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SCiENCE MaTTERS

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Can **NANOTECHNOLOGY**
make farming **MORE**
SUSTAINABLE?

**African
Wormwood
for Better
Seed
Germination**

**Can
Nanoparticles
Improve
Bioethanol
Production?**

**TB Bacterial
DNA
Detected
in Shared
Water
Sources**

FASTER DETECTION OF HARMFUL BACTERIA IN FOOD

“Science is a beautiful gift to humanity,
we should not distort it”

– A.P.J Abdul Kalam





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SCiENCE MaTTERS

Welcome to the second issue of Volume 8 of the National Research Foundation's (NRF) Science Matters magazine. This issue presents a collection of insightful research articles that address pressing social, environmental and technological challenges.

In this issue, we present research that explores how science is helping us understand and respond to a changing world. Covering topics ranging from water quality and public health to diabetes monitoring, climate change, food and water security, sustainable agriculture and renewable energy. These articles highlight both the challenges facing society and the scientific approaches being investigated to address them. Together, they show how South African research is contributing to new knowledge, emerging technologies and more sustainable ways of safeguarding public health, strengthening food security and protecting the environment.

The NRF would like to thank all the researchers who generously contributed to this issue of Science Matters. Their contributions allow us to showcase the unique perspectives of South African scientists and demonstrate how their work makes a difference every day.

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NANOTECHNOLOGY FOR MORE SUSTAINABLE FARMING:

overview and response of plant-associated microorganisms

Producing enough food for a growing global population while protecting the environment is one of agriculture's greatest challenges.

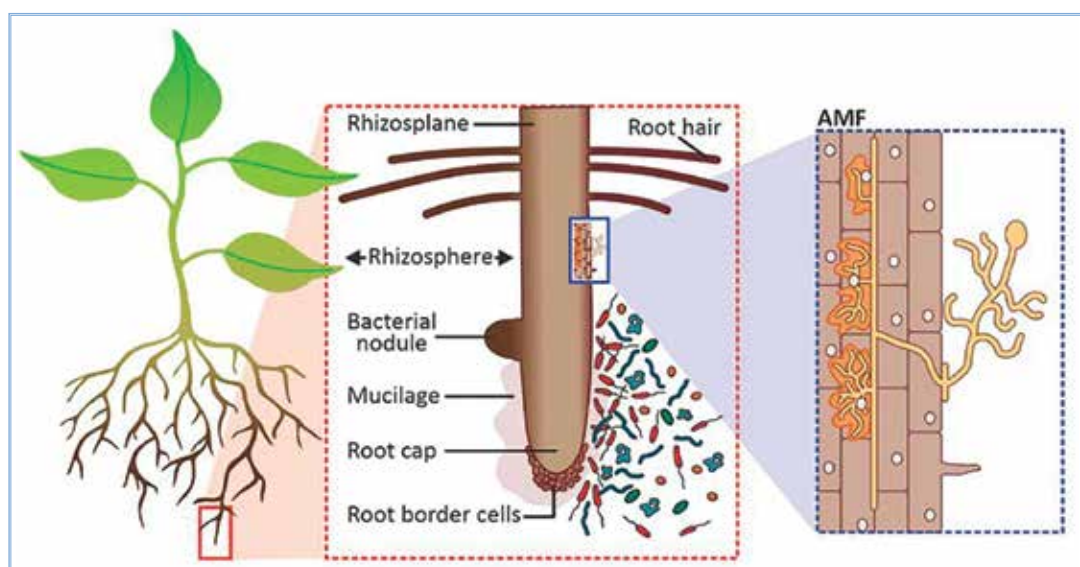
Conventional fertilisers and pesticides have helped increase crop yields, but they have also contributed to soil degradation, environmental pollution and risks to human and ecosystem health. Nanotechnology is emerging as a possible alternative: nanoscale fertilisers and pesticides may improve nutrient-use efficiency while requiring lower application rates. However, scientists still know relatively little about how these nanoparticles affect the beneficial microorganisms that are essential for healthy soils and productive crops.

An NRF-funded review by researchers from North-West University, the Agricultural Research Council, and the University of South Africa examined

current knowledge of the use of nanoparticles in agriculture and how these materials affect the microorganisms that live in and around plants. The review also explored potential benefits, environmental risks and research gaps that must be addressed before these technologies can be used more widely.

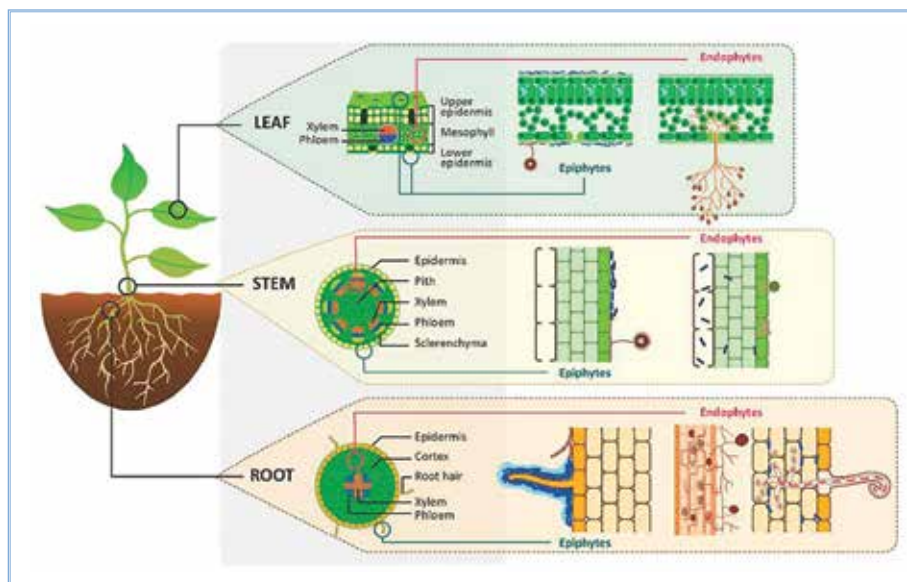
To achieve these goals, the researchers reviewed and synthesised published scientific literature on plant-associated microorganisms, nanotechnology in agriculture, nanofertilisers, nanopesticides and the reported effects of nanoparticles on microbial communities associated with plants. Rather than conducting new laboratory experiments, the review evaluated existing evidence to identify the

current state of knowledge, emerging trends and research gaps.



Components of the rhizosphere that includes symbiotic and saprophytic bacteria and arbuscular mycorrhizal fungi (AMF). Image adapted and modified from Philippot *et al.* (2013).

The review found that, compared with conventional agricultural inputs, nanofertilisers and nanopesticides could improve nutrient-use efficiency, crop productivity and disease management. At the same time, plant-associated microorganisms remain essential for nutrient cycling, soil fertility, plant growth and disease suppression. The researchers found evidence that nanoparticles can have both beneficial and harmful effects on these microorganisms depending on factors such as the type and concentration of the nanoparticle, crop species, soil properties and exposure conditions. However, they also found that current evidence remains limited, particularly regarding the long-term effects of nanoparticles under realistic agricultural conditions.



The location of epiphytes and endophytes within plant leaves, stems and roots. Image adapted and modified from Walker *et al.* (2020).

The review found that, compared with conventional agricultural inputs, nanofertilisers and nanopesticides could improve nutrient-use efficiency, crop productivity and disease management.

The researchers conclude that nanotechnology holds promise for more sustainable agriculture, but its environmental safety has not yet been fully established. They recommend further long-term research across diverse agricultural conditions and propose that plant-associated microorganisms could serve as sensitive indicators for assessing the environmental safety of agricultural nanomaterials. 

Full research study: <https://doi.org/10.3389/fmicb.2024.1354440>



USING AFRICAN WORMWOOD

to improve seed germination

Producing enough food while protecting the environment is one of agriculture's greatest challenges. Population growth, climate change, and the depletion of natural resources continue to place increasing pressure on food production.

Conventional fertilisers and pesticides have helped improve crop yields, but they have also contributed to soil degradation, nutrient losses, and environmental pollution. As a result, researchers are exploring more sustainable ways to support crop production, including the use of nanotechnology.

An NRF-funded study investigated whether iron oxide nanoparticles produced from *Artemisia afra* an indigenous Southern African medicinal plant commonly known as African wormwood could improve seed germination. The researchers also wanted to determine whether the concentration

of these nanoparticles influences early seedling growth. Before this study, *Artemisia afra* had mainly been explored for medicinal applications, with little research examining its potential for producing agriculturally relevant nanoparticles.

To achieve these aims, the researchers collected *Artemisia afra* leaves from the Eastern Cape and used the plant extract to produce iron oxide nanoparticles through a green synthesis process.

They characterised the nanoparticles using several laboratory techniques before testing them as a nano-priming treatment for spinach (*Spinacia oleracea*) and carrot (*Daucus carota*) seeds.



The seeds were exposed to six nanoparticle concentrations ranging from 5 to 150 mg L⁻¹, while hydro-primed seeds served as the control. Germination, root length, and shoot length were monitored over 12 days.

The study showed that the plant extract successfully produced iron oxide nanoparticles measuring approximately 15–20 nanometres in size. The researchers also confirmed that naturally occurring phytochemicals in *Artemisia afra* acted as reducing agents during the synthesis process.

When applied to seeds, the nanoparticles improved seed germination and early seedling growth, but the response depended on the concentration used.

The researchers also confirmed that naturally occurring phytochemicals in *Artemisia afra* acted as reducing agents during the synthesis process.

The best results were achieved with the lowest concentration of 5 mg L⁻¹. At this concentration, spinach seedlings reached root and shoot lengths of 41.7 mm and 26.7 mm, respectively, while carrot seedlings achieved root and shoot lengths of 73 mm and 9 mm, respectively. Higher nanoparticle concentrations slowed germination, and concentrations of 50 mg L⁻¹ and above resulted in no seed emergence in either crop.

The researchers conclude that green-synthesised iron oxide nanoparticles produced using *Artemisia afra* show promise as a nano-priming agent for enhancing seed germination and early plant growth.

However, they emphasise that the effectiveness of the nanoparticles depends on using appropriate concentrations. They recommend further research to better understand how nanoparticles are taken up by seeds during germination and how they behave within developing plants. 

Full research study: <https://doi.org/10.1021/acsagscitech.2c00205>



EVIDENCE OF TUBERCULOSIS BACTERIA in shared water sources in KwaZulu-Natal

Mycobacterium bovis (*M. bovis*) is a member of the *Mycobacterium tuberculosis complex* (MTBC) that primarily affects animals but can also cause zoonotic tuberculosis in humans.

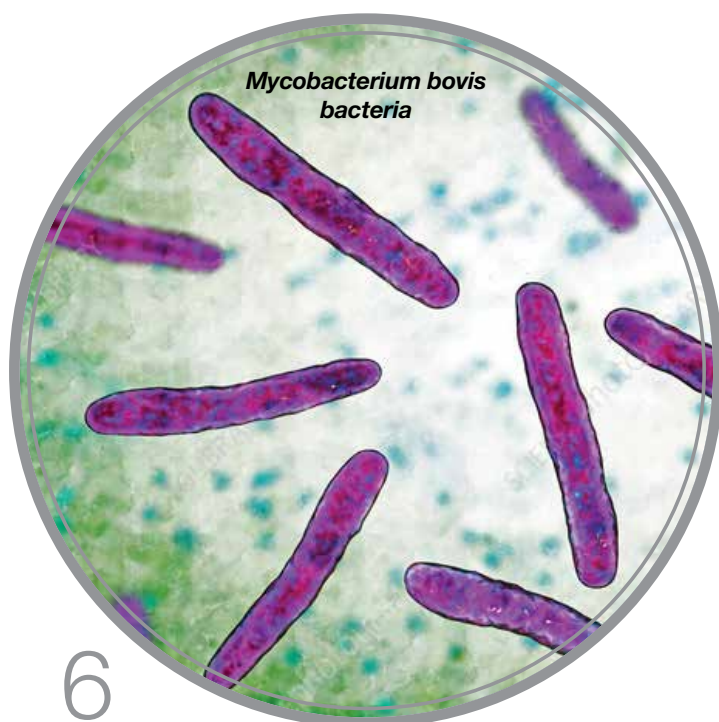
Transmission of *Mycobacterium bovis* (*M. bovis*) mainly occurs through close contact with infected animals or their products. However, infected animals can also shed *M. bovis* into the environment, where the bacteria may persist. This raises questions about whether environmental sources could play a role in tuberculosis transmission, particularly in areas where livestock, wildlife and people share resources.

Previous research suggests that *M. bovis* can survive in environmental material for one to three months. Its detection in soil, invertebrates and shared water sources near infected animal populations has therefore raised questions about the potential role of the environment in tuberculosis epidemiology. Understanding tuberculosis across

humans, animals and their shared environment requires a One Health approach.

A recent NRF-funded research study focused on rural communities in the UMkhanyakude District of KwaZulu-Natal, an area with a high burden of tuberculosis in both human and animal populations. Some of these communities border Hluhluwe-iMfolozi Park, where African buffalo populations are endemically infected with *M. bovis*. Cattle and goats infected with *M. bovis* have also been identified in surrounding rural communities. The study aimed to determine whether *M. bovis* DNA was present in shared water sources used by people and animals in the area.

To achieve their research aims, the researchers sampled 63 shared water sites across two municipalities in the UMkhanyakude District: 14 sites in the Mtubatuba Municipality and 49 sites in the Big Five Hlabisa Municipality. The sampling sites



The study aimed to determine whether *M. bovis* DNA was present in shared water sources used by people and animals in the area.

included water sources near schools, residences, community areas, medical facilities and farming areas where both people and animals had been observed using the water.

The researchers collected samples containing both water and sediment from the water's edge. These water sources had not been filtered or treated before sampling. DNA was then extracted from the samples and analysed using several molecular techniques to detect and identify mycobacteria, including PCR, Sanger amplicon sequencing, targeted next-generation sequencing and the GeneXpert MTB/RIF Ultra assay. Where MTBC DNA was detected, additional molecular tests were used to determine whether the DNA belonged specifically to *M. bovis*.

The researchers detected MTBC DNA at 12 of the 63 shared water sites. At four of these 12 sites, *M. bovis* DNA was confirmed using additional PCR-based methods. At the remaining eight MTBC-positive sites, the researchers could not determine which member of the MTBC was present. The different testing methods did not always produce the same results, but using multiple molecular techniques improved the researchers' ability to detect MTBC DNA in the environmental samples.

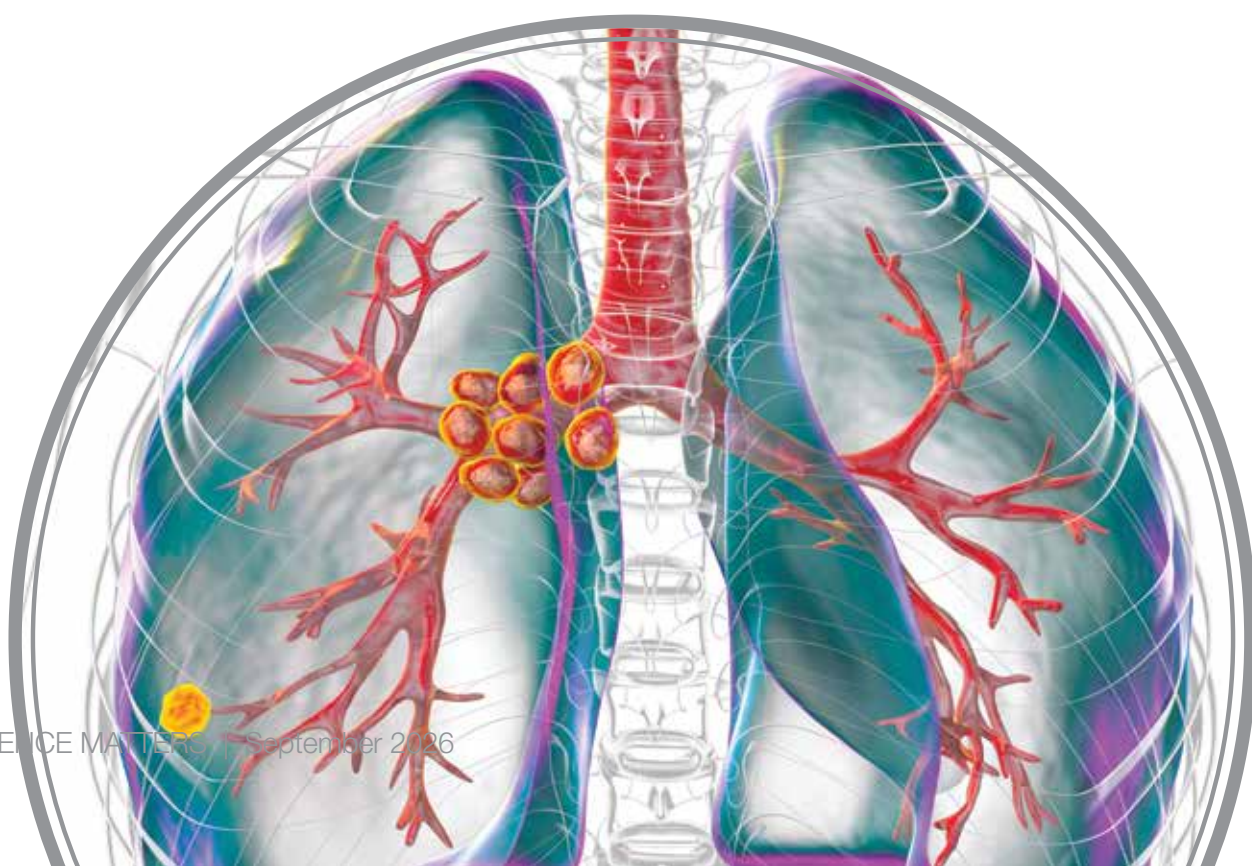
The detection of *M. bovis* DNA suggests that the shared water sources may have been contaminated by infected animals or potentially humans.

However, an important limitation is that the study did not establish that viable *M. bovis* bacteria were present in the water or that tuberculosis was being transmitted through these water sources. The samples were heat-inactivated before transportation, which meant that the researchers could not culture the bacteria to determine whether they were alive and potentially infectious.

The findings therefore provide evidence of *M. bovis* DNA in the environment, rather than proof that contaminated water is transmitting tuberculosis to people or animals. The researchers also highlight the value of using multiple molecular techniques when investigating MTBC in complex environmental samples.

The researchers concluded that the detection of MTBC and *M. bovis* DNA in shared water sources in a high-TB-burden area supports further investigation into the possible role of the environment in tuberculosis epidemiology. They recommended a One Health approach that considers humans, animals and their shared environments. Future research is needed to determine whether *M. bovis* detected in the environment is viable and to better understand the significance of environmental contamination in tuberculosis transmission. 

Full research study DOI:
[10.3389/fvets.2025.1483162](https://doi.org/10.3389/fvets.2025.1483162)



Wearable sensors for **LESS INVASIVE DIABETES MONITORING**

Checking blood glucose levels is part of everyday life for many people living with diabetes. Conventional monitoring often involves repeated finger-prick tests, which can be uncomfortable and may discourage regular monitoring.

Researchers are exploring wearable technologies that could provide continuous glucose information while reducing the need for invasive testing.

A recent review by researchers from the University of South Africa (UNISA) and the Central University of Technology (CUT) examined advances in flexible polymer-based wearable biosensors for glucose monitoring. Rather than conducting new laboratory experiments, the researchers critically analysed existing studies to understand how different materials and technologies contribute to the development of wearable glucose-monitoring devices.

A major focus of the review was polymeric materials. Their flexibility, biocompatibility, stretchability and ability to be chemically modified make them attractive for sensors designed to conform to the skin or other soft tissues.



The researchers grouped these materials into four main categories. Conductive polymers can help transfer electrical signals; biocompatible and biodegradable polymers can support safe interaction with biological systems; elastomers provide flexibility and stretchability; and hydrogels create hydrated environments that can support glucose sensing.

However, no single polymer provides all the properties needed for an effective wearable glucose sensor. For example, some materials provide good conductivity but can experience stability problems, while others are highly biocompatible but have poor electrical conductivity. The review therefore highlights the growing interest in polymer–nanomaterial hybrids, which combine different materials to balance properties such as conductivity, flexibility, biocompatibility and sensitivity.

The review also examined wearable devices designed to measure glucose using different body fluids. Examples reported in the literature include microneedle patches that sample interstitial fluid, mouthguards that measure glucose in saliva, eyeglass-based systems that analyse tears, and epidermal patches that measure sweat.

However, measuring glucose without using blood presents an important challenge. The relationship between glucose concentrations in sweat, saliva or tears, and blood glucose levels is not always

consistent. Differences in sweat rate, skin condition, individual metabolism and other physiological factors can affect measurements. The researchers therefore highlight the need for improved calibration and large-scale clinical validation.

Emerging technologies could further expand the capabilities of wearable biosensors. The review discusses the integration of microfluidics, self-powered technologies, Internet of Things connectivity and artificial intelligence (AI). AI and machine learning could potentially assist with calibration, identify abnormalities and analyse glucose trends. However, the authors caution that current studies provide limited detail on the actual implementation and clinical validation of these technologies.

Despite significant advances, most of the wearable glucose-sensing platforms reviewed remain at the proof-of-concept stage. Challenges include maintaining sensor stability over long periods, material degradation, biofouling, variations in

AI and machine learning could potentially assist with calibration, identify abnormalities and analyse glucose trends.

biological fluids, ensuring a reliable power supply and obtaining accurate measurements during everyday use.

The researchers conclude that flexible polymer-based biosensors offer a promising pathway towards the next generation of diabetes monitoring. However, moving these technologies from experimental prototypes to reliable healthcare tools will require more robust calibration, durable materials, standardised testing and large-scale validation. 

Full research study:

DOI: <https://doi.org/10.1016/j.isci.2026.115306>



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INDLELA IBUZWA KWABAPHAMBILI:

Can indigenous knowledge help shape environmental education in Africa?

For generations, African communities have developed knowledge about their local environments through observation, experience and practices passed from one generation to another.

This indigenous knowledge includes understanding seasonal changes, water sources, plants, soil, biodiversity and ways of managing natural resources. However, much of this knowledge remains outside formal education systems, where Western scientific approaches continue to dominate.

A research study funded by the NRF explored how Indigenous Knowledge Systems (IKS) could be better integrated into environmental education in Africa. The study was guided by the isiZulu proverb *Indlela Ibuzwa Kwabaphambili*, meaning that the path forward is found by seeking guidance from those who came before us.

Rather than conducting new fieldwork, the study reviewed existing research, policies and African case studies. A total of 84 scholarly and policy sources published between 1990 and 2024 were examined. The study also considered examples from South Africa, Ethiopia and Ghana to understand how indigenous environmental knowledge is passed between generations and how it could contribute to formal education.

The research study findings highlights the important role of elders as custodians of environmental knowledge. This includes knowledge about rainfall patterns, soil fertility, water sources,

biodiversity and sustainable agricultural practices. In South Africa, for example, the study discusses indigenous water-management knowledge among Nguni communities, where elders may use observations of rainfall, vegetation and animal behaviour to understand water availability.

However, several challenges remain. Indigenous knowledge is still sometimes regarded as informal or unscientific, while limited documentation, inadequate teacher training, institutional barriers and the gradual loss of oral traditions can make integration difficult.

The study proposes an environmental education model in which indigenous and scientific knowledge are valued alongside each other. It recommends stronger partnerships between schools and communities, greater involvement of elders and indigenous knowledge holders in education, improved teacher training and better recognition of indigenous knowledge within education policy.

The study concludes that drawing on knowledge passed down through generations could help create environmental education that is more culturally relevant while contributing to sustainability and the preservation of indigenous knowledge.

Full research study:
<https://doi.org/10.1007/s41297-026-00331-3>

Could overlooked crops help South African households cope with **FOOD AND WATER INSECURITY?**

Climate change, water scarcity and food insecurity are major challenges for rural farming households in South Africa.

These challenges can affect agricultural production and households' ability to access sufficient food and water. One possible response is to cultivate underutilised crops locally available crops that are grown and consumed but receive less attention in mainstream agriculture.

A research study funded by the NRF aimed to investigate the potential of underutilised crops to address climate change, water scarcity and food insecurity in South Africa. The study also examined the factors influencing farmers'

adoption of these crops and their potential contribution to household food and water security.

To achieve its research aims, the study conducted household surveys across Limpopo, Mpumalanga and North West, successfully interviewing 320 rural households from 25 villages. Households that cultivated underutilised crops were compared with those that did not. The study used statistical analysis to account for differences between households that adopted these crops and those that did not.



Researchers identified 21 underutilised crops, including fruits, vegetables and grains. These included Bambara groundnut, amaranth, pearl millet, mung bean and monkey orange. Of the crops identified, 47% were fruits, 29% were vegetables and 24% were grains.

The findings showed that adopting underutilised crops had a significant positive impact on household water security. Compared with households that did not adopt these crops, the Water Poverty Index increased by approximately 21% in Limpopo, 26% in Mpumalanga and 24% in North West among households that adopted them.

Adopting underutilised crops also significantly reduced food inadequacy. The study reported reductions of approximately 29% in Limpopo, 25% in Mpumalanga and 28% in North West, based on the Household Food Insecurity Access Scale.

The study reported reductions of approximately 29% in Limpopo, 25% in Mpumalanga and 28% in North West, based on the Household Food Insecurity Access Scale.

The study concludes that adopting underutilised crops can contribute to improving household food and water security. It highlights the potential of these crops to support more sustainable and climate-resilient agricultural systems and recommends greater investment in their research, development and promotion as part of efforts to address climate change, water scarcity and food insecurity in South Africa. 

Full research study: <https://doi.org/10.1038/s41598-025-03853-4>



BREATH TESTING AS A LESS INVASIVE WAY to monitor Type 2 diabetes

Monitoring diabetes usually involves measuring glucose and ketone levels through blood tests. While these tests provide important information about a person's condition, they either involve drawing blood or using devices such as glucometers. Researchers are therefore exploring less invasive ways of monitoring diabetes, including analysing substances found in a person's breath.

One substance of interest is acetone, which is produced when the body breaks down fat for energy. Acetone is one of three ketone bodies produced during this process. While acetoacetate and beta-hydroxybutyrate are found

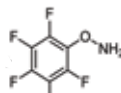
in the blood, acetone can also be released through exhaled breath. Changes in these ketone levels can provide information about a person's metabolic state.

A South African research study investigated whether measuring acetone in the breath could



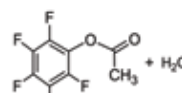
Acetone

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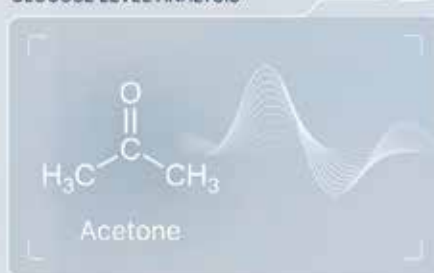
PFBHA

→



Acetone-oxime

GLUCOSE LEVEL ANALYSIS



NON-INVASIVE MONITORING

provide a less invasive way of monitoring people living with Type 2 diabetes. The researchers specifically examined the relationship between breath acetone and ketone bodies in the blood and assessed whether breath acetone could potentially serve as a biomarker for diabetes monitoring.

The study involved 30 adults with Type 2 diabetes and 28 participants without diabetes, all aged between 18 and 60 years. Blood and breath samples were collected during a single visit to a routine hospital clinic. Participants provided fasting blood samples, while breath samples were collected in specialised bags at the same time. The researchers measured blood glucose and two blood ketones—acetoacetate and beta-hydroxybutyrate and analysed acetone levels in participants' breath using gas chromatography-mass spectrometry.

The researchers found higher breath acetone levels among participants with Type 2 diabetes than among those without diabetes. Breath acetone concentrations above 1.8 parts per million were observed in some participants with diabetes, whereas concentrations below 0.8 parts per million were observed among participants without diabetes. However, the researchers noted that glucose and ketone levels can vary between individuals and from day to day, depending on factors such as diet, medication, stress and physical activity.

The study also found a strong positive relationship between acetone in the breath and ketones in the blood. Breath acetone was strongly correlated with blood acetoacetate ($R = 0.897$) and beta-hydroxybutyrate ($R = 0.821$). This finding indicates that breath acetone levels tended to increase as the levels of these blood ketones increased.

The participants with diabetes did not show dangerously high ketone levels during the study. The researchers explained that this does not mean that people with Type 2 diabetes cannot experience high ketone levels; rather, it indicates that the participants in this study appeared to have their condition under control.



The study concludes that the relationship between breath acetone and blood ketones suggests the potential for developing breath-analysis tools as an alternative to blood testing for diabetes monitoring.

The study concludes that the relationship between breath acetone and blood ketones suggests the potential for developing breath-analysis tools as an alternative to blood testing for diabetes monitoring. Such technology could eventually contribute to less invasive monitoring of both Type 1 and Type 2 diabetes and assist monitor the risk of diabetic ketoacidosis. 

Full research study:

<https://doi.org/10.3390/diagnostics9040224>

CLIMATE CHANGE is putting township food gardens under pressure

Urban food gardens can contribute to household food security and provide additional income, particularly for low-income urban households. However, these gardens are vulnerable to changing temperatures, rainfall patterns, pests and extreme weather events, which can affect crop production and the choices farmers make about what to grow.

A research study funded by the NRF investigated the impact of climate change on urban food gardens in Sobantu and Mpopophomeni townships in Pietermaritzburg, KwaZulu-Natal.

The study examined farmers' experiences of changing climatic conditions, how these conditions influenced their food gardens and adaptation practices, and the food security status of farming households.

To achieve its research aims, the study surveyed 103 subsistence farmers actively involved in urban food gardening. Face-to-face interviews were conducted in isiZulu using questionnaires containing open- and closed-ended questions. The study also analysed temperature and rainfall data collected from a weather station in Pietermaritzburg between January 2022 and October 2023. Household food insecurity was assessed using the Household Food Insecurity Access Scale.



The study found that most farmers had observed changes in climatic conditions. In total, 89.3% reported warmer winters and the same percentage reported hotter summers, while 91.3% said that climate change was affecting crops in their food gardens. The farmers' observations corresponded with the recorded weather data, particularly the temperature trends.

Farmers also reported changes in what they could grow. In total, 58.3% said that the effects of temperature had reduced their crop variety, while 14.6% reported an increase and 27.2% reported no noticeable impact. When asked about crop selection, 42.7% said that climate change affected their choices to some extent and 21.4% said that it affected them significantly.

The study also found differences in how farmers were adapting. In total, 34% used drought-resistant crops, 48.5% used water-saving irrigation techniques and 47.6% practised crop rotation and diversification. Access to resources was limited, with 33% reporting no access to water and 72.4% reporting no access to an extension officer.

Food insecurity was also common among the farmers surveyed. The study classified 60 farmers as moderately food insecure, 20 as mildly food insecure and 12 as severely food insecure, while 11 were food secure.

The study concludes that urban agriculture plays an important role in sustaining households but remains vulnerable to climate change. It recommends improving access to resources such as water, land and extension services, alongside climate-resilient agricultural practices, to strengthen farmers' ability to respond to changing environmental conditions. 

Full research study: <https://doi.org/10.1186/s40066-025-00581-w>

In total, 34% used drought resistant crops, 48.5% used water-saving irrigation techniques and 47.6% practised crop rotation and diversification.



A RIVER IN CRISIS AND THE PUBLIC HEALTH IMPLICATIONS of a South African urban river

Rivers are important for drinking water, irrigation, recreation and ecosystems. However, their water quality is threatened by urbanisation, population growth, industrial activities, agriculture and climate change.

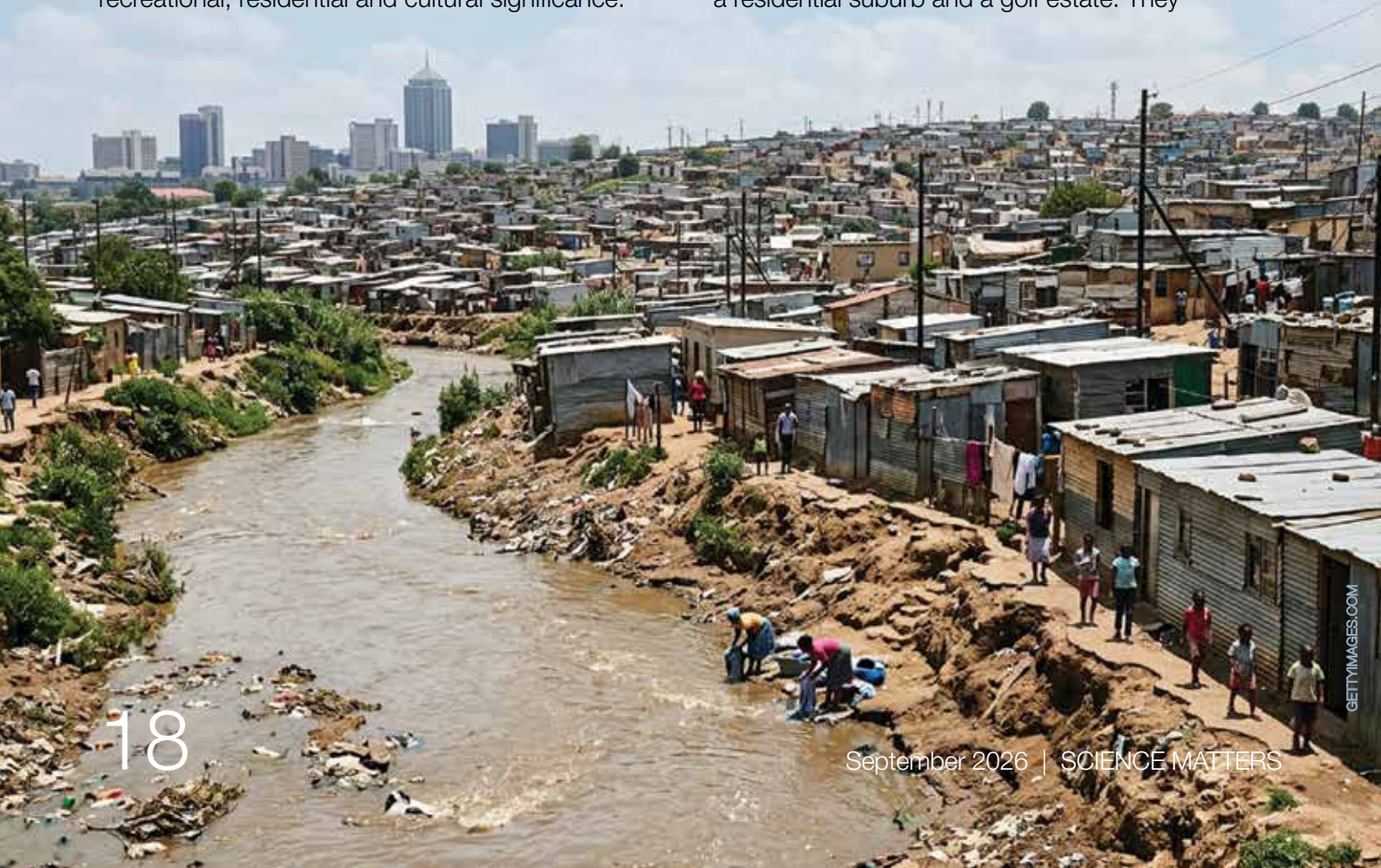
Contaminated rivers can transmit disease-causing microorganisms through various exposure routes, including swallowing polluted water and consuming contaminated food.

In South Africa, the focus of enteric pathogen surveillance is on clinical samples, often overlooking environmental sources such as river water that may also contribute to disease transmission.

A research study funded by the NRF examined the Jukskei River in Johannesburg, which has recreational, residential and cultural significance.

The study investigated microbial contamination and potential health risks from exposure to the river water. Its aims included evaluating water quality, assessing the extent of microbial contamination and determining public health risks related to enteric bacteria in the river water.

To achieve their research aims, the researchers conducted a study at five sampling sites along the Jukskei River, representing various surrounding environments: a business district, a recreational park, a densely populated informal settlement, a residential suburb and a golf estate. They



collected water samples monthly for a year, obtaining 60 samples in total. The analysis included measurements of pH, temperature and total dissolved solids, as well as tests for total coliforms and *E. coli* as indicators of microbial and faecal contamination. Further testing for pathogens such as *Salmonella*, *Shigella* and *Vibrio cholerae* was conducted using culture-based laboratory methods, with the results confirmed by real-time PCR.

Additionally, a quantitative microbial risk assessment was conducted to estimate the probability of infection under three accidental-ingestion scenarios: 1 mL during full-body immersion baptisms, 16 mL during adult swimming and 37 mL during non-adult swimming. The 1 mL baptism scenario was based on an assumption because scientific data on water ingestion during baptisms were unavailable.

The researchers found extensive microbial contamination in the Jukskei River. Total coliform and *E. coli* counts were above acceptable limits at most sites. *Salmonella*, *Shigella* and *Vibrio cholerae* were detected at all five sites. Sites C and D recorded particularly high contamination. Site C was situated within a densely populated informal settlement, while Site D was less than 2 km downstream. Site E, approximately 15 km downstream and alongside affluent neighbourhoods and a golf estate, generally recorded lower contamination.

Salmonella, *Shigella* and *Vibrio cholerae* were detected at all five sites.

For a single exposure involving ingestion of 1 mL of water, the estimated probability of infection ranged from:

- 2.57%–24.73% for *Salmonella*;
- 4.91%–15.99% for *Shigella*; and
- 1.44%–19.5% for *Vibrio cholerae*.

At Site C, a single swimming exposure produced estimated infection probabilities exceeding 50% for *Salmonella* and *Shigella* in both adult and non-adult scenarios. The estimated probability of infection increased with greater volumes of water swallowed and repeated exposure.

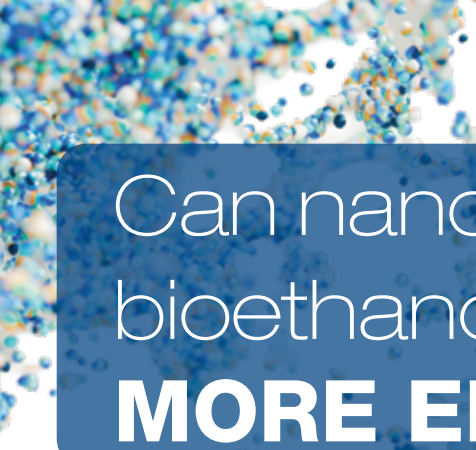
The researchers found high *E. coli* and total coliform levels, indicating significant faecal contamination. Contamination also differed among sampling sites, with Sites C and D recording higher levels than Site E. The researchers discussed these differences in relation to the socioeconomic conditions and sanitation infrastructure surrounding the sites. Importantly, the calculated infection probabilities were modelled risks, not actual cases of infection.

The study did not include an epidemiological investigation to determine whether the Jukskei River was directly responsible for infections in surrounding communities. The researchers also acknowledged limitations in the microbial risk assessment and microbiological methods used, including the confirmation of only a limited number of colonies using PCR.

The researchers concluded that, while some physical and chemical water-quality measurements were within acceptable guidelines, microbiological testing revealed significant faecal contamination and the presence of *Salmonella*, *Shigella* and *Vibrio cholerae*. Estimated infection risks were particularly high at sites near informal settlements.

The researchers called for improved water-quality management and interventions to reduce health risks in vulnerable communities. They also recommended future research using a One Health surveillance approach to better understand enteric pathogens and inform public health interventions in South Africa. [SM](#)

Full research study DOI: [10.1128/aem.01566-25](https://doi.org/10.1128/aem.01566-25)



Can nanoparticles make bioethanol production **MORE EFFICIENT?**

Bioethanol is a renewable fuel produced from carbohydrate-rich biomass and can be used either as a fuel or as a fuel additive. As demand for bioethanol increases, researchers are looking for ways to improve its production and reduce costs. However, high operational costs and low production volumes remain major challenges.

One potential solution is the use of nanoparticles extremely small particles measuring between 1 and 100 nanometres. Their small size and high surface-area-to-volume ratio give them properties that may help improve different stages of bioethanol production.

An NRF-funded review by researchers from the University of South Africa (UNISA) and the Agricultural Research Council (ARC) examined how nanoparticles are being used to improve bioethanol production. The researchers focused particularly on their use as nanocatalysts, nanocarriers and nanoadditives and reviewed their application during three important stages: pre-treatment, enzymatic hydrolysis and fermentation.

Bioethanol production from lignocellulosic waste begins with pre-treatment, which breaks down the structure of plant material and makes cellulose and hemicellulose more accessible. This is followed by enzymatic hydrolysis, during which enzymes break cellulose down into sugars. Finally, microorganisms convert these sugars into bioethanol through fermentation.

The review found that nanoparticles have been investigated as a way of addressing challenges across all three stages.

During pre-treatment, nanoparticles can help break down lignocellulosic structures and assist in removing compounds that may interfere with later stages of production. For example, one study reviewed by the authors used magnetic nanoparticles to detoxify waste potato peel hydrolysate. This improved bioethanol production by 6.6% compared with non-detoxified hydrolysate.

During enzymatic hydrolysis, nanoparticles can act as carriers on which enzymes are immobilised. This can improve enzyme stability and make it possible to recover and reuse enzymes. In one of the studies reviewed, α -amylase immobilised onto chitosan-coated magnetite nanoparticles was recovered and reused 20 times while retaining 79% of its initial activity.

The review found that nanoparticles have been investigated as a way of addressing challenges across all three stages.

Nanoparticles may also support fermentation by immobilising and protecting the microorganisms responsible for converting sugars into ethanol. One reviewed study found that *Saccharomyces cerevisiae* yeast cells immobilised with calcium alginate magnetic nanoparticles increased bioethanol production by 8.9% compared with cells immobilised using calcium alginate alone and by 36.1% compared with free cells.

Across the studies examined, iron oxide nanoparticles and iron oxide alloys were the most commonly reported nanoparticles. The authors suggest that their widespread use may be attributable to properties such as biocompatibility, relatively low toxicity, functionality and cost-effectiveness.

However, using more nanoparticles does not necessarily improve bioethanol production. Their

effects depend on factors such as the type and concentration of nanoparticles used. Although certain concentrations can promote fermentation and ethanol production, high concentrations can inhibit ethanol-producing microorganisms. The review concludes that nanoparticles show promise for improving pre-treatment, hydrolysis and fermentation during bioethanol production.

However, the specific mechanisms through which nanoparticles produce these improvements still require further investigation. Understanding these mechanisms will be important for improving process efficiency, sustainability and cost-effectiveness, and for determining the viability of nanoparticle-assisted bioethanol production on a larger scale. 

Full research study: <https://doi.org/10.1016/j.fuel.2025.135336>



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RECENT DEVELOPMENTS

in *Salmonella* and *Listeria monocytogenes* detection technologies

Foodborne illnesses remain a major public health concern worldwide. According to World Health Organisation estimates cited in a recent review, foodborne illnesses affect approximately 600 million people annually and cause more than 420,000 deaths, most of which occur in low- and middle-income countries. Among the high-risk bacteria associated with foodborne diseases are *Salmonella* species and *Listeria monocytogenes*.

Listeria monocytogenes is of particular concern because it can grow at refrigeration temperatures and may contaminate foods such as ready-to-eat products, cold deli meats, seafood salads, unpasteurised milk and soft cheeses. People with compromised immune systems, pregnant women, older people and infants are among those at greater risk of developing severe listeriosis. *Salmonella*, which causes salmonellosis, is commonly associated with foods such as eggs, poultry, meat and dairy products.

A recent NRF-funded review examined developments in technologies used to detect *Salmonella* species and *Listeria monocytogenes* in food. The researchers reviewed conventional and emerging detection approaches, paying particular attention to electrochemical biosensors and their potential applications in food testing and monitoring.

Detecting harmful bacteria can be time-consuming. Traditional culture-based methods remain widely used and are considered the “gold standard” for

microbiological food analysis. These methods involve growing microorganisms on specialised culture media so that they can be isolated and identified. They are relatively simple and affordable and can provide information about viable microorganisms present in food samples.



However, culture-based methods can also be slow. The review reports that the process from preliminary isolation to final confirmation can typically take between two and five days. It involves several steps, including media preparation, enrichment, plating, incubation and confirmatory testing.

This lengthy process can be challenging for food manufacturers that require rapid results before distributing their products, as well as for border inspection agencies responsible for assessing imported food.

The researchers also reviewed newer approaches, including molecular methods such as polymerase chain reaction (PCR) and loop-mediated isothermal amplification (LAMP), as well as immunological, spectroscopy and mass spectrometry-based methods. While these technologies can improve the speed, sensitivity or specificity of bacterial detection, the review identifies several limitations

including the need for expensive equipment, extensive sample preparation requirements, specialised personnel, as well as difficulties associated with on-site testing.

The review highlights electrochemical biosensors as a promising alternative. These devices use biological recognition elements, such as antibodies, nucleic acids or bacteriophages, that are attached to an electrode. When a target pathogen is recognised, the resulting interaction is converted into a measurable electrical signal.

The review discusses different types of electrochemical biosensors that have been investigated for detecting *Salmonella* and *Listeria monocytogenes*. These include systems that use antibodies, DNA and bacteriophages to recognise specific bacteria. However, these technologies are not without challenges.

The researchers identify barriers to commercialisation, limitations relating to environmental stability, difficulties in integrating nanomaterials with biological components, challenges associated with miniaturisation for on-site detection, and interference caused by complex food samples. These matrix effects can influence the accuracy, sensitivity and reliability of biosensors.

In conclusion, the study shows that the electrochemical biosensors have significant potential as tools for detecting *Salmonella* species and *Listeria monocytogenes*. However, further research and development are needed to improve their performance, accessibility and robustness for practical applications. 

Full research study:
<https://doi.org/10.3390/foods14234139>

The review highlights electrochemical biosensors as a promising alternative.



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