

Systems thinking, sustainable development and chemical elements

**Sustainable development and the chemical elements:
Chemical elements from the perspective of the United Nations'
Sustainable Development Goals
#IYPT2019 #science4SDGs**

This [National Science and Technology Forum \(NSTF\)](#) Discussion Forum addressed sustainable development by providing a detailed perspective on selected [Sustainable Development Goals \(SDGs\)](#). Furthermore, the aim was to include as many elements in the Periodic Table as possible – in celebration of the United Nations (UN) International Year. As experts shared their knowledge and views about some of the critical and complex global problems of our time, important issues emerged.

There were two organising frameworks – the Periodic Table of Chemical Elements and the 17 SDGs. However, the real discussion emerged from linkages between these, and relating them to contexts where critical problems need to be solved.

Prof John Bradley proposed one-world chemistry and systems thinking as a way of tackling complex problems (and for teaching children and students). He was presenting at the NSTF Discussion Forum with the theme of [‘Sustainable development and the chemical elements: Chemical elements from the perspective of the UN’s Sustainable Development Goals’](#). Prof Bradley is an Honorary Professor, University of the Witwatersrand and presented on [‘From Chemistry’s Big Bang to One-World Chemistry – a story for chemical education’](#). This NSTF Discussion Forum was held on 16 May 2019, in partnership with the [Department of Science and Technology \(DST\)](#) and [Dow Southern Africa \(Pty\) Ltd](#).

The UN proclaimed 2019 the [International Year of the Periodic Table of Chemical Elements](#). The UN recognises the importance of raising global awareness around chemistry. This includes chemistry’s role in solving global challenges such as the SDGs.

The NSTF provides neutral collaborative platforms where issues and sectors meet

- One of the National Science and Technology Forum (NSTF) functions is to hold [discussion forums](#), bringing the private and public sector together to address important issues and engage with [government policy](#).
- Feedback from these discussion forums is given to stakeholders.
- Recommendations are put forward to government as part of the [SET community’s](#) lobbying efforts.



Chemistry with context

Prof John Bradley says that: “Chemistry cannot be separated from the context in which it is conducted and its practice must be considered in relation to its impacts on many interconnected systems.” This includes a focus on sustainability.

One-world chemistry looks at embedding in chemistry education a growing awareness of the ways that chemistry interconnects with other disciplines and its application in context.

Prof Bradley notes that teaching and practice need to be informed by systems thinking, including embracing multi-disciplinary and cross-disciplinary approaches. He says that sustainable development is neglected in the school system. This is somewhat alarming considering that sustainability links to human survival.

From agriculture, medicines, and plastics to electrical power and ICTs, chemistry has contributed to development across the globe. However, all this has come with consequences. Prof Bradley points to recent examples, such as the nine million people killed by pollution per year. This statistic comes from the UN Environment Programme’s ‘Global Environmental Report 2019’.

The report further notes: “Modern society is living in the most chemical-intensive era in human history; the pace of production of new chemicals largely surpasses the capacity to fully assess their potential adverse impacts on human health and ecosystems.”

The NSTF Discussion Forum and systems thinking

Systems thinking considers that the “component parts of a system will act differently when isolated from the system’s environment or other parts of the system” ([‘Systems thinking, learning for sustainability’](#)). It’s a holistic approach that expands the way we think about things. It explores inter-relationships, connections, influences, and multiple perspectives.

It will take an extremely comprehensive systems thinking approach to tackle the SDGs which address the intractable problems of our times. This needs international and national leadership. At the NSTF Discussion Forum, the different presentations linked to various levels of systems, with topics touching on some of the areas.

Systems thinking moves beyond events, into patterns and trends, system structure and drivers, and then predominant social paradigms (mental models and world views). This is known as [‘The Iceberg Model of Systems Thinking’](#) by Michael Goodman.

Responding to the water challenge

South Africa has a clear water challenge. As noted by Prof Edward Nxumalo, South Africa is the 30th driest country in the world. It’s also had the worst drought in 23 years. At the same time, agriculture, mining and chemicals industries are producing emerging types of pollutants.

Prof Nxumalo is an Associate Professor, University of South Africa (Unisa). He presented on [‘The Interlink between the Periodic Table and Water Treatment: A Nano Perspective’](#). South Africa needs to recognise that current water treatment processes are not designed to deal with emerging contaminants, such as ibuprofen and paracetamol.

Part of his research deals with using membrane science for drinking, sea water, and wastewater purification. He and his team have also developed a solar-driven filtration system which is currently at testing phase.

He noted that there are a number of potential nanotechnology applications for water treatment. These include: membranes and membrane processes, photocatalysis, and disinfection and microbial control. Emerging contaminants can be tackled with these advanced techniques.

Responding to the fertiliser and food challenge

The way agriculture has been practised has contributed extensively to soils lacking in vital nutrients. This affects the nature and size (yield) of crops. Consequently, fertilisers are essential.

Mr Harry Dube presented on [‘Important minerals in agriculture: essential and contaminants’](#). He is from the Directorate: Agriculture Inputs Control; Department of Agriculture, Forestry and Fisheries (DAFF). He notes that there are five main plant nutrients – with three that are absolutely critical for humankind’s survival: nitrogen (N), phosphorus (P), and potassium (K).

Mr Dube says that without the industrial production of nitrogen, agricultural production would not have been possible at its current scale. However, we need to relook at the use of nitrogen fertilisers. Most soils in South Africa are acidic (and thus less productive) because of the overuse of these type of fertilisers.

Phosphorus is the most deficient in soils in terms of plant nutrition, says Mr Dube. Increased phosphorus means increased crop yields. This nutrient is not a renewable resource – it is mined. While South Africa has 10% of the world’s reserves, it exports most of it. Mr Dube notes that phosphorus, a finite resource, needs to be managed carefully. (Excessive phosphorus has negative effects including poisoning soils and leaching into water, reducing the quality of the water.)

Potassium is a fairly common mineral nutrient in soils. About 2.3% of earth crust is potassium but it’s not evenly distributed, says Mr Dube. South Africa has none.

Potassium is also a finite resource. Mr Dube says that it’s not if but when potassium and phosphorus will be depleted. To continue food production in a sustainable way, we need to relook at how we use fertilisers and consider organic fertilisers and using conservation agriculture.

A body of chemical reactions
Ms Nathalie Mat, from Nathalie Mat Deltians, presented on [‘Mineral elements for health’](#). She looked minerals (calcium, potassium, sodium, and magnesium) and trace minerals (iodine, iron, and zinc).

She noted that the body is made of different systems, all the way down to cells and atoms. In fact, we could see ourselves as a body of chemical reactions.

Responding to the health challenge

Dr Palesa Sekhejane spoke on [‘South Africa’s skill’s position for achieving sustainable development: What is feasible for driving pharmaceutical or vaccine production industry?’](#). She is a Research Specialist: Human Sciences Research Council (HSRC).

Vaccination is much needed for a healthy population. Dr Sekhejane says that local production of some vaccines will assist with some of the challenges that South Africa has around supply and availability. Vaccines are also lucrative, promoting economic development. However, processes – such as getting vaccines approved – are very lengthy in South Africa. There is also no clear strategy for developing vaccines in South Africa, says Dr Sekhejane.

She noted that South Africa has not identified strategies to develop human capacity for the vaccine industry. Of the skills produced currently, they don’t all meet the needs of this industry. Government needs to create platforms to test the skills, and tertiary education needs to cater for learning about the manufacturing process.

Furthermore, the policy environment needs to address some basic fundamentals for South Africa to play a deeper role in the vaccine production space. She says that South Africa has an opportunity to invest in local manufacturers. It also stands to gain regionally as there is not vast competition. The country needs to develop systemic competitiveness starting with policies.

Patterns and trends

When Prof Paul Nex presented on [‘Critical Raw Materials, “Hype Cycles” and the 4th Industrial Revolution’](#), he explored context, as well as patterns and trends. He is an Associate Professor, University of the Witwatersrand.

He noted that what is considered ‘critical’ in critical raw metals (CRM) is different for different countries and different contexts and at different times: “Any definition depends on the country you are in, the technology / industry you are interested in, your perceived risk of future supply, and perceived demand. ALL of these are subject to change.”

Certain commodities are seen as critical for the 4th Industrial Revolution (4IR), but global demand for these go through ‘Hype Cycles’. Demand peaks quickly, then drops steeply, and perhaps stabilises at a level in between (or disappears). The prices for such raw materials follow demand. When prices stabilise somewhat, it may no longer be profitable to mine and extract them.

In terms of CRM for South Africa, Prof Nex says that it depends on what South Africa envisages for itself in next 10, 50 and 100 years. Furthermore, we can’t place a value on our raw metals if we don’t know what we have. There isn’t a great deal of information on Africa’s and South Africa’s resources and reserves. This can only happen with further exploration.

CRMs need to be contextualised to see the larger picture. Part of this is their relation to climate change and green technologies. Consider that, according to Prof Nex, electronic vehicles use four times as much copper (Cu) as our current engines. This means ‘green’ needs mining. Furthermore, Prof Nex says that renewable energy requires more raw materials, not less, at least in the short and medium term.

It’s about understanding the larger system for decision making. We need the materials for 4IR and this means mining. At the same time, we need to develop a carbon free or low-carbon economy to reduce the impact on climate change. A lot that is associated with a low-carbon economy (for example, electronic vehicles, renewable energy sources, and fuel-cell energy) are not ‘clean’ solutions. There needs to be a balance and not an ‘either/or’ scenario, says Prof Nex.

What is the DST and the rest of government doing?

DAFF’s Chief Directorate: Chemicals Management is coordinating – across government – the chemicals management work the country needs to achieve the SDGs by 2030. Government is using the SDGs as a framework to look at chemical management from various perspectives. For example, SDG 5 looks at gender equality. This translates to the target of women’s full and effective participation and equal opportunities in chemicals management.

This was part of the presentation by Dr Mahlori Mashimbye called [‘Harnessing the South African Chemical Sector for contribution to Sustainable Development Goals’](#). He is the Director: Chemical and Related Industries, DST.

DST planning includes supporting the National System of Innovation by:

- Generating data for monitoring, planning, and tracking for informed decisions
 - Promoting the generation of knowledge and analysis for policy, planning, and delivery
 - Assisting in developing and localising technological solutions
 - Promoting the demonstration, testing, and diffusion of technological solutions
- The DST and the National Research Foundation (NRF) are looking at funding further research, research chairs, and research infrastructure, where needed. They have also launched specific initiatives and are aiming to drive global and national partnerships.
- Dr Mashimbye says that there are, primarily, two approaches for the chemical sector regarding the SDGs: remediation (ie regularity including banning and restricting use) and R&D and industrial development of alternatives (ie new environmentally-friendly chemical products).

Speakers can be contacted through the spokesperson, [Ms Jansie Niehaus](#). [Video clips](#) with the [full presentations](#) can be found on the [NSTF website](#).

There have been previous NSTF Discussion Forums on related topics:

- [Chemical elements for South Africa’s Future](#), 18-19 March 2019
- [The Water-Energy-Food Nexus](#), 23-24 October 2018 – initiated by the representatives of the NSTF Science Councils and Statutory Bodies sector
- [Sustainable Energy for All in South Africa](#), 16-17 April 2018
- [How can research and innovation in publicly funded institutions support the sustainable development goals?](#), 4-5 September 2017 – initiated by the representatives of Science Councils and Statutory Bodies sector of the NSTF

About the NSTF
The National Science and Technology Forum (NSTF), established in 1995, is a broadly-representative stakeholder body for all SET and innovation organisations in South Africa, which seeks to influence policy formulation and delivery.

The NSTF Awards are unique in SA, recognising the outstanding contributions of individuals and groups to SET and innovation.

The science bursaries page <http://www.nstf.org.za/bursary/> provides information on bursaries and bursary providers for science, engineering and related studies.

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