POLICY BRIEF

August 2019
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Quantifying and managing agricultural nitrogen and phosphorus pollution

The application of fertilizer while an important part of successful crop production, can lead to the pollution of water resources through runoff and drainage from agricultural lands. Management of nitrogen and phosphorus pollution should be done carefully so as not to impact agricultural yield and profitability. The Water Research Commission (WRC) initiate a study to improve our understanding of nitrogen and phosphorus dynamics, to determine the pollution potential of different cropping systems and to identify mitigation measures to address the problem of nitrogen and phosphorus pollution in South Africa.

Various modelling and in-field investigations were undertaken during the study, which focused on the Lower Vaal and Middle-Olifants catchments. The study confirmed the contribution of agriculture to nitrogen and phosphorus pollution in these catchments, and various suggestions are made to improve nutrient uptake by crops and reduce the leaching of nitrogen and phosphorus into watercourses in these areas. Policies to regulate the use of fertiliser, monitor its use and prevent its overuse, are also recommended.

Background

Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water. In agriculture, soil, fertilizer, and manure are all sources of nitrogen and phosphorus to grow crops.

But when too much nitrogen and phosphorus enter the environment, for examples, from runoff and excess drainage from fertilised agricultural fields, water resources can become polluted. Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae – a process known as eutrophication – harm water quality, food resources and habitats.

Eutrophication of waterways is a major problem in South Africa, and agricultural non-point source pollution has been identified as an important contributor to eutrophication. Agricultural nitrogen and phosphorus pollution is extremely difficult to quantify because of the challenges in measuring nutrient losses via runoff and drainage at the plot scale, and the complications to upscale field measurements to a catchment scale.

Agricultural nitrogen and phosphorus pollution is also difficult to mitigate because of the diffuse nature of the pollution and the essential role that nitrogen and phosphorus fertilisation plays in enhancing agricultural productivity. Reducing nitrogen and phosphorus rates can lead to reduced yields, so management practices that lead to a higher nitrogen and phosphorus use efficiency by the crop are needed to reduce pollution by these chemicals without impacting yields and profitability.

Therefore the WRC initiated a project to improve our understanding of nitrogen and phosphorus dynamics in arable fields and provide data for model testing, to determine the pollution potential of different cropping systems in South Africa, to identify mitigation measures, and to define upscaling techniques to improve the quantification of pollution at catchment scale.

Study methodology and results

Firstly, a scoping study was conducted to assess potential 'hotspots' where irrigated agriculture may be contributing to surface water eutrophication and enriched groundwater nitrate levels via non-point source nitrogen and phosphorus pollution. Based on the study, the lower Vaal and Middle Olifants catchments were selected for more detailed research in this project.

Various models were investigated that are commonly used internationally to investigate non-point source pollution from agriculture. A brief description of each of these models (Hydrus, APSIM and SWAT) are provided in the final report, along with a table comparing the different relevant processes simulated and input parameters provided.

After testing various nitrogen and phosphorus in-field measuring techniques, the research team from the universities of Pretoria and the Free State undertook various in-field trails, using crops such as wheat, potato and maize. Among others, the purpose of the trials was to understand the contribution of irrigated agriculture to nitrogen and phosphorus concentrations in the Lower Vaal and Middle Olifants catchments. Different techniques were used to, among others, quantify nitrogen leaching from the rootzone of crops and determine fertiliser nitrogen use efficiency, investigate the use of different irrigation scheduling tools to reduce leaching, and test the accuracy of various models.

Main findings and recommendations

Even in a carefully managed winter wheat trial with scientific irrigation and nutrient scheduling, only 68% of the applied fertiliser was taken up by the crop. This still represents a significant improvement from the 50% efficiency often reported in the literature. Careful application of best management practices, the use of suitable crop rotations, including catch crops, and adoption of new technological advances, such as decision support systems and precision agriculture can assist farmers with improving the efficiencies of applied fertilisers. (A catch crop is grown to retrieve available nutrients still in the soil following an economic crop and prevents nutrient leaching over the winter)

In the Lower Vaal study, observed nitrogen concentrations in deep drainage water were substantial and higher than that of river water and borehole water in the region. It is therefore likely that nitrogen leaching from irrigated cropped fields forms a considerable contribution to nitrogen pollution of sub-surface and surface waters.

Nitrogen leaching is associated with the high fertiliser input rates used in intensive potato production systems. These nitrogen leaching risks in potato-based rotations may be minimised by rotating shallow-rooted potato with a deep-rooted crop with a high nitrogen demand, such as maize, which can partly recover some of the nutrients lost in drainage to deeper soil layers.

In dry climates, farmers in South Africa using appropriate irrigation scheduling tools may have limited deep drainage and associated nutrient losses in crops, even in soils with relatively low water-holding capacity. Heavy rainfall events, however, disturb the balance between water input and evapotranspiration and can lead to substantial drainage. This type of drainage cannot be avoided through improved irrigation management, and ultimately it comes down to whether fertiliser nutrient supply is well matched with crop demand over the longer-term.

The mobility of water and nitrogen are closely linked, and irrigation beyond the crop demand leads to deep drainage and nitrogen leaching. Under-irrigation reduces crop yield and the nitrogen use efficiency of the crop, leaving more nitrogen behind in the soil that can be leached, and is therefore not recommendable either. Split applications of nitrogen fertiliser is even more practical through fertigation in irrigated systems. This can greatly improve nitrogen use efficiency and reduce leaching, especially in sandy soils with a lower water and nutrient holding capacity.

Towards a policy to reduce agricultural nitrogen and phosphorus pollution

In certain parts of the world, for instance in the European Union, fertiliser use and leaching loads are carefully monitored and highly regulated. This may be through pre-defined ceilings for fertiliser application rates, and through management tools such as the obligatory cultivation of nutrient catch crops in periods when no crop is in the field means the risk of leaching is high.

In South Africa, regulations regarding fertiliser use by farmers is minimal and monitoring of nutrient losses from cropped fields non-existent. Commercial farmers often depend on representatives of fertiliser companies for advice on fertiliser application rates. These companies do not necessarily have an interest in reducing fertiliser application rates.

Due to a lack of reliable decision support systems for nutrient use, farmers generally rather apply a bit too much fertiliser rather than running the risk of under-supplying nutrients and harming yield. This is especially true for high-value crops such as potato, onions and other vegetable crops. To reduce nutrient pollution from cropped farming, South Africa needs to begin to implement the monitoring of fertiliser use and prevention of over-use.

For more information,

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The associated report, ***Quantifying and managing agricultural nitrogen and phosphorus pollution from field to catchment scale*** (**WRC Report No. TT 792/19**) can be downloaded from www.wrc.org.za.