Finding toxic carcinogenic metals faster in foods and water

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Researchers at the University Johannesburg have developed an efficient and more sensitive method to test for dangerous levels of heavy metals like arsenic, cadmium and chromium in vegetables and water. The method can be used to test other foods, also. It is possible to test for several metals at the same time and the process can be automated. The process involves technology readily available in laboratories in developing countries.

Trace metals such as lead (Pb), arsenic (As), cadmium (Cd) and thallium (Tl) are toxic even at very low concentrations. Arsenic, cadmium and chromium hexavalent compounds are also recognised as carcinogens by the International Agency for Research on Cancer (IARC) and the US National Toxicology Program (NTP). Combining accurate and established techniques, the method makes it possible to test for several trace metals simultaneously.

"The study provides a simple, fast and sensitive method for laboratories with limited resources. The research results can also improve food quality for consumers," says lead author Prof Philiswa Nomngongo, the SARChI Chair of Nanotechnology for Water at the University of Johannesburg.

"This study contributes data that can be used as a reference when setting up or revising the guidelines for the maximum allowable levels in common vegetables and palatable water," she adds.

"The method is environmentally friendly and conforms to green analytical chemistry principles. It does not introduce secondary pollution."

New combination of techniques

Previous studies used similar methods, but for analysis of organic pollutants says Dr. Luthando Nyaba, co-author of the study, also at the University of Johannesburg.

"This is the first time where a clay-based adsorbent is combined with a cloud point extraction method for simultaneous analysis of trace metals in vegetables and palatable water," he says.

"In this method, we convert solid vegetable samples into liquid form. This makes it possible to directly analyse trace metals with a suitable analytical instrument. Direct, simultaneous analysis means that more vegetable samples can be analysed at the same time, more quickly than was possible before," adds Nyaba.

The method uses ultrasound-assisted cloud-point extraction and dispersive micro-solid phase extraction to preconcentrate samples from vegetables and water. The samples are then directly analysed with inductively coupled plasma optical emission spectrometry. The equipment used for the research is a few years old, says Nomngongo. However, he says, "If we buy vegetables at 8:00 in the morning, we have the analysis results by 1:00 in the afternoon," she adds.

To identify trace metals in foods and water requires analytical chemistry techniques. These evolve over time, much like apps on mobile phones, he says.

"The developers of a phone app can fix software bugs without rewriting the app completely. They add fixes to a new version, and users download the new version to benefit.

"Analytical chemists are like software developers, making updates to an existing method to make them compliant with new analytical chemistry principles. In this case, one of our goals was to significantly the reduce the amounts of hazardous solvents traditionally used in testing for trace metals," adds Nyaba.

Hard to detect

All over the world, unwanted trace metals are showing up in vegetables and drinking water. These metals are among many pollutants that seriously affect human health. Monitoring which metals occur in foods and beverages can really challenge a laboratory. First, labs often cannot directly measure some trace metals in foods, because they occur in concentrations that are too low for the the equipment to detect. This means that sophisticated methods and expensive equipment are needed to detect the presence of some trace metals.Secondly, vegetables are inherently complex to analyse for chemical elements accurately, and often require long, time-consuming procedures to prepare samples for metal testing. This means that monitoring for trace metals in agricultural produce is generally slow, expensive, and can only be done by highly qualified scientists. For developing countries, monitoring can be inaccessible because of that.

To stay healthy, humans need to eat vegetables and drink water. High-quality vegetables contain many micronutrients, including trace metals the body needs to function well. But high doses of some metals can make people sick, though health conditions such as cancer may take years to manifest. Others are so toxic that very low amounts can make people extremely ill within days or weeks.

"We need to eat foods containing some trace metals, such as copper, zinc and iron. But others are toxic—lead, arsenic cadmium, mercury, among others. On the one hand, vegetables form a vital part of human nutrition. On the other, they are good accumulators of heavy metals," says Nomngongo. "Knowing the level of metal contamination in the vegetables we eat and the water we drink can make a difference to health and quality of life," she adds.

Metals everywhere

Unwanted metals affect food crops and drinking water worldwide.

Heavy metals pollution from urbanisation, factories, mines, and other industries filter into sources for drinking water and irrigation in agriculture. Some agricultural fertilizers, including re-purposed sewage sludge, also affect food crops. Many of these metals bio-accumulate in the human body, in animals, plants and the environment. This means that the metals cannot be removed and that the resulting problems can only be managed, not cured.

The World Health Organisation (WHO) and national governments publish drinking water guidelines and other standards showing which levels of metals in food and water are likely to affect human health. And the WHO's International Agency for Research on Cancer (IARC) and the US National Toxicology Program (NTP) publish lists of known and probable human carcinogens.

Locally, the research results can help improve the quality of life for communities that depend on the studied water sources, says Nomngongo. "The results can also assist the South African government and environmental protection agencies to set, review and enforce water quality regulations," she adds.

More information: Luthando Nyaba et al. Determination of trace metals in vegetables and water samples using dispersive ultrasound-assisted cloud point-dispersive µ-solid phase extraction coupled with inductively coupled plasma optical emission spectrometry, *Food Chemistry* (2020). DOI: 10.1016/j.foodchem.2020.126749

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