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Department of Agriculture
Western Australia

Nitrates in the groundwater beneath horticultural properties

Farmnote 2/95

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Summary

Nitrates from nitrogen fertiliser leaches rapidly from sandy soils to the groundwater, where it can make the groundwater dangerous to drink and contribute to algal blooms. Adjust the fertiliser application on irrigated crops to allow for nitrogen from groundwater. Calculations for this are described and also ways to reduce nitrate leaching.

Nitrates from nitrogen fertiliser are readily leached from all soils. Leaching is particularly rapid on sandy soils because of their limited capacity for holding nutrients and moisture.
High nitrate concentrations in the groundwater below horticultural properties are common on the Swan coastal plain. This is of interest for three reasons:

- health concerns from drinking water with high nitrate levels;
- the growth of algae in surface water; and
- the amount of nitrogen applied to crops in irrigation water.

Health concerns

Drinking groundwater that has high levels of nitrates is dangerous to your health and that of your children.

In 1991, just under half the bores sampled (40 market gardeners' bores) contained concentrations in excess of the World Health Organisation Guideline of 10 mg/L nitrate-nitrogen.

Drinking water with nitrate levels exceeding this limit is especially serious in infants. It is important that people who drink groundwater from their private bores have the water analysed for its nitrate content. The Chemistry Centre (W.A.) or a private laboratory can conduct the analysis.

If your domestic bore is located near a septic tank or poultry manure heap, also have a sample analysed for harmful bacteria that can cause gastroenteritis. Samples taken by local health surveyors can be analysed by State Health Laboratory Services.

The growth of algae in surface water

In saline estuaries and shallow coastal waters, nitrates can cause the growth of algae and phytoplankton. Algal blooms choke waterways, give off foul odours and may kill seagrass, fish and birds.

Groundwater flowing from agricultural and urban areas can carry nitrates, which may ultimately reach estuaries or the ocean and contribute to algal blooms.

Nitrogen applied to crops in irrigation water

Irrigation with nitrogen-rich groundwater can add a considerable proportion of a crop's nitrogen requirement. Calculate the amount of nitrogen applied in the irrigation water and adjust their fertiliser programs accordingly - see below for how to do this.

Nitrogen in the groundwater can be so high that the crop suffers nitrogen toxicity. In this case, use no further nitrogen fertiliser, or mix the water that is high in nitrogen with a different, uncontaminated source before irrigating.

Nitrogen levels in the groundwater are likely to be higher in areas where horticulture has been practised for a long time and where the groundwater source is shallow. It is important to regularly check the nitrogen concentration in bores and to readjust fertiliser programs if nitrogen concentrations change.

Other nutrients

Potassium concentrations in the groundwater beneath horticultural properties may also build up to the point that irrigation with this water supplies a significant part of the crop's requirement. A potassium analysis can be done at the same time as a nitrogen analysis. The results may indicate that potassium fertiliser applications can also be reduced.

Phosphorus concentrations in groundwater under horticultural properties are unlikely to increase, since this nutrient is held tightly by most soils and not readily leached. However, levels may increase in the shallow groundwater below horticultural properties that are located on white sands.

Nitrogen analyses

The result should be expressed as ppm or mg/L of total nitrogen. If your results express the nitrogen concentration as nitrate-nitrogen, this figure can be used, but will underestimate the total amount of nitrogen being applied, because additional small amounts of nitrogen are usually present in the groundwater as ammonia and organic nitrogen. If the water analysis is expressed as nitrate, divide by 4.5 to get the nitrogen concentration.

Four steps to calculate the amount of nitrogen applied in irrigation water

Step 1

Have a sample of your bore water analysed to determine its nitrogen content. Take a sample of at least 100 mL of water in a clean bottle with a tight lid. Keep the sample cool in an ice pack or Esky® and deliver it to the laboratory (Chemistry Centre W.A. or private laboratory) within a few hours. Frozen samples will last up to four weeks (fill the bottle only two-thirds full, to allow for expansion during freezing).

Step 2

Calculate the volume of irrigation water (m^3) applied per hour over one hectare:

Output of one sprinkler (L/h) *multiplied by* 10 *divided by* distance (m) between sprinklers along each lateral *multiplied by* distance (m) between laterals).

Step 3

Calculate how many kilograms of nitrogen are applied per hectare per hour in the irrigation water:

Nitrogen analysis results *(Step 1) multiplied by* volume of water/ha/h *(Step 2) divided by 1000.*

Step 4

Calculate how many kilograms of nitrogen are applied per hectare over the crop's life. Hours of watering will vary with time of year, crop stage and rainfall:

Kg of nitrogen/ha/h (*Step 3*) *multiplied by* total number of hours of watering over the crop's life.

The figure obtained in *Step 4* is the extra nitrogen that is applied to the crop per hectare from the nitrogen in the groundwater.

Example

If the nitrogen concentration of bore water used in a market garden is 15 ppm, how much nitrogen is being applied through the irrigation system over one crop's lifetime? Assume the following:

- output of a Pope Premier sprinkler (size 12 nozzle) at a pressure of 300 kPa = 1452 L/h (24.2 L/min);

- sprinklers 12 m apart along the laterals;
- laterals 13 m apart;
- crop watered 11/2 h per day (on average); and
- the crop is a cabbage crop that takes 72 days to mature.

Step 1

The nitrogen content of water is 15 ppm (which is the same as 15 mg/L).

Step 2

Calculate the volume of irrigation water (m^3) applied per hour over one hectare:

Output of one sprinkler (L/h) *multiplied by* 10 *divided by* distance (m) between sprinklers along each lateral *multiplied by* distance (m) between laterals).

That is: 1452 L/R *multiplied by* 10 *divided by* 12 m *multiplied by* 13 m = 93 m^3/ha/h

Step 3

Calculate how many kilograms of nitrogen are applied per hectare per hour in the irrigation water:

Nitrogen analysis results (*Step 1*) *multiplied by* volume of water/ha/hour (*Step 2*) *divided by* 1000.

That is: 15 mg/L *multiplied by* 93 *divided by* 1000 = 1.40 kg of nitrogen/ha/h.

Step 4

Calculate how many kilograms of nitrogen are applied per hectare over the crop's life:

Kg of nitrogen/ha/hour (*Step 3*) *multiplied by* total number of hours of watering over the crop's life

That is: 1.40 *multiplied by* 108 (1½ hours/day *multiplied by* 72 days) hours = 151 kg of nitrogen/ha/crop.

A cabbage crop generally requires about 400 kg per hectare of nitrogen for optimum growth. This grower only needs to apply 249 kg of nitrogen per hectare (400 kg minus 151 kg) because of the contribution from the irrigation water.

Ways to reduce nitrate leaching

- Apply no more nitrogen fertiliser than the crop needs for good growth. Refer to Department of Agriculture fertiliser recommendations for different crops.
- Do not over-water. Excessive applications of water infiltrate through the soil and leach nutrients away. Small, frequent waterings are best on sandy soils, keeping the root zone moist without excessive water loss by deep drainage.

- Ensure that your irrigation system applies water evenly. Uneven application leads to over-watering in some areas in order to supply enough water to the drier spots. This excess water drains below the root zone, taking nutrients with it.
- On sandy soils, apply nitrogen fertiliser in small, regular doses throughout the life of the crop. This will limit leaching (caused by heavy rain or over-watering) to the most recent small application.
- Slow-release nitrogen fertilisers can reduce leaching, because they supply nitrogen at a steady rate over an extended period. This can result in efficient nitrogen use by crops, with less nutrients available for leaching. At present these forms of nitrogen are more expensive and generally uneconomic.
- Match nitrogen application rates with crop growth stage. Young crops require lower rates of nutrients than crops in mid-growth. However, apply nutrients in more frequent, smaller doses when crops are young, because their root systems are smaller. Reduce nutrient applications as the crop approaches maturity.
- When plants are young, place nitrogen fertiliser with droppers immediately adjacent to plants. When crops develop more extensive roots they are better able to extract nutrients spread over the whole garden, orchard or vineyard.
- Do not apply high rates of poultry manure, which will increase soil nitrogen levels far beyond what the plant can use and lead to nitrogen leaching. All nitrogen contained in poultry manure is leached within about four weeks of application. The maximum recommended rate for vegetables is 30 m^3/ha per crop.
- Conduct tissue testing to determine whether the crop has sufficient nitrogen and adjust nitrogen applications. Sap testing kits provide a quick method to determine the nitrogen status of a crop.

Irrigating with nitrogen-rich groundwater can supply a large percentage of a crop's fertiliser requirement, particularly on established horticultural properties.

Further reading

- Bulletin 4175 'Nitrogen and phosphorus disorders in vegetable crops' (Agdex 250/632).
- Farmnote No. 66/95 Irrigating vegetables on sandy soil' (Agdex 250/560).
- Farmnote No. 22/90 'Scheduling for trickle, sprinkler and flood irrigation' (Agdex 561)
- Farmnote No. 23/90 'Irrigation scheduling - how and why' (Agdex 561).
- Farmnote No. 35/90 'Evaluating sprinklers and trickle irrigation systems' (Agdex 200/560).
- Farmnote No. 30/92 'Design guidelines for fixed sprinklers and micro-irrigation systems' (Agdex560).
- Farmnote No. 48/92 'Efficiency of irrigation systems' (Agdex 565).