IRRIGATION AND FOOD SAFETY

Dishing the dirt: the long road to food safety in South Africa edges forward

Pollution in rivers doesn't stay confined to the waterway. Its influence can ripple outward and into everyday life. Bacteria carried in the water may end up in leafy greens that we bring home and serve at the table. So writes Petro Kotzé.



For more than a decade, the Water Research Commission (WRC) has funded researchers to follow that journey from the river to the farm to the market stall, each study building on the next and filling gaps in current knowledge. One of the latest recent studies, led by the University of Pretoria (UP) and the University of KwaZulu-Natal (UKZN), looked more closely at the circumstances on smallholder farms and in informal markets, and how the risks can be mitigated.

The report, ***Fit-for-purpose guidelines for managing microbiological water quality risks in smallholder farms and informal fresh produce supply chains*** (**WRC Report No. 3268/1/26**), is another piece of the puzzle that grows more complex as we learn what we eat and how interconnected the elements that influence it are.

A trail of questions

The first broad sweep was an investigation into the quality of water used to irrigate our food, published in 2012 under Prof Trevor Britz, who led the Department of Food Science at Stellenbosch University at the time. His team monitored major irrigation rivers and found exceptionally high microbial and pathogenic loads. Their report uncovered the bleak state of our rivers, and the concomitant risk to those that depend on them. "The potential of pathogenic organisms being transferred from irrigation water to the surface of fresh produce plus their ability to survive in these unfavourable conditions presents the scenario where consumers unknowingly face a high risk of being infected with harmful organisms when consuming fresh produce," they wrote (**WRC Report No. 1773/1/12**).

Senior Researcher at the UP's Department of Plant and Soil Sciences, Dr Erika du Plessis, working within Prof Lise Korsten's team, continued the work in 2015 (**WRC Report No. 1875/2/15**). The project followed microbial contamination from the farm to the market and showed early signs of antibiotic-resistant

Shushan Yemane



An ongoing WRC-funded study is surveilling the Apies River for antimicrobial resistance, testing 14 sites (like this one) along the river.

E. coli, with crops eaten raw of particular concern. Then, in 2017, a revision of the national irrigation water guidelines was being developed by Meiring du Plessis et al., which introduced a risk-based Decision Support System (DSS) that allowed far greater site specificity than the generic 1996 guidelines.

In 2021, du Plessis, with Dr Stacey Duvenage and Prof Lise Korsten of UP, compared formal and informal supply chains in the Cape Town and Tshwane metros (**WRC Report No. 2706/1/21**). They flagged leafy greens as the highest-risk crop and found multidrug-resistant bacteria in the mix. Still, they also remarked that little was known about the informal sector, despite its economic importance. They pointed out that guidance written for commercial growers was not achievable for smallholders.

"There was nothing fit for purpose specifically for smallholder farmers," says Dr Loandi Richter-Mouton, researcher in the same fresh produce and water safety group at the Department of Plant and Soil Sciences. "If that is the only water that they have available to use for irrigation, and there is ***E. coli*** in the water, you can't tell the farmers not to irrigate their crop with [this]," she says. "You must think of alternative methods to try and help them with their available resources." Following the retirement of Dr du Plessis, Dr Richter-Mouton led the next study in the Korsten team, which aimed to address this.

Filling the gap

Dr Richter-Mouton is not new to the question, having completed her Honours on the 2015 project led by Dr du Plessis and Prof Korsten. The existing guidelines, she explains, were not designed for smallholders whose only water source could be contaminated. In the recent project, the team looked for practical ways smallholder farmers could improve their water quality, even though they can't necessarily reduce inputs at the source of contamination.

For this project, the UP team was joined by microbiologist Prof Stefan Schmidt of UKZN. They tested everything from water chemistry to the full genetic code of individual bacteria and looked for traditional foodborne pathogens, as well as a broader range of bacteria and the genes that make them resistant to antibiotics or harmful to people.

The researchers sampled nine smallholder farms and one river, arranged in three case studies. They selected farms that included different farming methods and water sources.

The first case study covered six farms in Gauteng, North West and Limpopo that used varied water sources, irrigation methods, crop types and systems. Their water came from boreholes, a river, a dam and the municipal supply, and the farmers used overhead and drip irrigation and a hosepipe. Between them, they grew leafy greens, roots, and fruits, using aquaculture, integrated livestock, and organic and conventional farming methods.

On one farm, for example, the farmer grows tilapia and vegetables together. Borehole water runs through the fish tanks, picks up nutrients from the fish waste, and settles in a dam before the top water irrigates lettuce, kale, tomatoes, okra and spinach. On another, Chinese spinach, rape and kale grow beside pigs and chickens, and the manure goes straight onto the fields.

The second case study examined three small farms that combine vegetables and pigs, using pig waste to fertilise the crops. Each kept 20 to 25 pigs and used the same borehole water to irrigate spinach and to supply water for the pigs to drink. Workers cleaned the pens daily; one farmer said he occasionally applied pig manure to the fields, and on one farm the pigs roamed freely in the enclosure.

The third case study moved to Sobantu township in KwaZulu-Natal, where small-scale farmers irrigate from the uMsunduzi River. Failing wastewater infrastructure often pollutes the

Michelle Adams



The impact of polluted rivers that are used for irrigation in South Africa has been under investigation for years. The photo shows the Apies River, which is heavily polluted and the subject of a current study.

Lindiwe Mbau



Panellists at the recent farmer engagement, as part of the ongoing WRC-funded study. (From left) Dr Eunice Ubomba-Jaswa (WRC); Dr Vashnee Govender (UP Faculty of Veterinary Sciences); Prof Lise Korsten (UP Faculty of Natural and Agricultural Sciences); Dr Mahlane Godfrey Kgatle (Gauteng Department of Agriculture Land Reform and Rural Development); and, Dr Loandi Richter-Mouton (UP Faculty of Naturla and Agricultural Sciences).

river. Here the team sampled the river itself and tested leafy vegetables from street vendors in town.

What they found

Across three case studies and more than 200 samples, the team did not detect any classical foodborne pathogens on fresh produce, and only one Salmonella isolate was recovered from a single baby carrot sample. "The big wow of this study," Richter-Mouton says, "is probably that we didn't get any pathogenic ***E. coli*** in our fresh produce." She reads it as a sign that farmers who are not regulated are already doing some things right: "We didn't actually find foodborne pathogens even in environments where it looks likely, which tells me that the farmers do have some sort of best practices that they are implementing at some level."

Their results come with a caveat: they visited each farm only once, and they could not trace the vegetables at the informal market back to their farms of origin. Without repeat sampling, the team cannot yet say whether the same organisms and genes persist or shift with the seasons. Nor does it mean the water carries no risk. The river showed the problem most starkly. On all 37 sampling occasions, the uMsunduzi exceeded the recommended limits for faecal bacteria in water used to irrigate produce that may be eaten raw. An earlier study of the same river had recorded a highest ***E. coli*** count of 7 900 most probable number (MPN) per 100 ml. This time it reached 170 000 MPN/100ml. Salmonella was confirmed in the river on seven occasions. Across the study, irrigation water emerged as the primary driver of contamination.

The more complex issue, Dr Richter-Mouton says, is antimicrobial resistance (AMR). All ***E. coli*** isolates from the farm case studies were multidrug-resistant (resistant to three or more classes of antibiotics). Sequencing found clinically significant resistance genes, and near-identical DNA fingerprint and resistance profiles in a farm's irrigation water and its harvested crops, which the report treats as confirmation of direct water-to-produce transmission.

In the KZN river, most ***E. coli*** isolates were susceptible to the antibiotics tested. However, more than a fifth were resistant to ampicillin, and one strain belonged to a lineage linked to urinary tract and bloodstream infections elsewhere in the world.

The leafy greens from the market carried no ***E. coli*** above the detection limit but did carry antibiotic-resistant opportunistic bacteria. "If you become sick, treatment options become difficult if the pathogens are resistant to the specific antibiotics," Dr Richter-Mouton explains. AMR is "a much bigger, much more complex problem worldwide." It is also why the team went beyond counting bacteria to reading their genes. The same species can be harmless or not, depending on what it carries. In the case of Enterobacter, the same organism can be harmful or helpful depending on its genes. With one set, it causes diseases; with another, it acts as a biocontrol agent that naturally destroys harmful organisms.

Resistance reaches food from various places. When resistant organisms from hospitals enter the waterways through effluent or wastewater, she explains, their resistance genes can be

transferred to the bacteria already in the environment, "and now you get expanded resistance in your normal natural flora that's on your products." She points to faulty wastewater treatment works pumping raw sewage into the rivers as one of the current biggest influences. "It's very difficult to remove once the system is compromised," adding that, though they are careful to avoid the politics, it's also important to show what's going on.

Water first

The aim, she stresses, is awareness, not blame. "If you think about your food, you also need to think about the environment it was grown in... What is upstream of your water, what is downstream of your water?"

The project outcomes included two ten-page guides approved by the WRC, in plain language, one for farmers and one for informal vendors. For vendors, a three-step routine of test, treat and wash is recommended. For farmers, they propose simplified risk tiers linked to water source, crop and irrigation method, with stricter limits for raw-eaten leafy greens and surface water than for borehole or municipal water.

Decision trees, low-cost testing, and basic treatments such as sand filtration are meant to help farmers assess risk without a laboratory. Where water cannot be cleaned up, the report points to multiple barriers, such as drip irrigation where feasible, safe composting and washing produce in clean water.

Further along the trail

The research team is already busy with the follow-up study. The current WRC-funded study (C2024/2025-01602) focuses on longitudinal antimicrobial resistance (AMR) surveillance along river systems. They are sampling at 14 sites along the Apies River, from its origin to its convergence with the Pienaars River, Dr Richter-Mouton explains, on a bi-monthly basis for a year, starting in July 2025. Again, collaborating with UKZN, three sites along the uMsunduzi river are also being sampled.

Their analysis grows clinically significant bacteria from the water in the lab and also reads the DNA directly from the water to map the full set of resistance genes it carries, known as the resistome. They aim to determine whether the same organisms and genes appear over time and across seasons, working towards a proper risk assessment, with the results going into an open-access dashboard.

To mark their mid-project findings, they held a meeting with local farmers to share their findings and learn what they would like the study to address further based on the results. But Dr Richter-Mouton says the discussion rapidly shifted away from antimicrobial resistance and focused instead on the immediate, day-to-day challenges farmers face along the highly polluted Apies River.

They spoke of clear, cumulative losses on the Apies, including crops failing, lucerne yields far below normal, polluted farm dams (including sludge from a 2025 Rooiwal wastewater treatment works failure), sharp drops in labour, land values down ~50%, and water-truck deliveries stopped in early 2023. They also described years of meetings with no repair and pollution from both sewage and industrial sources, with the river damaged by the authority meant to protect it.

For Dr Richter-Mouton, their feedback clarified that while researchers may pursue a defined question and objective, effective science communication requires prioritising the broader needs and realities of the farmers themselves. Addressing the foundational pollution problem is a necessary first step, she says, adding that it is almost unfair to expect farmers to engage with antimicrobial resistance in the water when the scale of the underlying contamination remains so extensive.

The work continues, and results will leave more questions for future research projects to answer. Some of those, already raised at the meeting, include facilitating shared, cross-departmental action, stronger biosecurity, the participation of farmers in industry and animal-safety forums and, in the long term, ranking rivers according to how safe they are to use, and more proof to support One Health (the idea that human, animal and environmental health are tied together) impacts.

For enquiries, contact Dr Loandi Richter-Mouton at loandi.richter@up.ac.za

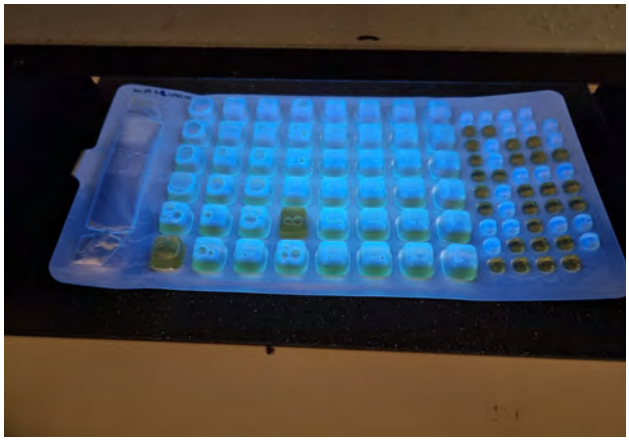


Photo supplied

E. coli *fluorescence of Colilert enumeration – a standardised laboratory method used to detect and quantify total coliforms and Escherichia coli (E. coli) in water samples.*



Loandi Richter-Mouton

The site of clear wastewater input into the Apies River, which is used for, among other uses, irrigation and agriculture.