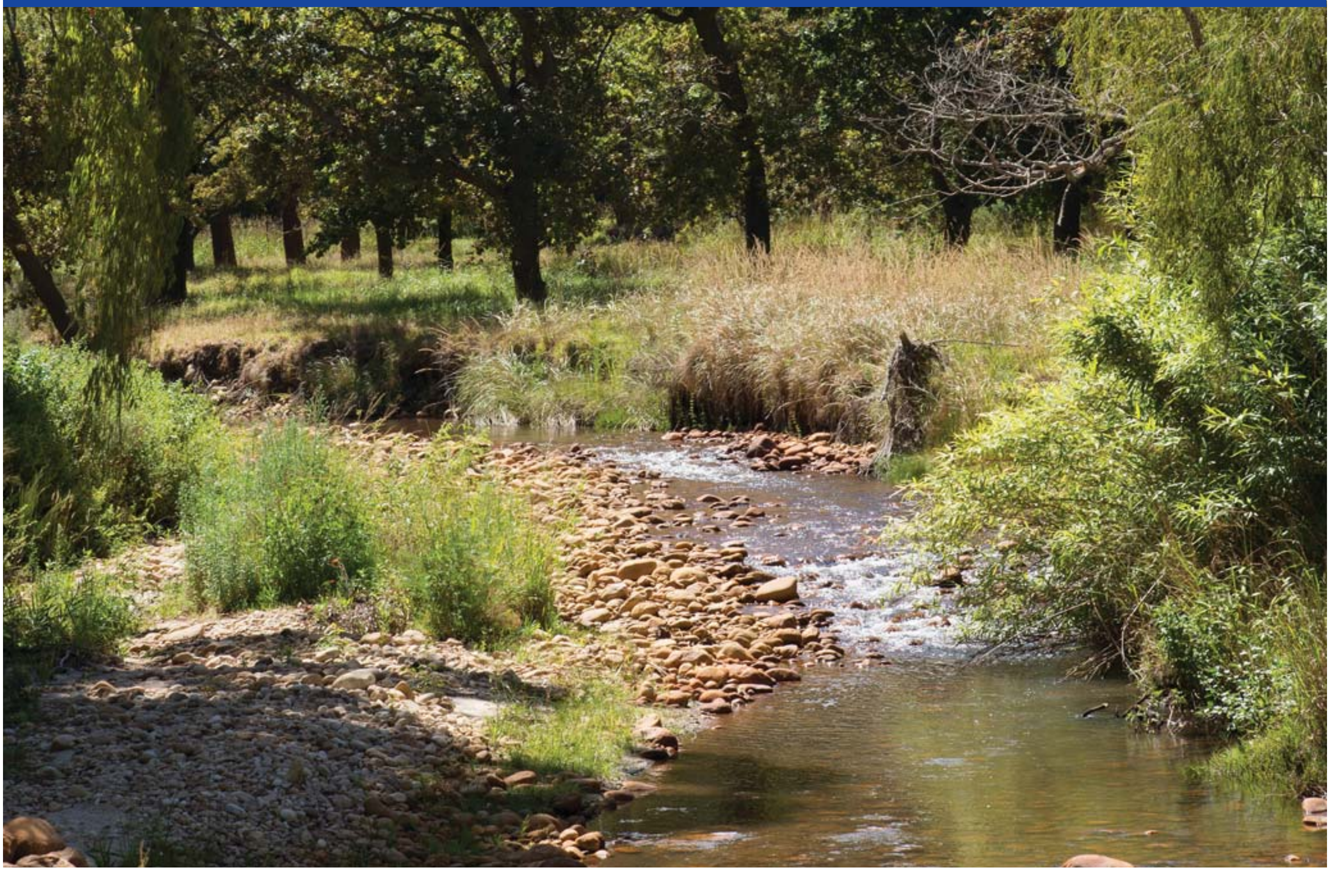
WATER AND THE ENVIRONMENT

Constructed wetlands to deal with pesticide pollution

A Western Cape wetland study has demonstrated that green infrastructure has the power to filter pesticide polluted water. Article by Petro Kotzé.



Using the power of nature to manage the impact of people on the planet is not revolutionary anymore. Constructed wetlands, in particular, have grown in popularity. These green engineered systems use plants, soil and organisms to treat wastewater, and they are relatively common in the treatment of municipal or industrial wastewater, greywater or stormwater.

In recent years, artificial wetlands to treat effluent have also become somewhat more commonplace on farms. In the Western Cape, it has been punted as a cost-effective choice to treat wastewater generated during the wine production process. On some farms, wetlands are also used to treat sewage to irrigation water standards.

Lesser known in the country is that one of the earliest studies internationally that proved the capacity of constructed wetlands to filter pesticides before it enters streams and rivers, also took place in the Western Cape. Though this has now been proved successful in different countries, it's not widely applied, or common knowledge on local shores.

"We did a good job of finding things out, and did a bad job to sell it to society," said Prof Ralf Schulz, from his office at the University of Koblenz and Landau, Germany where he heads the Ecotoxicology and Environment Group. What they did find out, was that an artificial wetland close to Somerset West was "extremely effective" at not only the task it was built for, but also the one they tested it for – filtering out pesticides before it entered the Lourens River.

Once, there was a wetland

Schulz spent time in South Africa for a post-doc at the University of Stellenbosch in the early 2000s, during which time they came upon a wetland constructed on a tributary of the Lourens River. The Lourens is a 23 km stream, declared a Protected Natural Environment by the City of Cape Town. In the very upper reaches in the Hottentots Holland Mountains it remains pristine, but on its way to where it spills into the Atlantic Ocean at Strand it travels through surrounding farmlands, residential, commercial and light industrial areas. Downstream, the river is plagued by pollution and alien vegetation. In a 2004 water quality study of the Lourens River, high levels of pesticide contamination downstream of multiple farming areas were also found.

In this way, the Lourens River is not unique. Water pollution from agriculture has been well documented, though it is complex and multidimensional. Soil erosion from farming activities, for example, impact water quality and quantity downstream. Poorly applied fertilisers can leech into rivers, polluting water sources and causing algal blooms that deplete the water's dissolved oxygen, produce toxins and kill aquatic life.

Pesticide pollution is another outcome of the growing need to produce more food, the impact of which ripples far beyond the target crop the poison was meant to protect. The resulting destruction of communities of invertebrates is well known. Over and above the negative consequences for ecology, drinking water quality can be affected once the pesticides filtrate to groundwater, which will necessitate treatment, rippling out to an added economic impact.

The term pesticides embrace a range of manufactured substances or biological agents. Insecticides (to protect crops from insects), herbicides (to protect crops from weeds) and fungicides (for protection against fungal diseases) all fall under the umbrella of pesticides. Surface water is often on the receiving end. Worldwide, pesticides that enter streams after being washed off the fields (runoff), or carried to it with the wind (spray drift) account for the majority of contamination.

Schulz explained that the impact of the pesticides on the broader environment depends to a large degree on its solubility. Insecticides generally have a lower ability than herbicides and fungicides to dissolve in water. As such, insecticides are less likely to filtrate to groundwater, but would probably enter surface water bodies with contaminated runoff or spray drift.

Because the affected water quickly flows away, leaving behind little trace of the contaminating agent, the impact of insecticides is often underestimated, says Schulz. In comparison, traces of herbicides and fungicides may occur for months on end.

The artificial wetland in question, located on the Vergelegen Estate, received water from a tributary that flowed through pastures of fruit orchards. The estate is well known for its large scale investing in sustainable farming and land rehabilitation. At the time the organophosphorus insecticides Azinphos-methyl (AZP), chlorpyrifos and endosulfan were applied to orchards.

According to research reports, the wetland was constructed in 1991 to retain soil washed from surrounding farmlands before it could enter the river and eventually, be lost to the sea. At the time, the wetland was 0.44 ha in size, (134 m x 36 m), free of plants for the first 30 m, and then mostly covered with bulrush (*Typha capensis*). A small part (around 10%) was covered with dune slack rush (*Juncus kraussii*) and there was also a bit of papyrus (*Cyperus dives*).

By the time the researchers found it, it had accumulated up to 1.2 meters of sediment at some points. "So, we thought, if it works so well for the sediments, why not pesticides," said Schulz.

When pesticides meet wetlands on their way to a stream

It was not a completely new thought. Researchers at the United Stated Department of Agriculture's Agricultural Research Service had been studying the capacity of constructed wetlands to mitigate the impact of pesticides. Back in South Africa in 2000, the researchers found Vergelegen's retention pond too, to be effective to reduce pesticide contamination during rainfall-induced runoff, as well as spray drift. In fact, the wetland did this tremendously well.

High levels of chlorpyrifos and endosulfan introduced via runoff were not detectable in samples taken at the outlet. Between 77% and 93% of water diluted AZP introduced via runoff was retained. About 51% of the AZP introduced via spray drift was retained. Bio-assays of bloodworms above and below the wetland showed a reduction in toxic contamination from 41% to 2.5%. The wetland trapped 78% of total suspended solids, 75% of orthophosphate, and 84% of nitrate during wet conditions.

The principle idea is that the flow of the contaminated water slows down in the wetland, said Schulz, allowing particles to settle down, where it is trapped by the sediment. The second aspect is the vegetation, which act as biofilters that reduce the amount of pesticides in the water, allowing it to degrade over time while it is trapped in the wetland.

Although there was a tremendous layer of sediment that built up over the years, Schulz said, only the very upper centimeters still contained pesticides then in use. In the deeper layers they only found traces of an old pesticide that has been discontinued in South Africa. "We assume there is no accumulation of pesticides in the wetland," he said. To maintain the constructed wetland as an efficient filter for pesticides, their only recommendation is thus to dig it out every couple of years, and preferably, return the nutrient rich soil to the farmed land – something which is already common practice today.

Schulz said the study turned into one of the first, world-wide on the capacity of constructed wetlands to mitigate the impact of pesticide contamination. At the time, he said, their work was exciting enough for another wetland to be constructed on a neighbouring farm along the river.

However, almost two decades down the line, the results of the so-called Lourens River artificial wetland study remain relatively unknown in South Africa.

Finding the Vergelegen wetland

Vergelegen confirmed that the structure is still used as retention pond to capture silt and remains roughly the same size as described in the project reports. Since then, however, the land use activities in the catchment area has changed significantly, as have the type of pesticides they now apply on the farm, in general moving ever towards more environmentally friendly options and practices as these have become available.

Next door at Lourensford, vineyard manager Pieter Uys has been with the farm since 1991. Though he was not familiar with the study he could also located the second wetland that was later constructed from an old photo that Schulz sent. Uys remembers that the retention pond used to accept run off from a nursery and compost plant, though neither exist anymore. Coincidently, the structure was cleaned just recently, which entailed trimming the reedbed and scooping out the accumulated sediment to returned to the fields.

Though the concept of using wetlands to mitigate the impact of pesticides is not widely known in South Africa, it has since been more extensively studied elsewhere.

International examples of the capacity of wetlands to filter pesticides

A literature study on pesticide mitigation by vegetated treatment systems completed in 2010, identified 24 studies published between 1996 and 2009. In these cases, the majority of pesticide concentrations originated from runoff and spray drift. The majority (27 systems) of the studies evaluated systems in the United States, with only one system in Australia and one in Norway. Two were analyzed in South Africa (the Vergelegen retention pond, and the second at Lourensford, though data from the latter was never published).

In the evaluated studies, 34 pesticides were evaluated, including 9 herbicides, 23 insecticides, and 2 fungicides. The majority of retention performances were over 80%, with only a small proportion of the
pesticide trapping efficacies below 40%.

Another example is the Live Environment ArtWET project that took place from 2006 to 2010 in Europe. The project entailed the construction of artificial wetlands to investigate whether they were a sustainable and promising option to treat runoff and spray drift pesticide pollution, particularly from wetlands. Six wetlands were built in three European countries for this purpose. The wetlands achieved a pesticide retention performance of between 40% and 88%, even when very young. After monitoring total concentrations of 18 pesticides it was expected that efficiency would increase more as the systems and vegetation matured, to achieve a 73% reduction in the total load estimates.

The ArtWET project showed that bioremediation (the use of microbes) can totally remove some pesticides such as glyphosate. Additionally, a recirculation of water – for example through biomass-beds – achieved an efficiency of 99.8% for pesticides mitigation even with strong concentrations of active ingredients widely used in vineyards, such as metalaxyl, penconazole and chlorpyrifos. High efficiency of mitigation was also shown for several herbicides used in corn, wheat and tomato crops.

What to treat with wetlands?

Schulz says that wetlands are a particularly good option for the retention of insecticides before the toxins reach downstream surface waters. For herbicides and fungicides wetlands could be less efficient because these are more soluble and likely to filter to the groundwater first. Furthermore, wetlands are a particularly attractive option to mitigate the impact of insecticides because the infrastructure is permanent, and works constantly, negating the need to locate the affected water for treatment.

In order for such an application to work best, he says, among other considerations is the correct location that makes the most sense. Tributaries where the wetland would be the most efficient need to be located. Then, adequate space is necessary, preferably in areas not used for agricultural production.

Today, this knowledge is widely available and accessible and, said Schulz, many of the papers have been written specifically to be as applicable as possible, with guidance on how to move forward.

Back at Vergelegen, the retention pond that quietly became the topic of the now pioneering study, is still quietly doing its job and much more. In their constant and ongoing efforts to keep the river clean, Vergelegen takes bi-annual water quality samples all along the Lourens River as it runs through their property to measure any impact on the river and ensure it remains minimal. Though the input to the constructed wetland has changed through the years, results still show the water to be of similar or better quality below the outflow of the retention pond, in comparison to samples taken just up-stream where there is no effluent from their farming activities that can enter the river. According to Vergelegen, this is proof as good as any study, that farming in collaboration with nature, through the use of green infrastructure like artificial wetlands, can result in a minimal impact on the very system they depend on to do it.

Vergelegen Estate

The Vergelegen wetland