WATER AND THE ENVIRONMENT

The establishment of a knowledge hub for contaminants of emerging concern

Contaminants of emerging concern have aroused increasing concern due to their ubiquitous presence in the environment and harmful potential. A current research project is aiming to collate existing knowledge on these emerging pollutants in a central, accessible space. Article by Tarryn Lee Botha of the Agricultural Research Council – Soil, Climate and Water and Ashira Roopnarain of the North-West University's Water Research Group.

Historically, society's response to a risk has been based on the level of the current threat and public outcry related to available evidence – whether scientifically supported or not. However, as we are in the information age, the interest and availability of information on the dangers of contaminants in water is gaining ground. Newspaper headlines such as "Testing to begin for 'Forever Chemicals'"- ***The Sun*** or "An invisible killer is lurking in our consumer products, warn scientists"- ***Sky News*** and "Let's turn the tide on plastic"- ***Daily Mail*** are appearing more frequently worldwide.

In order to address this, the Agricultural Research Council (ARC) initiated a project funded by the Water Research Commission (**WRC Project No. 2021/2022-00256**), in collaboration with Tshwane University of Technology and North-West University, to establish an online portal consisting of information relating to newly detected aquatic pollutants. The aim of the Contaminants of Emerging Concern Knowledge Hub (Figure 1) is to develop a database of contaminants of emerging concern (CECs) in South African water resources. The specific objectives are to collate all available data on CECs and display it in a user-friendly online format to enable regulatory bodies as well as researchers to avoid duplication of studies and to establish potential hotspots. Furthermore, it will provide an easily understandable information guide for the public on what CECs are and how they end up in our environment.

The selection of CECs was based on current information in the literature as well as international databases. The following CECs were selected as the primary contaminants within the Knowledge Hub: Perfluoroctane Sulfonate (PFOS), Alkylphenols (APs) and Alkylphenol Ethoxylates (APEs), Polybrominated Diphenyl Ethers (PBDEs) or flame retardants, Polychlorinated Biphenyls (PCBs), Polycyclic Aromatic Hydrocarbons (PAHs), current use pesticides, Pyrethroid, Cypermethrin, Chlorinated Paraffins, pharmaceuticals and personal care products, microbiological CECs, Triclosan, Microplastics, Engineered Nanomaterials and Heavy metals.

Figure 1: *The proposed Contaminants of Emerging Concern Knowledge Hub logo for WRC project no. 2021/2022-00256*

What are contaminants of emerging concern (CECs)?
The current Target Water Quality Guidelines only include known contaminants. CECs, however, are pollutants that have previously been at levels below detection limits which are now being detected by water professionals in our water bodies. These can include nanomaterials, flame retardants, microplastics, agricultural waste, microbial contaminants, heavy metals, pharmaceuticals and personal care products, which may cause ecological and human health impacts. The continued unregulated use of these products could lead to further ecological risks. The effects of these contaminants on the environment is becoming increasingly important (Pool and Rusch, 2014). Therefore, in order to address this, more research needs to focus on collating currently available outcomes and the results need to be made available to regulators in order to develop environmental laws in a proactive manner.

How do CECs end up in our water bodies?
The production and use of consumer products is the major contributing factor to pharmaceuticals and personal care products (PPCPs) in our water bodies which are either not removed or chemically transformed throughout wastewater treatment processes (Kiesling et al., 2019). If you consider your own morning routine and the contaminant exposure we are faced with on a daily basis (Figure 2), you will be able to appreciate the magnitude of CECs released into our ecosystems. The CECs present in PPCPs each have a function within the product and can range across a variety of classes, e.g. tricolsan (anti-bacterial), phalates (solvents), retinyl palmitate (antioxidant and vitamin A), ethyl alcohol (astringent/ preservative), oxybenzone (absorbs UV-A rays), diazolidinyl urea (stops bacterial growth), lead acetate (colourant in hair dyes), methylene glycol/formaldehyde (hair-straightening products), propyl paraben (antifungal agent), quaternium-15 (preservative), microplastic beads (cleansers and exfoliants), sodium benzoate (preservative), nitrosamines (adjust the pH level or act as wetting agents) and nanomaterials (UV-filters, anti-bacterial).

Figure 2: *Pharmaceuticals and personal care products we use in our daily routine which contain CECs*

Furthermore, population growth has continued to climb over the past few years, which requires more efficient methods of maintaining food security that can include greater use of pesticides and fertilizers, increased pharmaceuticals release, product packaging, goods transport, industrial processes and commercial agricultural practices. As more products are being consumed, the technology for production is advancing and the types and applications of CECs are increasing which, in turn, leads to higher production rates (Benson et al., 2017). Other contaminant classes (organic and heavy metal pollution) can be released during agricultural and mining activities, leading to atmospheric deposition and runoff into aquatic ecosystems. Current risks of CECs are unknown in South Africa even though there have been several research efforts in order to determine the current environmental concentrations.

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An overview of current findings
A scoping study of available literature revealed that the only nanomaterial characterised and detected was titanium dioxide (white pigment in food colouring and UV-filter in sunscreens). However, for microplastics, several publication entries were found for fibres, films, fragments, polystyrene and monofilaments from fishing lines. In the class of alkylphenols (organic industrial chemicals used in the production of lubricating oil additives, laundry and dish detergents, and emulsifiers) the most entries were found for nonylphenol which is a persistent breakdown product.

The most entries for heavy metals were available for lead (several applications including soldering or welding) and chromium (mined) in the environment. Unsurprisingly the majority of microbial inputs were on ***Escherichia coli*** and coliforms. However, recent studies that have utilised advanced molecular methods such as Next Generation Sequencing, have revealed a plethora of additional potentially pathogenic microbes in several South African water bodies.

Just over 300 entries were found for PPCPs, including acetylsalicylic acid (commonly known as Aspirin), carbamazepine (anticonvulsant medication used primarily in the treatment of epilepsy and neuropathic pain), clarithromycin (an antibiotic), ibuprofen (a nonsteroidal anti-inflammatory drug class used for treating pain, fever and inflammation), sulfamethoxazole (used to treat a wide variety of bacterial infections) and triclosan (antibacterial and antifungal agent added to soaps and body washes, toothpastes and some cosmetics). Several entries were also found for PAHs which are produced due to the incomplete combustion of fossil fuels and burning of organic compounds such as wood. Those detected in aquatic bodies which broadly break down from coal tar included acenaphthene anthracene chrysene, fluoranthene, naphthalene and pyrene.

The way forward

One of the major reasons for CECs occurring in our environment is the lack of knowledge and education related to what they are and how they end up in the environment. We are therefore drawing up easily understandable information sheets for public use and downloadable agricultural practice standard operating procedures, which will assist in avoiding further contamination.

Whilst a thorough literature survey is currently underway to collate all data related to the classes of aquatic CECs selected to be included in the database, we are aware that additional data might be available that is yet to be published or was not intended for scientific publication. We hereby request anyone who is willing to share such data to please contact us. A concerted effort will be required to develop a holistic, up-to-date Knowledge Hub that can provide valuable information to scientists, policy-makers, farmers and the general public. This valuable resource will also guide us in pre-empting any aquatic catastrophe relating to CECs by identifying the problem and taking relevant, informed steps to prevent it from escalating beyond control. In so doing we can collectively preserve and improve the quality of our precious, limited resource….fresh water.

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