for Science and Technology Advancement