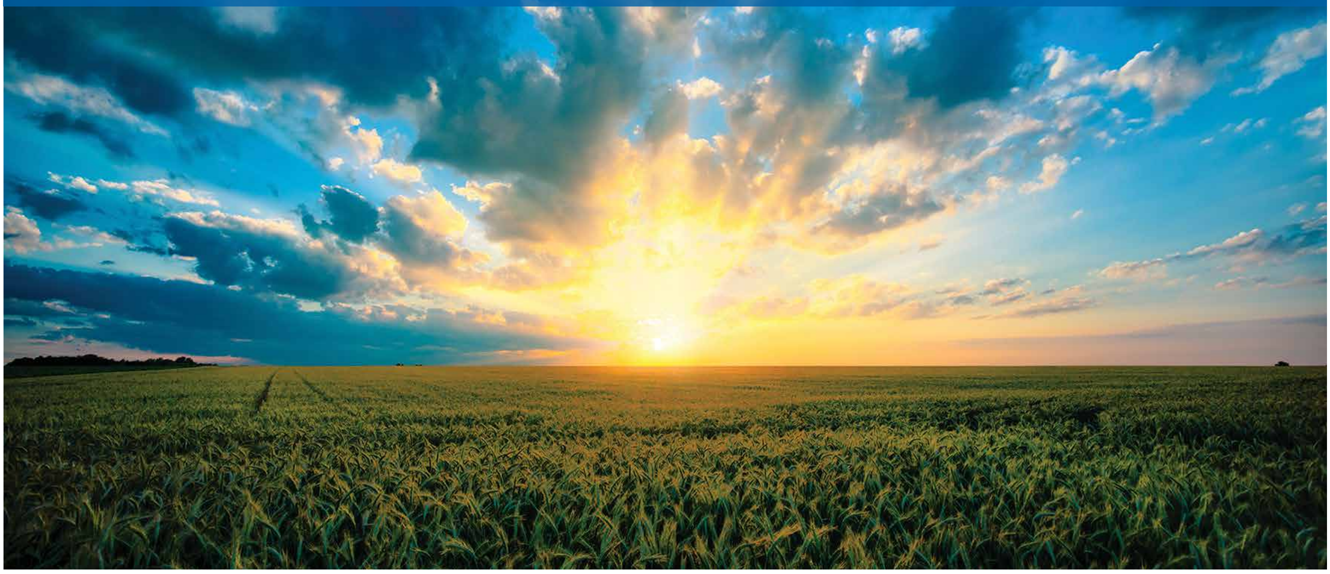
Water and health

Pin-pointing pesticide contamination and the damage it can do to people

In a South African first, a Water Research Commission (WRC) study has created agricultural pesticide maps for improved risk management.

Article by Petro Kotzé.



As with many developing countries, agriculture remains vitally important to South Africa's economy. Though it has decreased as a percentage of GDP over the past four decades, currently contributing around 2%, the sector formally employs 638 000 people, and an estimated 8.5-million people are directly or indirectly dependent it for an income. The sector's significance is a key focus of the New Growth Path, a governmental strategy to create 5 million new jobs by 2020.

Yet, the sector is impacting negatively on the resource that it is most dependent on – our limited freshwater supplies. Regardless of limited monitoring studies, there is sufficient information to indicate that many currently used agricultural pesticides enter surface and groundwater.

According to the latest Department of Agriculture, Forestry and Fisheries (DAFF) database, there are in excess of 8 000 herbicide, insecticide and fungicide products registered for use in South Africa. Many of these include active ingredients that are either carcinogenic or classified as endocrine disruptors (EDs), while for most pesticides these endpoints have yet to be defined.

This is particularly concerning considering that many communities do not have any or reliable access to treated water, and often make use of water collected directly from the resource for drinking purposes. Given the potential human health effects associated with exposure to agro-chemicals and their intensity of use, in combination with the questionable supply and quality of drinking water in many South African communities, it is important to identify and prioritise pesticides that are particularly toxic, and areas where people may be exposed to these priority chemicals.

"We know that these things do enter the water and much research focus has been on the impact on the aquatic ecosystem," notes Dr James Dabrowski, Principal Researcher in Environmental Chemistry and Water Quality at CSIR. "We also need to focus on the potential effects on human health with water as the pathway, and in particular the impact of current pesticides," he says, pointing out that much work has rather been done on pesticides banned for agricultural use, such as dichlorodiphenyltrichloroethane, popularly known as DDT.

Dr Dabrowski is the principal researcher of a WRC initiated project to answer some of these questions. The five-year study, which concluded in 2015, aimed to determine the extent and the level of contamination by agricultural chemicals in selected water resources as well as determine their risk to animal and human health, both in terms of toxicity and ED effects.

The study was led by the CSIR together with collaborators from the universities of Pretoria and North-West, and made significant advances in addressing knowledge gaps in managing the risks of agricultural pesticides in South Africa. According to Dr Dabrowski, the study involved multiple aspects, including identifying the most problematic pesticides among the huge amount registered, looking at their potential impact on human health, identifying which ones are most likely to enter the resources and identifying where in the country these pesticides are being used.

Prioritising pesticides according to risk and locality

The project selected three agriculturally intensive catchments representative of important commercial crops produced in South Africa, namely maize, sugarcane, citrus and subtropical fruit.

The study areas were the Letsitele catchment in the vicinity of Tzaneen, an area dominated by tropical and citrus fruit production; the Lomati catchment which drains into the Komati River in the vicinity of Komatipoort (dominated by sugarcane production as well as by other tropical and citrus fruits); and the Vals and Renoster catchments in the Free State, both of which enter the Vaal River, in the vicinity of Kroonstad and Viljoenskroon. The latter is an area of intensive maize production.

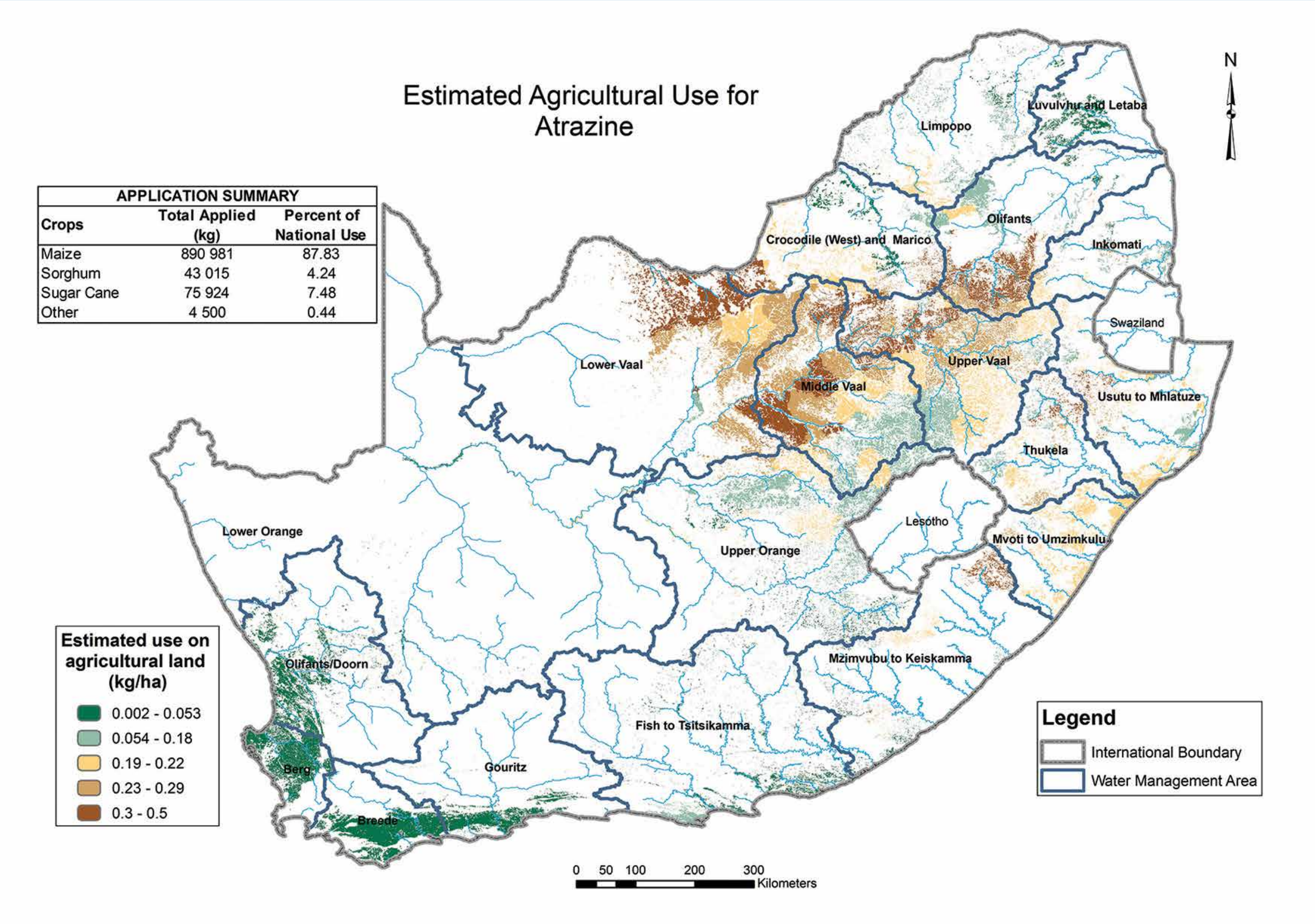
Seasonal sampling for ED bioassays and organic and inorganic constituents from surface water resources, sediments and groundwater in the three selected sites were conducted.

These results were interpreted against guideline values (in the case of inorganic constituents) or subjected to detailed risk assessment methodologies (in the case of pesticides) so as to assess the potential risk of agricultural chemicals to human and animal health. In addition, pesticides were prioritised based on quantity of use (QI), toxicity potential to human health (TP) and hazard potential (HP), which combines toxicity with environmental mobility. The data was fed into an Excel-based risk indicator. When all three are combined, you get the weighted hazard potential, which expresses the HP as a function of the quantity of use of the pesticide.

"It is a simple process enabling users such as water resource managers, catchment management agencies, water treatment works and farmers to prioritise pesticides at a national or crop-specific scale according to any one of these indices."

The importance of verifying models

The study proved to be a great example of the usefulness of models in human health and ecological applications. During the course of the study, researchers validated the AGDISP model, used to to accurately predict the deposition of spray material released from spraying equipment. "We used the model to predict concentrations of pesticides in the air in various distances from the application," explains Dr James Dabrowski from the CSIR. Though the predicted cancer and toxicity risks based on exposure to pesticides in water in each of the case study sites is low, results from the spray drift study indicate that inhalation of airborne pesticide levels potentially poses a greater risk to human health than those derived from use of water resources.



One of the maps produced that give a spatial overview of the likely distribution of specific active ingredients (in this case atrazine), based on their application to crops and the distribution of those crops throughout the country.

According to the final project report, a major limitation associated with the sampling approach adopted in this study is that pesticide contamination in water resources is typically transient, with peak concentrations most often being associated with specific events (i.e. during actual spraying of pesticides or during heavy rainfall events when runoff becomes a major contributing factor). The sampling frequency adopted in all catchments in this study is therefore unlikely to represent peak concentrations, but these are likely to be present for relatively short periods of time (a few hours) and exposure of humans and livestock to these peak concentrations through the water pathway is likely to be low. The concentrations detected in these study areas are therefore likely to be representative of a typical exposure scenario.

A further outcome of the study is a set of maps that give a spatial overview of the likely distribution of specific active ingredients, based on their application to crops and the distribution of those crops throughout the country. It's a first for South Africa. While a number of geographical and physico-chemical factors influence the movement of pesticides into surface waters, the quantity and rate of application of pesticides used in an area is the most important indicator of the potential for contamination of non-target environments. In this respect, the maps provide important information not only in terms of estimated application rates but also in terms of identifying where in the country specific pesticides are most likely being applied.

The maps thus prioritise those areas that are likely to be of greatest concern and can therefore make useful contributions to the design of water quality monitoring programmes, interpretation of monitoring data and as input into regional human health and ecosystem risk assessments.

The impact of pesticides on human health

In regards to pesticides' risk to human health, researchers actually found levels to be "pretty low, with negligible risk associated with consumption or use of water from the study areas". Yet, there are some warning signals. Despite the monitoring limitations mentioned, the study revealed relatively high concentrations of particularly atrazine, terbuthylazine and simazine (all known EDs) in maize and sugarcane areas. Samples collected in the Vals and Renoster rivers in particular showed comparatively higher values than other study areas. Furthermore, atrazine in particular was detected at similar concentrations over different seasons (wet and dry) indicating that it has essentially saturated water resources in these catchments.

"Pesticides are often only present after events such as application but atrazine, for example, is found constantly in the water," notes Dr Dabrowski. "This is because it is used so much, and has high environmental mobility in comparison to other pesticides." Their ubiquitous presence in water resources warrants further investigation in areas where use is high. In particular, more detailed surveys of groundwater resources and boreholes that deliver drinking water and for human and animal consumption should be surveyed in more detail.

Though there was not much risk found from a human health perspective, it does require more research, particularly regarding their potential ED effects, adds Dr Dabrowski. Bioassays conducted on water and sediment samples collected in the study areas indicated ED activity on many occasions.

Dr Dabrowski cautions that it must be kept in mind that the researchers did not look at all the listed pesticides and, where bioassays indicated ED effects, it was not possible to link these to the use of a specific pesticide. "This would be very difficult to do," he says, referring to the range of other contaminants such as sewage flows, which also contribute to the contamination of water resources.

Dr Dabrowski suggests that a possible approach could be to link or prioritise land use types or activities to ED effects instead of to specific pollutants.

He also points out that the ED science is still relatively new and guidelines for safe levels of ED response to human health do not yet exist, making it challenging to say how problematic the situation is. "It's not to say that there is a problem, or that there is not a problem, but rather that the bioassays provide a screening level assessment indicating that contaminants may be causing an ED response, and a cautionary approach should be applied and further research conducted where necessary."

On a positive note, the detection of pesticides was well predicted by indices used in the prioritisation procedure in all study areas, particularly quantity of use and mobility. The frequent detection of atrazine, terbuthylazine and simazine in maize and sugarcane areas is undoubtedly a reflection of their high quantity of use as well as their high mobility in the environment. Similarly,

The Letsitele River, with locals collecting water and doing washing.

imidacloprid, which was also highlighted as being highly mobile in the environment, although not detected as frequently, was also found in comparatively high concentrations when detected. Other frequently detected pesticides (e.g. carbofuran, diuron and hexazinone) were also well predicted by outputs from the prioritization procedure (i.e. crop specific use and mobility). These results indicate that indices of use and mobility are very useful in terms of prioritising specific pesticides for detailed monitoring in study areas of interest.

Moving forward

The pesticide use maps and supplementary data developed in this study provide the most detailed overview of pesticide use in South Africa produced to date. This information can be used to make national, provincial and catchment-based assessments which are essential for performing spatial assessments of human and environmental risk associated with pesticide use. Yet, according to Dr Dabrowski their application can be much broader, and can be developed as a prioritisation tool for the monitoring of aquatic ecosystems that could potentially be at risk. "For example, we can look at where endangered fish species occur in relation to the maps," he says.

The team's work is not over, as there are a number of recommendations that flowed from the study. For example, passive monitoring, which measures contamination over time could be applied, in order to include peak pesticide concentrations associated with certain events.

Furthermore, "despite getting the maps and information out, we need to have a more proactive approach," notes Dr Dabrowski. "The regulation of pesticides from a risk assessment perspective is not that great. We do not have a good idea of how much is used where, and there are currently no water quality guidelines for most pesticides being used in South Africa."

Though the current project results are of particular use to policy makers, a follow-up study is in progress to produce products that can be used by farmers. In the meantime, the project results have been published. All data collected and produced during the course of this project (including the maps) is available in the final reports or from the CSIR, Natural Resources and Environment in Pretoria.

To order the reports emanating from this project, *Investigation of the contamination of water resources by agricultural chemicals and the impact on environmental health Volume 1: Risk assessment of agricultural chemicals to human and animal health* (**Report No. 1956/1/15**) and *Volume 2: Prioritising human health effects and mapping sources of agricultural pesticides used in South Africa* (**Report No. TT 642/15**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.

A rural residential area with fruit orchards in close proximity.

Maize is the most highly produced crop in South Africa, and is associated with high atrazine application.

Air sampling and spraying for AGDISP validation.