Detecting the invisible: Encouraging results from study on emerging contaminants

Emerging contaminants are becoming a worldwide concern as world authorities are grappling with the contaminating byproducts of our modern society. A study funded by the Water Research Commission (WRC) has tested the local waters for these previously elusive substances with encouraging results. Article by Lani van Vuuren.

Humans have witnessed incredible progress in the modern era – our technologies are getting smarter, our beauty products are allowing us to remain beautiful and medical breakthroughs are making us live longer, healthier lives. But these developments come at a price. Pollutants which have erstwhile been undetected and are largely unregulated are now entering our water resources at levels that may be posing risks to human health and the aquatic environment.

New detection and monitoring methods are now allowing us to determine the potential risk of these emerging contaminants and monitor their levels in our water sources. WRC Research Manager, Dr Kevin Murray, explains: "Emerging contaminants include chemicals and microorganisms that up to now have not been considered a problem in our natural waters. This may be because they are new or because it has only now come to light that they may be problematic as a result of new analytical methods that can now detect them or because of new toxicity information."

These substances include pharmaceuticals, pesticides, hormones, disinfection byproducts, personal care products and fragrances,

industrial and manufacturing chemicals, nanoparticles, organic solvents and recreational and non-controlled drugs, among others. Since many emerging contaminants are legislatively unregulated this may allow substances to be released into water resources at levels that could pose a health risk.

In some cases, these compounds may interfere with our endocrine systems (these substances are known as endocrine disrupting compounds or EDCs). EDCs have developmental, reproductive, neurological and immunological effects at certain levels of exposure. Research has shown that such effects are most pronounced during prenatal and early post-natal development, at a time when organs and neurological systems develop.

The contamination of countries' water systems by these products is quite widespread. A survey by the US Geological Survey (USGS), for example, found at least one emerging contaminant in 80% of streams assayed. Compounds such as antidepressants, caffeine, cholesterol, the plasticiser Bisphenol A, and tricoslan (an antimicrobial found in many disinfectant soaps) are frequently detected in streams.

EMERGING CONTAMINANTS AND DRINKING WATER

The levels, seasonal fluctuations and effects of emerging contaminants on health at environmentally observed concentrations are largely unknown. Typically, acute toxicity is not a real concern with these compounds (except in the case of a major chemical spill), however, there is concern regarding the potential effects of long-term exposure to low dosages.

Advances in detection and monitoring technology, such as mass spectrometry, have allowed the highly sensitive detection and identification of emerging contaminants in water samples, thus increasingly attracting the attention of water quality administrators and environmental scientists. Many developed countries have started taking action against emerging contaminants. In the US, for example, the Environment Protection Agency (EPA) has published maximum contaminant level goals while the USGS has an emerging contaminants project and a list of contaminants proposed for regulation. In the European Union, drinking water directives have been issued which include guideline levels for a range of emerging contaminants.

Christiaan Odendaal, a Ph.D. student in Environmental Management at the University of the Free State, attaches a column to a high performance liquid chromatography system which separates emerging contaminants before they are detected or quantitated in a mass spectrometer.

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South Africa's present knowledge of emerging contaminants, on the other hand, is not well developed. Until now, no comprehensive, national survey has been undertaken on the presence of emerging contaminants in drinking water in South Africa, and there is no national programme that reviews possible health impacts of EDCs or routinely monitors emerging contaminants in drinking water.

According to Dr Murray, this is partly because the analytical methods required to detect and monitor these contaminants are quite demanding and expensive. Detecting emerging contaminants requires not only appropriate scientific instruments, but also highly-trained staff. "We are only now beginning to establish the necessary expertise in South Africa to detect and monitor these contaminants."

It has become crucial to significantly and urgently expand our knowledge on emerging contaminants in our water resources, and to develop a coherent scientific response to this presence. It is for this reason that the WRC has been funding a scoping study into emerging contaminants and their potential influence over drinking water quality in South Africa. The study has been led by the Advanced Biomolecular Research Cluster at the University of the Free State.

The ultimate aim of the research project – which was being finalised at the time of writing – is to provide the necessary scientific knowledge to guide future policy directives regarding emerging contaminants in South Africa. A research strategy to guide further research into emerging contaminants is also being developed as part of the study.

According to project leader, Prof Hugh Patterton, Professor and Director: Advanced Biomolecular Research Cluster, the WRC-funded study has provided an important first glimpse into the state of drinking water in South Africa in terms of the presence and levels of emerging contaminants.

TESTING THE WATERS

In order to gain insight into the range of possible emerging contaminants present in South African drinking water the project team first undertook a limited, qualitative screen of drinking water in two major cities. Samples were taken at different times over several months. The team used liquid chromatography tandem mass spectrometry – a chemistry technique that combines the physical separation capabilities of liquid chromatography with the mass analysis capabilities of mass spectrometry – to analyse the samples.

The aim of the exercise was to develop a rough list of possible ECs to eventually quantitate as part of a national survey. A total of 11 contaminants were detected over the sampling period. From the initial list three emerging contaminants were selected for further study, namely atrazine, terbuthylazine, and carbamazepine. The first two contaminants are widely used pesticides, while the latter is an anti-convulsant and mood-stabilising drug. The three contaminants were chosen on the grounds of the severity of their adverse health effects as well as their widespread presence in the initial water samples.

Water samples were then taken over four seasons at water treatment plants in all of South Africa's major cities where the treated water enters the reticulation system. Tap water was also tested at several sampling points. All of the water treatment plants were willing participants in the project. Prof Patterton reports that the logistical arrangements to get the water samples back to the laboratory as quickly as possible after taking each sample proved quite a challenge.

Satellite imagery of the sampling sites played an important role in identifying critical precursors of pollution in areas surrounding water treatment plants and in catchment areas. Factors including agriculture, forestry and human habitation may suggest an expected degree of pollution. For instance, areas of high agricultural activity will suggest likely pesticide pollution. Sites such as industrial areas and power stations will also be important sources of water pollution.

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Carbamazepine was primarily found at higher concentrations in the tap water of Bloemfontein and Pretoria. In turn, atrazine was found to be more prevalent in Bloemfontein and Johannesburg, where run-off from farms in major summer grain producing regions could conceivably introduce the weedicide into the drinking water. The highest concentrations of terbuthylazine were found in Pretoria.

The news was not as bad as expected, however. *All* of the samples analysed for all of the contaminants from all the water treatment plants in each of the four seasons were below the limits at which these contaminants pose a health risk, according to the EPA. This is assuring news, says Dr Murray. "From this project we know that the three selected contaminants at least do not seem to be at levels that should cause immediate alarm. This means we have our eye on the ball at present."

Prof Patterton adds that, while it is unlikely that the levels of the three emerging contaminants in the drinking water sampled currently pose a risk, there are many emerging contaminants which have not been quantitated, and which still require attention. "There is a clear need for a more comprehensive, routine testing of drinking water for the presence of emerging contaminants in South Africa, including borehole water and untreated surface water consumed by rural communities. More research is also required to better understand the impact of the many compounds on human and environmental health."

Various actions can already be taken to reduce the risk posed by emerging contaminants. This includes proper management of landfill and medical waste sites, proper discarding of unwanted medicines, appropriate use of modern pesticides matched to the need of the pesticide, the use of organic agricultural approaches wherever possible, and the strict enforcement of legislation governing introduction of industrial waste into surface water systems.

The study has contributed significantly to the groundwork required to effectively manage emerging contaminants in South Africa. It has also built much needed capacity and expertise. "The project has established a centre of analytical expertise, while providing important information on the levels of some of these contaminants in our drinking water around the country," says Dr Murray.

Future investigations are expected to build on the results of the WRC project. This will create the armoury of knowledge necessary to take decisive action against the challenge of emerging contaminants in South Africa. ❑

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Christiaan Odendaal adjusts the flow of a solid phase extraction (SPE) cartridge manifold. Water is passed through a SPE cartridge to concentrate emerging contaminants in a water sample prior to analysis.