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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Drinking water

Assessing currently known and emerging contaminants influencing drinking water quality

The Water Research Commission funded the first national survey on emerging contaminants in drinking water in South Africa.

Background

Over the past decade studies on contaminant levels in European and North American drinking water revealed the presence of an extensive range of extraneous chemicals, including pesticides, pharmaceuticals, industrial and manufacturing chemicals and personal care products. Some of these components are known carcinogens or endocrine disruptors, and may pose a severe health risk to humans and the environment.

The majority of these chemicals as well as emergent pathogenic microorganisms are not legislatively regulated, and their levels, seasonal fluctuations and effect on health at environmentally observed concentrations are unknown. These chemicals are collectively referred to as 'emerging contaminants' (ECs), and range from pharmaceuticals, pesticides and hormones to personal care products, industrial and manufacturing chemicals as well as recreational and non-controlled drugs, among others.

Advances in mass spectrometry and refinement of the polymerase chain reaction have allowed the highly sensitive detection and identification of ECs in water samples, thus increasingly attracting the attention of water quality administrators and environmental scientists. To date, no comprehensive, national survey has been undertaken on the presence of ECs in drinking water in South Africa. This is of great concern to water health regulators considering the findings from Europe and the US.

It was therefore crucial to significantly expand knowledge on ECs that may be present in South African drinking water, and to develop a coherent scientific response to this presence.

National survey

A limited, qualitative survey was undertaken on drinking water sampled on multiple occasions in two major cities in South Africa. The project team concentrated on the detection of polar, water soluble compounds.

A careful consideration of the severity of the possible health effects of each of the identified contaminants finally provided three chemical determinants with the highest potential of having a negative health impact. These were the herbicides atrazine and terbuthylazine, and the anticonvulsant, carbamazepine.

Then an extensive national survey was undertaken on the concentration of these three chemicals in drinking water of several metropolitan areas. A qualitative screening was also performed on each of the water samples. For this study a liquid chromatography linked to tandem mass spectrometry (LC-MS/MS) quantitation method was developed and validated.

Samples were collected from water purification plants in Bloemfontein, Johannesburg, Pretoria, Durban, Pietermaritzburg, Port Elizabeth and Cape Town at points before the water entered the reticulation system. Water was also collected from domestic taps in southern and northern Bloemfontein, served by different water sources.

Main results

In total, 34 pharmaceuticals and pesticides (out of 618 tested) were detected in the water samples over a four-season period. In line with the preliminary screen, atrazine,

carbamazepine and terbuthylazine were detected in the highest number of water samples and with the most number of seasonal occurrences.

Apart from these compounds, compounds that were detected in three or more seasons included hexazinone, phenytoin, and tebuthiuron (Durban), tebuthiuron (Johannesburg), and fluconazole, phenytoin and tebuthiuron (Bloemfontein). The antimalarial, cinchonidine, was detected in at least three seasons in each of the seven cities that formed part of the study.

Quantification of the herbicide atrazine showed that it was present at elevated levels (approximately 12 ng/ℓ) compared to the other cities, in each of the four seasons in Johannesburg. A similar elevated seasonal presence was observed in Johannesburg for the herbicide terbuthylazine. The anticonvulsant carbamazepine was present at elevated levels (about 200 ng/ℓ) in all four seasons in Bloemfontein.

The highest level of atrazine (163 ng/ℓ) and terbuthylazine (206 ng/ℓ) determined, were in Pretoria in the autumn. The highest level of carbamazepine was 324 ng/ℓ in Bloemfontein in the summer.

The maximum contaminant level (MCL), a level set by the Environment Protection Agency of the USA (i.e. a level where there is no known or expected risk to health) was stipulated at 3 µg/ℓ for atrazine and terbuthylazine, and 12 µg/ℓ for carbamazepine. Thus, the maxim levels detected for each of the three surveyed compounds never exceeded the stipulated MCL.

In fact, the maximum never exceeded 6% and 7% of the MCL in the case of atrazine and terbuthylazine, respectively. In the case of carbamazepine, the highest detected level did not exceed 3% of the MCL. It therefore appears that even the highest recorded levels of the three ECs included in this survey never approached a level where it would be expected to have an impact on human health.

A major consideration when determining the observable impact of contaminants in drinking water is not only the quantitated level of the contaminant, but also the size and demographics of the population that would routinely consume the water. This impact is generally expressed as a risk, and is a function of the hazard, the vulnerability of the population, and the capacity of the population to overcome the hazard.

The severity of a hazard can be expressed on a scale from 1 to 5, corresponding to levels where the effect of the hazard is described as negligible and increasing to a level where it is described as extremely severe.

In order to map the hazard severity level of a compound, detailed data on the health impact, preferably from medical case studies or epidemiological studies, must be available, including exposure concentrations, conditions, and health effects.

Very little precise data is available over an environmentally relevant concentration range in the case of the three ECs studied. However, by making use of available data, the project team was able to roughly correlate the concentrations of these compounds to severity levels.

A hazard matrix was then developed by combining the severity of the hazard with the frequency of its occurrence. This allowed us to propose a risk matrix ranging from 1 to 20, representing the range from low severity/low frequency to high severity/high frequency risks.

Since the average and the highest quantitated levels of the three tested ECs were well below the MCL, a severity score of 1 for each is proposed. The hazard risk was then mostly an effect of the fractional seasonal occurrence of each of the tested ECs.

Using banded ranges, the occurrence of atrazine and terbuthylazine in the water sourced from Bloemfontein, Johannesburg, Duran and Pietermaritzburg was found to represent a medium hazard. Terbuthylazine was a medium risk in the water from Cape Town.

Carbamazepine was found to be a medium risk in the water from Johannesburg, Pretoria, Bloemfontein, Durban, Pietermaritzburg, Cape Town and Port Elizabeth. However, the frequency and level of the detected compounds did not require any specific and aggressive remedial action.

The project team noted that careful attention must be given to what is understood by risk, hazard and health impact, and these concepts must be used consistently. It is also necessary to be extremely rigorous to arrive at an accurate risk assessment, and any assumptions made in that assessment must be clearly stated.

Conclusion

The study was extremely valuable in that it demonstrated the presence of a range of emerging contaminants in South African drinking water. Several areas were also clearly identified that require further research to fully understand

the possible impact of ECs on the South African water consumer.

Although the quantitated levels of the three most frequently observed ECs were less than 10% of their respective MCLs, the range of ECs observed may indicate a growing problem. A national programme in which drinking water is seasonally or bi-annually qualitatively screened, and frequently observed ECs quantitated, should be considered.

Furthermore, the proposed hazard matrix showed that the country lacks information on the vulnerability of populations and their capacity to overcome the posed hazard. The ability is particularly acute for economically repressed, rural populations that were excluded by the scope of the study. It is recommended that a similar qualitative screen and quantification of the level of select, identified ECs be undertaken in one or more rural communities that routinely use raw water directly from rivers or dams.

Lastly, medical waste and pesticides are often dumped in unprepared locations, where leaching of pharmaceuticals and pesticides into groundwater reservoirs is possible. The contamination of groundwater and retrieval and use of such water through boreholes remain unexplored. A study on the presence of pharmaceuticals in borehole water due to leaching from medical waste dumping grounds is thus recommended.

Further reading:
To order the report, *Scoping study and research strategy development on currently known and emerging contaminants influencing drinking water quality* (**Report No. 2093/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za, or Visit: www.wrc.org.za to download a free copy.