Drinking water as a potential medium for the development and dissemination of drug resistant microorganisms

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Results from a Water Research Commission (WRC) scoping study have indicated that low levels of antimicrobial substances (including antibiotics) and antibiotic resistant bacteria may be present in the final drinking water reaching the South African consumer.

Background

The increased resistance of micro-organisms to substances originally designed to be effective against them is becoming a significant problem throughout the world. Apart from natural causes, this problem is exacerbated by the inappropriate/overuse of anti-microbial substances in human infection control, as well as agricultural and animal production.

These substances end up in our water resources systems, e.g. rivers, lakes, dams, and groundwater, which are used for drinking purpose and food production. The presence of antimicrobial sub-stances, for example antibiotics, in the water serves as a selective pressure resulting in the development and/or dissemination of resistance bacteria and genes. The potential for antibiotic resistant bacteria (ARB) and antibiotic resistance genes (ARGs) dissemination into the human body through drinking water is a major public health threat.

This threat becomes even more pronounced if resistance is transferred to clinically relevant human pathogens and opportunistic bacteria, as complications in infection control may arise due to diversified antibiotic resistance patterns and development of multidrug resistance phenotypes. Trace levels of antibiotics as well as the presence of antibiotic resistant bacteria in source water and treated drinking water is an emerging health and water-quality issue. Antimicrobial substances are introduced into our raw water systems by various pollution settings including; discharges of partially treated or even untreated wastewater; animal production and healthcare waste; agricultural run-off and industrial waste.

Disposal of such wastes into the aquatic environment creates new sources of emerging contaminants. Trace levels of these contaminants, such as antibiotics,

may be detected in the final drinking water reaching the consumer as conventional drinking water treatment processes are not capable of their complete removal. The presence of these antibiotics in water environments has been shown to result in a selective pressure for the development and/or dissemination of resistance bacteria and genes. Water environments thus act as reservoirs for antibiotic resistant bacteria and genes.

A WRC scoping study was commissioned in order to assess the levels of antimicrobials and presence of antibiotic resistant bacteria in drinking water produced from impacted water sources. Three conventional drinking water production facilities located in Gauteng and North West province abstracting their raw water from sources receiving wastewaters from a variety of anthropogenic activities were selected for this study. Raw and final water samples were collected and analysed for levels of antimicrobial substances and antibiotic resistant profiles.

Levels of antimicrobials and presence of antibiotic resistant bacteria in drinking water

Findings from this study indicated that a cocktail of antimicrobial substances (including antibiotics and other pharmaceutical personal care products and agrochemicals) enter drinking water production facilities as part of the source water. The levels of these substances were very low ranging from 0.0040 to 0.9700 µg/ℓ.

Generally, these substances were mostly detected in the source waters, and were reduced by the drinking water production processes. However, some of these compounds were not completely removed during drinking water production process and were detected in the final water. Antibiotic resistant bacteria (ARB) were detected in source waters of all three drinking water facilities.

The obtained results showed that some ARBs present in the source water may survive the drinking water treatment process and manifest in the final water in the distribution system. Elevated resistance to some antibiotics was observed in source and final water samples. In particular, resistance to β-lactam antibiotics and trimethoprim was common amongst the isolates. In some cases, the isolates were also resistant to oxytetracyline, chloramphenicol as well as erythromycin and selected aminoglycosides.

Conclusions

The inappropriate use of antimicrobial drugs for human infection control, agriculture and in animal husbandry, favours the emergence and selection of resistant strains. From the results it is evident that both antimicrobial substances, including antibiotics, and antibiotic resistant bacteria may survive conventional drinking water processes and manifest in final drinking water.

Although very low levels of a range of antimicrobial substances were detected in some of the final water samples collected in this study, diversified resistance patterns were observed in the isolates investigated in the study. Results obtained in this study further demonstrate the interlinkages between antimicrobials and their role in the development of resistant bacteria and genes.

In addition, the results support earlier reports which suggest that water environments are reservoirs of ARBs and ARGs and drinking water may be an important exposure route for the dissemination resistant bacteria and transfer of resistance genes into the human body. Transfer of these genes from environmental bacteria to known and opportunistic human pathogens may result in poor infection prevention and control, which may further result in the emergence and spread of diversified antimicrobial resistance patterns and multidrug resistant phenotypes.

Moreover, the linkages between antimicrobials and development of antibiotic resistance could have far more reaching implications in the use of chemical disinfectants for drinking water treatment. The contribution of drinking water chemical disinfectants on the development of resistance profiles is an issue which requires further investigation.

Further research

The study made several recommendations for further research to understand and manage this phenomenon.

A follow-up WRC study is thus underway, the overall goal of which is to establish methodologies to monitor the dynamics of antibiotic resistant bacteria and genes in raw and final water samples drinking water samples in selected conventional and advanced drinking water plants in South Africa.

Through this project, the WRC will engage with international research partners and participating national government departments to align WRC research with related antimicrobial resistance activities. Methods to be established in this study will be a vital contribution towards the surveillance of antimicrobial resistance activities in the water sector and possible alignment with existing activities in the health sector.

Furthermore, outcomes from this study will inform future water quality monitoring considerations on the reclamation of wastewater for drinking purposes. This project will also provide a platform to engage on the broader on antimicrobial resistance, with the potential to arrive at a multi-sectoral research agenda.

Further reading:

To obtain the report, *A scoping study on the levels of antimicrobials and presence of antibiotic resistant bacteria in drinking water* (**Report No. KV 360/16**), contact Publications at Tel: (012) 761-9300; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.