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TECHNICAL BRIEF

Nanotechnology

Framework for a WRC research programme on engineered nanomaterials

A WRC-funded study developed a strategic research plan for nanomaterials in South African water systems.

Background

Nanotechnology has taken the world of science by storm since it allows for the development of new materials with extraordinary properties. Nanomaterials are defined as objects with one, two or three external dimensions in the size of 1-100 nanometres. Examples of novel nanotechnology applications include the development of highly accurate and sensitive medical diagnostic devices, new ways of disease therapy, and the monitoring and remediation of basic water supplies.

South Africa, through the National Nanotechnology Strategy (NNS), has initiated a national coordinated effort to guide the country's nanoscience and nanotechnology to ensure that we remain competitive within the international research community in this fast-developing field. The NNS broadly groups the benefits of nanotechnology of national importance in South Africa in six focus areas, namely water, energy, health, chemical and bioprocessing, mining and minerals, and advanced materials and manufacturing.

Potential water applications

The pressing issues of water resources and water-supply systems of South Africa with respect to water quantity as well as water quality has made researchers to investigate nanotechnology to provide viable alternatives to current purification methods that may require improvement. Demands on water sources are increasing at an accelerated rate due to population growth as well as increasing industrial activities. The rapid rate of urbanisation since independence in 1994 causes increasing demands for safe drinking water in urban areas, thus resulting in the need to upgrade and expand water-supply systems on a continuous basis in order to meet these demands.

During this WRC-funded project the state of nanotechnology in South Africa was investigated. The main findings of the investigations were that:

- Nano-scale research in South Africa is driven by individual researchers' interests and it is in its early stages of development;
- The country's nano-scale research is below what one would expect in light of its overall publication output;
- The country's nano-research is distributed at a number of universities, with a sub-critical concentration of researchers.

Calculating the risk of nanotechnology

With the rapid progression of nanotechnology from laboratory to industrial applications and commercialisation of products, it is imperative that risk that may be associated with engineered nanomaterials (ENMs) requires attention at its infancy phase to ensure safe and responsible long-term development of this novel technology. With the widening gap on the understanding and knowledge on the risks of ENMs to the environment and the increasing application of nanotechnology it is not surprising that there is a growing volume of international scientific literature expressing concern towards environmental distribution and effects of these materials.

The reason for this concern lies in the unique inherent physical and chemical properties of nanomaterials that make them suitable for successful application e.g. in water treatment, medicine etc. also provides them with potential for biological uptake and effects in non-target organisms.

To fully elucidate the potential impacts of ENMs, risk profiling these materials requires scrutiny at different lifecycle phases. By using the toxicological data from the studies of nanomaterials in aquatic systems and the exposure potency, risk profiles can be determined. Such profiles will indicate which materials needs further attention, and also provide basis for deriving suggestions on how such ENMs can be re-engineered to function as intended, but with minimised potential to cause adverse effects in ecological organisms.

Purpose of the document

In this document an outline on the development of a research framework and a motivation as to why the different components were selected to address the research needs into risk assessment of ENMs in waters of South Africa are presented. To stay in line with current national initiatives, a research programme is required to increase the country's collective understanding on the potential risks and mechanisms of addressing such risks adequately.

Ecological risk assessment (ERA) is a structured approach that describes, explains and organises scientific facts, laws and relationships to provide a sound basis to develop protection measures for the environment. It is the key concepts of the ERA process, i.e. identification of the hazard, exposure assessment, assessment of the dose-response relationship and risk characterisation that provides guidance into identification of the research priorities for understanding environmental exposures, environmental dose and bioavailability and effects following internal exposure to ENMs in South African waters.

The five research priorities are to:

- Identify principle sources of exposure and exposure routes;
- Determine the dominant physic-chemical properties that affect environmental transportation of ENMs;
- Understand transformation under different environments;
- Determine the applicability of effects tests on individual species; and
- Determine ecosystem effects.

Conclusion

In many respects, data needs for risk assessment of ENMs will deviate from those of traditional counterpart parent chemicals. Enhancing our ability to detect and characterise ENMs and establish their linkages to behaviour and effects in laboratory-based bioassays as well as natural systems will result in improved robustness of the risk assessment process. This will substantively reduce uncertainty to allow for more informed decisions about managing ENMs.

The key to the successful understanding and development of nanotechnology is in interdisciplinary and international collaboration. This will require the development of a new generation of both analytical and adequately trained human resources.

Further reading:
To order the report, ***Framework document for a WRC research programme on engineered nanomaterials*** (**Report No. TT 549/12**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za, or Visit: www.wrc.org.za to download a free copy.