Emerging contaminants

The drugs we wash away: What happens to antiretrovirals in the aquatic environment?

With increasing frequency countries are faced with a new set of chemicals that are contaminating the environment. These so-called 'emerging contaminants' hold potential risk to humans and/or the environment. The challenge is that, generally, little is known about the occurrence of these pollutants, the actual risks and the approach to formulate appropriate policy and legislation. The CSIR is increasing awareness and knowledge in this area through its study of antiretrovirals as an emerging contaminant. Article by Chavon Walters.

Increasing amounts of personal care products have been detected in the aquatic environment in recent years. Antiretrovirals (ARVs), used to treat human immunodeficiency virus (HIV), are regarded as emerging contaminants that have received increased attention due to their potential negative effects on the environment.

South Africa has more people living with HIV and AIDS than any other country, and therefore utilises more ARV compounds per capita. Approximately 2 150 880 people received ARVs in South Africa in 2012 versus the approximate 199 000 people on ARVs in Eastern Europe. As such, it is theorised that these compounds will be present in the environment to a much greater extent.

The environmental release of ARVs is of considerable concern due to potential ecosystem alterations and the development of viral resistances. Despite the high prevalence of HIV in South Africa and consequent high consumption of ARV drugs, few studies have to date reported on the presence of ARVs in the aquatic environment in South Africa. Traditional wastewater treatment technologies remain ineffective to treat complex and complicated chemicals.

The presence of pharmaceutical and personal care products have recently attracted the interest of researchers due to concerns regarding the occurrence of a wide variety of pharmaceuticals in the environment as a result of inadequate wastewater treatment. These compounds are, if not completely metabolised, excreted via faeces or urine. As such, they can enter the environment via discharges from wastewater treatment plants.

Pharmaceuticals such as ARV compounds (including zalcitabine, tenofovir, abacavir, efavirenz, lamivudine, didanosine, stavudine, zidovudine, nevirapine, indinavir, ritonavir and lopinavir) have been detected in treated and raw wastewater and rivers, and are therefore not effectively removed in wastewater treatment plants.

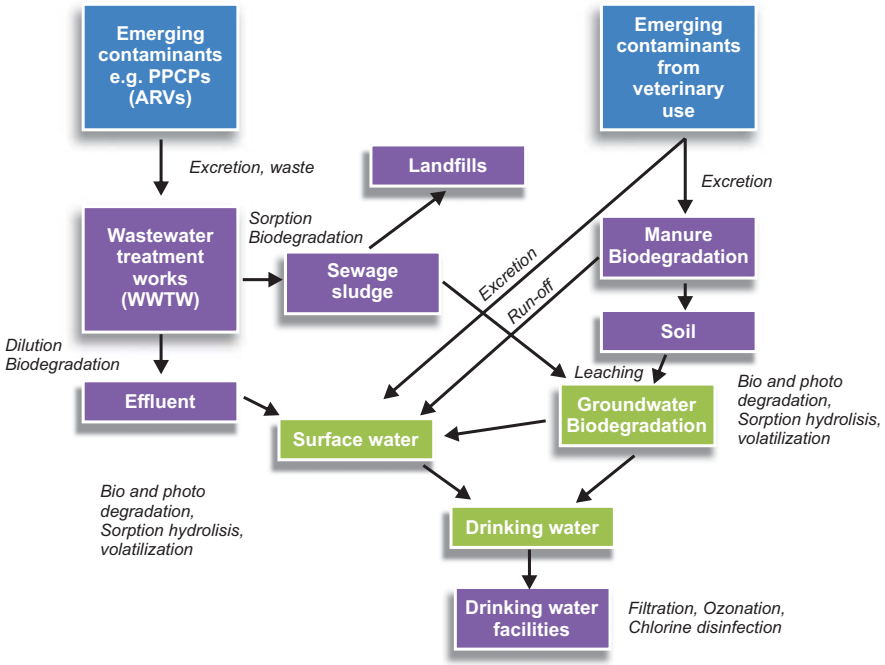

Figure 1. Pathways of emerging contaminants in the environment.

Past studies

Limited research has been carried out in South Africa to determine the presence of pharmaceutical and personal care products and their degradation products, and the few studies undertaken have focused only on a select group of these products. ARVs are an emerging class of pharmaceuticals and their studies are also limited.

In the first reported countrywide survey of South Africa's surface water for the quantification of ARVs, a 2015 study detected quantifiable concentrations of zalcitabine, tenofovir, lamivudine, didanosine, stavudine, zidovudine, nevirapine, and lopinavir in Pretoria, and zalcitabine, tenofovir, didanosine and zidovudine, in Bloemfontein.

Concentrations for ARVs were below the instrument level of detection in the Cape Town and Durban metropole regions. In a later study, published in 2015, the presence of nevirapine and efavirenz were detected in wastewater influent and effluent in Gauteng. In another 2015 survey, the presence of most ARVs were detected except efavirenz and saquinavir.

Nevirapine, zidovudine and tenofovir were quantified in the effluents of two wastewater treatment plants; stavudine, nevirapine, Ttenofovir, nelfinavir and saquinavir were detected in seven of 18 groundwater samples; while nevirapine and didanosine were detected in five and three drinking water samples, respectively. Transformation products formed during wastewater treatment processes, which are released into the environment, further confounds the effects of pharmaceutical and personal care products in the aquatic environment. Wood et al. (2016) reported on the resistance of nevirapine to degradation, which potentially substantiates its ubiquitous presence in South African surface waters.

Collectively, these studies have reported on the occurrence of various ARVs in various environmental matrices in South Africa. More sensitive and reliable analytical methods are required to detect previously undetectable compounds.

Current initiatives

As depicted, no data is currently available which reports on the occurrence and levels of ARVs in the Western Cape. An integrative team of researchers at the CSIR with expertise in freshwater, riparian, ecological river health, water chemistry and sediment, aquatic ecotoxicology, and water resource management are currently undetaking a study, with the aim to determine the environmental occurrence of the emerging contaminants (i.e. selected ARVs), and to characterise the sources, pathways and fate of these contaminants in the environment.

However, a greater number of ARVs could be detected if detection limits of analytical methods were significantly improved. As such, one of the major outcomes of this project is will be to develop the analytical capabilities to detect the presence of selected ARVs in surface water, wastewater (influent and effluent) and sediment/sludge.

The lack of information on the effects and concentrations of pharmaceuticals such as ARVs makes it difficult to be regulated and to manage the levels already existing in the environment. The usage and discharge of ARVs, and the discharge of insufficiently treated wastewater effluent, should be considered as important factors that influence the contamination levels of ARVs in different geographical areas. As such, the environmental and human health significance of chronic exposure to these chemicals remains unclear. Special attention should be given to the transformation products.