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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 treatment

Managing EDCs in drinking water treatment

WRC-funded research has investigated the feasibility of using a health risk assessment framework to derive guidelines for EDCs in South Africa.

Research towards a framework for deriving EDC guidelines in drinking water

Globally, endocrine disrupting chemical (EDC) research has been ongoing for the last 20 years. In South Africa, the Water Research Commission (WRC) has maintained a focus on endocrine disrupting compounds in water since 1998 and has also been a partner in several global research initiatives relating to this topic.

Most of the SA research done to date has focused on the reproductive effects and endpoints of EDCs in the environment, with a few investigations into EDC effects on the immune system and thyroid function. Oestrogenic activity has been found to be present to varying degrees in both raw and treated waters.

There is agreement, internationally, that precautionary action should be taken in addressing this issue. Currently, the levels at which endocrine disruptors adversely affect health are somewhat uncertain, despite indications that adverse effects do in fact occur.

Previous WRC-sponsored research resulted in a proposed framework for dealing with EDCs and protecting human health, pending the derivation of more inclusive guidelines for drinking water provision in South Africa. The proposed framework recommends a precautionary, risk-based, tiered approach, whereby trigger values for oestrogen activity are derived and screening for active compounds in the water environment takes precedence over testing for specific target chemicals. Any indication of oestrogenic activity in excess of the recommended trigger value would necessitate further investigation and testing of the water in question.

The following questions have subsequently arisen: How feasible is it to implement such a health risk assessment framework in deriving guidelines for EDCs in South African treated drinking water? Are the tools and necessary organisational structures available for carrying out tests that would reveal the exceedance of trigger values and consequently enable tiered testing of water samples to take place as needed?

Feasibility of implementing the proposed framework in deriving EDC guidelines for SA drinking water

The trigger value

The proposed framework makes use of an oestrogenic activity trigger value, with oestrogenic activity being determined by means of bio-assays. Oestrogenic activity in water is measured in terms of oestradiol equivalents (EEQ) per litre (ng/ℓ). Oestradiol is the most potent of compounds in terms of oestrogenic activity and also the standard against which oestrogenic activity of all other compounds is measured.

The trigger value of 0.7 ng EEQ/ℓ is based on the World Health Organisation's value for an acceptable daily oestradiol equivalent intake of 50 ng/kg of body mass, also taking into consideration that exposure through water intake probably accounts for only about 10% of the total exposure to oestrogenic activity. Furthermore, in calculating the trigger value, an average body mass of 65 kg and daily water intake of 2 ℓ were assumed and allowance made for a safety factor of 1 000 to compensate, among others, for sensitive populations. Considering the ranges of human body mass and daily water intake that could realistically be encountered, the trigger value

could vary, with 90% certainty, between 0.14 ng EEQ /ℓ and 3.44 ng EEQ /ℓ.

Work-shopping the trigger-value approach

Potential problems with the trigger value and its use, which, if not addressed, could impact on the feasibility of implementing the proposed framework, were examined during the course of workshops held to share current knowledge regarding EDCs and ideas for dealing with them in the context of managing drinking water quality and protecting human health.

At these workshops, scientists discussed the difficulties in detecting EDCs, whilst government representatives concerned with water quality management raised issues regarding the development of water quality guidelines. A central focus was on how current knowledge could facilitate the use of the oestrogenic activity trigger value as an interim EDC-related water quality guideline and early warning mechanism.

Oestrogenic activity in relation to the trigger value

A variety of environmental and drinking waters were subsequently tested for oestrogenic activity to assess whether the proposed trigger value was realistic and useful in practice. River waters generally had oestrogenic activities above the trigger value of 0.7 ng EEQ/ℓ. Most drinking waters originating from conventional treatment systems or from taps had activities below 0.7 ng EEQ/ℓ.

The trigger value was exceeded in many cases where samples were taken from water stored for consumption in plastic drums. This is not surprising, as the bio-assays are highly sensitive and the sampling procedures generally exclude water in contact with plastic.

On the whole, bio-assay results were within anticipated ranges, indicating that use of the South African framework, based on a trigger value for oestrogenic activity, is indeed feasible. Instances of the trigger value being exceeded do not necessarily indicate that endocrine disrupting effects will follow, as the trigger value is very conservative and its use highly precautionary. On occasions when the trigger value is exceeded, additional situational analysis might explain the possible source of the oestrogenic activity. If this is not possible, then targeted chemical analyses should be conducted to determine the source and, consequently, the need for further intervention.

Testing procedures for inclusion in the proposed framework for EDCs in water

Bio-assays are becoming increasingly popular as screening tools because the specific chemical nature of an environmental sample is not always known. In the case of EDCs, bio-assays currently measure total oestrogenic and androgenic activity resulting from all the endocrine disrupting chemicals present in a water body.

No single assay can accurately predict the total oestrogenic activity of complex samples. The need, in fact, still exists to develop a recommendation for a suite of suitable and reliable methods including both *in vitro* and *in vivo* bioassays. International and local research on the compilation of a toolbox of bio-assays for detection of oestrogenic activity in water has produced some results but research remains ongoing.

Some of the techniques included in the toolbox's battery of tests are sufficiently advanced and can be used as a cost-effective, first-pass detection system. Together with other standard analytical methods, they can be used to measure oestrogenic pollutants in environmental waters.

A major shortcoming, however, is the lack of standardisation with regard to data analysis or interpretation. Standardisation has been identified as a crucial step towards more accurate, bio-assay-derived, measurements of oestrogenicity. Currently, other shortcomings with regard to the use of bio-assays relate to cost (about R2 000 per sample), time (one technician is capable of processing no more than four samples per week) and limited capacity (only two local university laboratories are set up to conduct bio-assays routinely and only a few experienced individuals are capable of carrying out these tests).

In measuring oestrogenic activity, the focus is mainly on potential reproductive effects of EDCs in water. Other possible effects, such as immunological, neurological, cognitive and metabolic effects, would require different assessment tools and measurements. Internationally, tests for thyroid activity are currently being developed along a path similar to that followed in arriving at the battery of tests now available for assessing oestrogenic activity.

Conclusion

The feasibility of using the proposed South African framework to assess endocrine disrupting activity in water relative to a trigger value has been demonstrated. In the

event of the trigger value being exceeded, the possible cause or source of the oestrogenicity would need to be identified by a multi-disciplinary team, given that possible sources of oestrogenic activity include industry, agriculture, waste streams, etc. Follow-up sampling and analysis to identify the specific chemicals responsible for the oestrogenicity would then need to be undertaken before remedial action could be instituted.

Despite the considerable progress made in identifying bio-assays for the assessment of oestrogenic activity in drinking waters, more research is needed to build South Africa's capacity in this regard. Research should focus specifically on reducing the cost and duration of these assays, whilst continuing to develop standard operating procedures for the current set of *in vitro* and *in vivo* assays. Steps in the direction of standardisation are currently being taken through compilation of a series of guideline documents that address EDCs in SA's water resources.

Further development of bio-assays requires a greater focus on *in vivo* methods in order to enhance capacity for studying EDC-related trans-generational effects and whole-organism metabolism. Research is also needed to develop extended capacity for studying EDC effects on thyroid function, immune-suppression and neuro-development, in addition to those on the reproductive system.

From an EDC control perspective, it would seem that a properly functioning water treatment works removes most of the EDCs – an inference supported by the finding that most treated drinking waters contain less than the recommended trigger value for oestrogenic activity and would therefore not require additional, specific investigation. This is fortunate, since most drinking water treatment facilities would not have the capacity and finances to test for oestrogenic or other endocrine activity.

In order to optimise the role of water treatment facilities in controlling EDCs, a database containing information on the size, functioning, and treatment processes utilised at each of the water treatment facilities should be compiled. This information should be related to similarly compiled information on local conditions, in order to assess potential human health risks arising from endocrine disrupting substances that are produced locally (e.g., by industry or agriculture) and cannot be removed effectively by current water treatment processes.

Some indication of the hormone removal efficiencies of WTWs throughout the country could be acquired through the use of a simple enzyme-linked immune-sorbent screening assay (ELISA) for the standard hormone, oestrone. Overall, the risk assessment approach might be more feasible and cost-effective than an approach which requires each of the treatment facilities to test its own waters for oestrogenic activity.

Further reading:
To obtain the report, *The feasibility of using a health risk assessment framework to derive guidelines for oestrogen activity in treated drinking water* (**WRC Report No. 1749/1/09**), contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.