Developing a Code of Practice for the release of solutions from soilless greenhouses onto land

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Abstract

A Code of Practice for the land treatment of solutions from soilless greenhouses has been developed in cooperation with the industry in New Zealand. which has converted to modern. It addresses the issue of how nutrient solutions from large automated high performance greenhouses using soilless media can be released onto land without causing nitrogen pollution of groundwater or waterways. Based on pasture growth rates and nutrient models, the code proposes that it is environmentally safe to make regular releases up to a maximum of 30 kg N/ha every 21 days, provided strict criteria are met. Solution release is under the control of the greenhouse manager because it is in a closed system of pipes, a unique situation in the primary industries. The Code will adapt with improving knowledge and grower testing.

Additional keywords: nutrient solutions, nitrogen leaching, soil moisture deficit.

Introduction

A Code of Practice (Lewthwaite *et al*. 2006) for the land treatment of solutions from soilless greenhouses onto land was written because of increasing awareness of the potential risk of adverse environmental effects from such discharges and the need to comply with the Resource Management Act 1991. Its format followed the already published NZ Fertiliser Manufacturer's Research Association *Code of Practice for Fertiliser Use* (Anon., 1998) and is based on *best practice* and the *best practicable option*. The watering and fertiliser system of a modern greenhouse is entirely different from other primary industries because it is closed. The components of the solution, water and fertilisers, are mixed in a tank, distributed in pipes to the plant roots and then returned to the mixing tank where they are adjusted and recirculated. The solution can be released when the manager determines the environment is able to accept it safely. In all systems, some solution has to be released; varying from small regular daily volumes to a large volume in an annual cleanup.

On a national basis, the potential impacts of released solutions are minimal compared with the impacts from a larger industry such as dairying. However, the larger greenhouses have a potential for point source pollution of waterways and groundwater, especially from nitrogen.

Methods, Results and Discussion

1. Preliminary Work

A liaison group was convened in January 2003. Then individual property information was collected to enable the development of a calculator to estimate the amount of water and nutrients released from greenhouse vegetable and flower crops. This part of the project provided gross annual data but could not answer the more practical question about 'when' and 'how much' solution could be released to land and so was set aside.

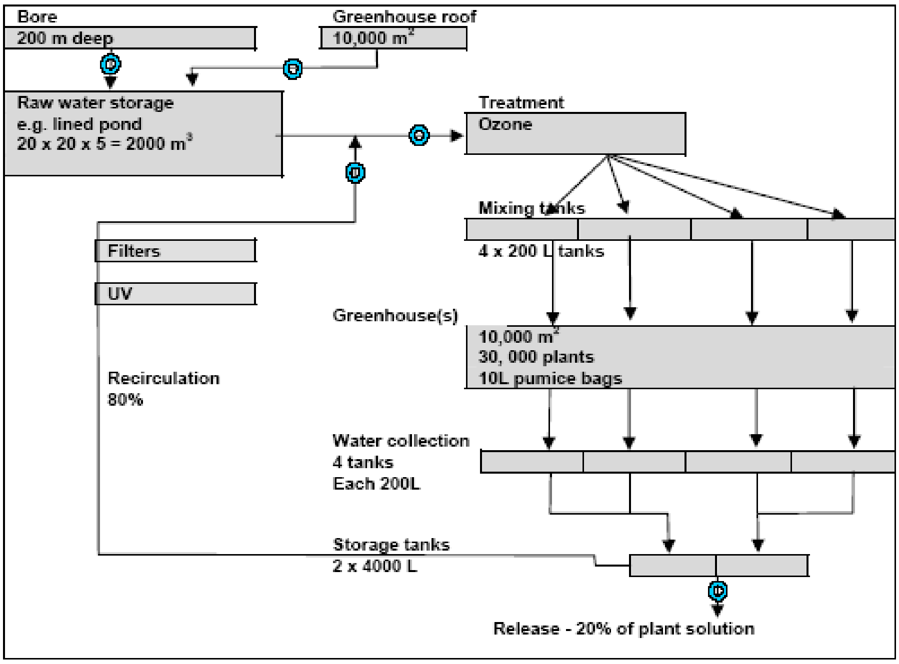


Figure 1: An example of a solution flow diagram in a soilless greenhouse

2. Current form of the Code

The Code operates in a three-stage decision process; from system design, to storage and then release of solutions to the environment.

Stage A
Soilless growing and media systems

The grower is responsible for greenhouse and property design, including managing water quality and water treatment, and the release of water. An example of a solution flow diagram in a soilless greenhouse is shown in Figure 1.

Stage B
Solution collection and storage

The Code requires that solutions shall be stored until application sites are at a suitable soil moisture deficit condition and adverse climate conditions are not in the short forecast. The volume of storage required for either the 'winter' period of the year when soil moisture deficit is low or the 'summer' period when soil moisture deficit is high can be calculated. The calculation firstly involves considering average daily 'winter' or 'summer' plant water use (Figure 2) to estimate the daily volume of solution released. The length of periods in the year when soil moisture deficits are too low to safely apply released solutions to land then need to be considered. From long term NIWA soil moisture deficit data, the 'winter' period runs for about 6 months in Pukekohe, 5 months in Richmond and 3 months in Lincoln.

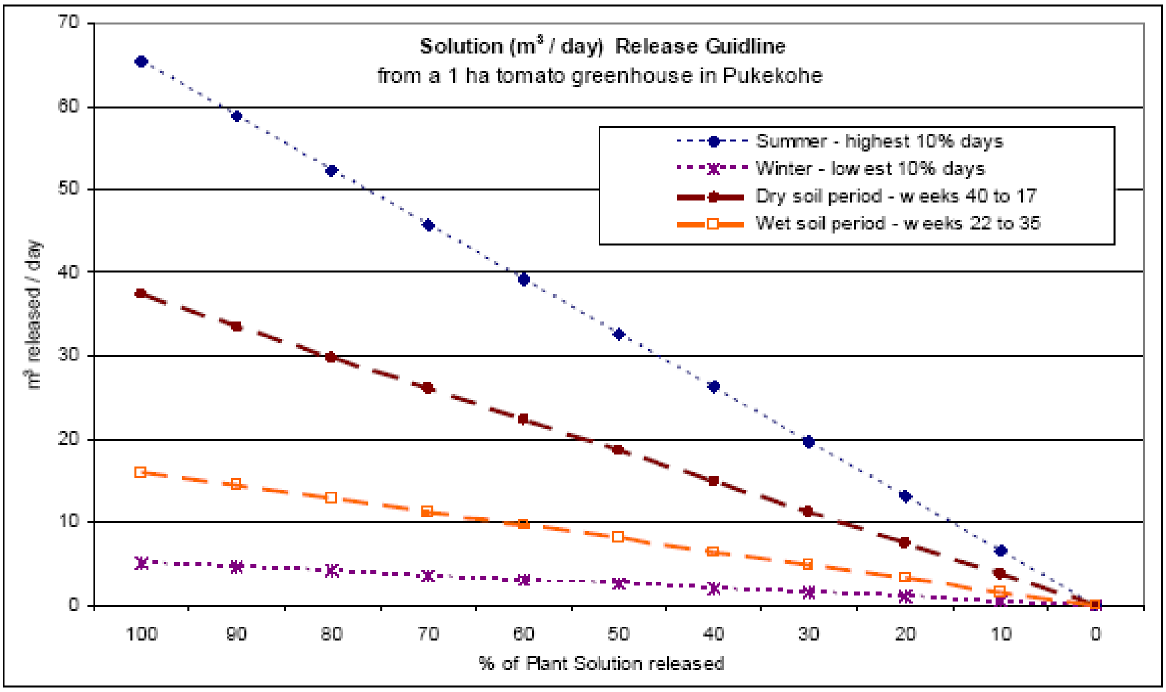


Figure 2: Solution (m^2/day) Release Guideline[MJH1]

Note: In Pukekohe, plant growth normally requires about 2 ml of nutrient solution/m^2 of greenhouse for each J/cm^2 of radiation. Some add an extra 1 ml/m^2 to allow dilution of the solution which is then released on a daily basis. If this 1 ml/m^2 is released the calculated release rate is 50%. The graph above shows the volumes of solution released in different seasons for a 1 ha greenhouse.

Stage C
Solution release

This is the most critical stage of managing solution release from modern greenhouses.

i) Identify and evaluate potential release sites

The basic principles of the Code are that here shall be sufficient land allocated to take into account the plants' ability to absorb all the nitrogen; water shall be applied to recharge the root zone; no application shall be made over sensitive areas.

The preferred plant systems for release sites in priority order are; pasture conservation, grazed pasture, annual and permanent crops, and catch crops. The full summary of the Code provisions is given in Appendix 1.

Growers are required to describe site details e.g. soil type, contour, sensitive areas, plant cover, riparian strips and buffer zones.

ii) Design application methods for released solutions and evaluate application efficiency

The most suitable systems are those that spread solutions thinly and evenly over an area, such as set sprinklers, travelling irrigators and K lines.

The application method must meet the criteria of the *Irrigation Evaluation Code of Practice* (Bloomer, 2006) or *The Irrigation Code of Practice and Irrigation Design Standards* (McIndoe, 2006).

iii) Evaluate risk the day before release and calculate disposal area needed

Before release check the condition of the soil, plant cover, growth rate, weather forecast. Also calculate the nitrogen loading – the total kg N to be released and check the kg N /ha meets the Code standards. Keep full records for five years.

3. Validations of critical parts of the Code

The basic principle was for solution release to be allowed when there is the least chance of nitrogen polluting waterways or ground water. The solution is required to be stored until conditions are suitable for release and then only 30 kg N/ha can be applied every 21 days, subject to strict conditions given in Appendix 1. The main condition is that there is a high plant cover that is actively growing and so is able to absorb the applied nitrogen. Data from McLaren and Cameron (1996) shows that moderate production pasture (5000 kg DM/year) takes up on average 29 kg N/21 day period, and high production pasture (8000 kg DM/year) takes up on average 46 kg N/21 day period. Crops appear to have an even higher rate of nitrogen uptake; the total uptake for lucerne, maize and grain wheat is listed as 500, 330, and 110 kg N/ha over the life of the crop (McLaren and Cameron, 1996).

The rate of uptake of nitrogen changes throughout the year, caused by variations in temperature and plant cover. Data extrapolated from pasture dry matter growth rates from Dexcel (Anon., 2006) shows the average rate of nitrogen uptake for 21-day period by month (Figure 3). Non-irrigated pasture often falls below the Code standard even when temperature and plant cover are adequate for growth. The Lincoln data shows the potential increased uptake when pasture is irrigated.

The Code criteria were checked against the Nitrogen Leaching Estimation Model (Figure 4) of Di and Cameron (2003). At moderate growth rates, there is very little leaching on conservation pasture (cut and carry) even when nitrogen application rates are as high as 400 kg/ha. If application drops slightly the NLE model shows there is no leaching.

The recommendation in the Code of 30 kg N/21 days gives a theoretical application rate of 521 kg N/ha/year. But it is likely however that no more than half this rate could ever be applied in most years due to adverse soil moisture or temperature conditions in winter.

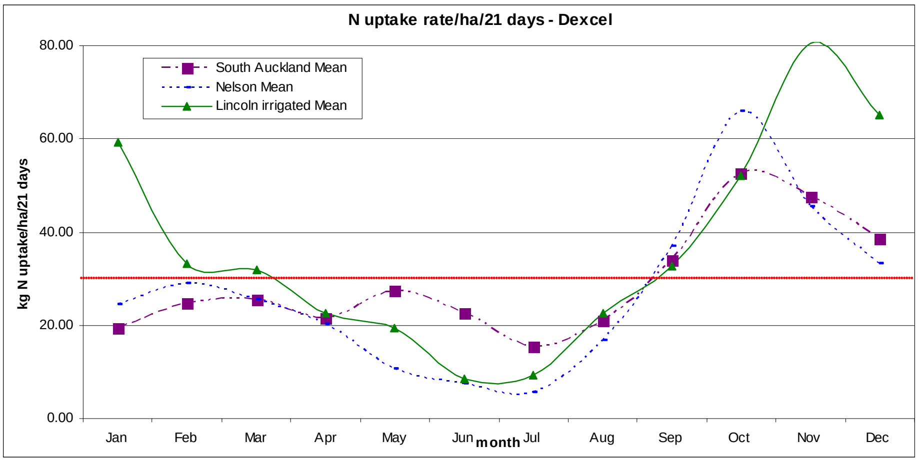
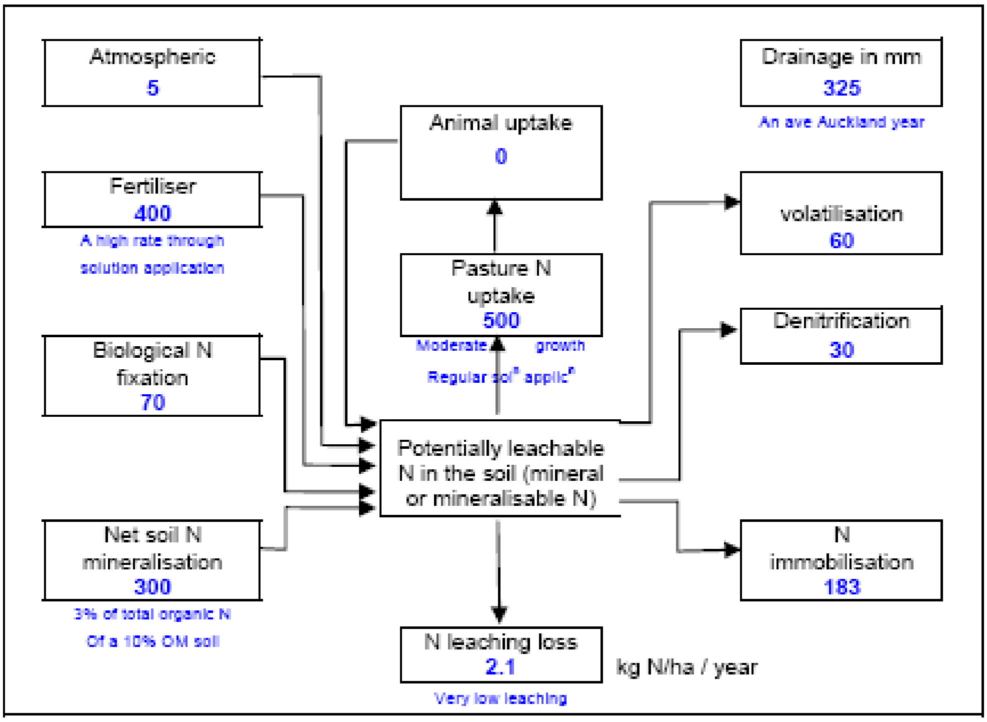


Figure 3: N uptake rate/ha/21 days

Note: Dexcel (Anon., 2006) has published daily dry matter growth rates for pasture for each month of the year for New Zealand districts. This growth rate was converted to average nitrogen uptake (at 4% N content for 21 day periods).



Summary of nitrogen pathways	*kg*
Total application	775
Plant uptake and losses	590
Leaching	2.1
Immobilisation by soil organisms (the balance of the N)	183

Figure 4. Nitrogen Leaching Estimation (NLE)

Note: Standard soil conditions are illustrated to estimate the potential for leaching under conservation pasture (cut and carry). This example shows there is very little leaching even under high application.

4. Future Development

Because a greenhouse manager is in total control of solution release, we have been able to set high standards that could eliminate leaching when solutions are applied to conservation pasture and not add to leaching in grazed pasture. This requires capital cost as well as management skill in areas not normally needed by greenhouse growers.

Follow up research needs to include; the practicability of implementing the recommendations in the Code; the assumptions relating to plant uptake of nitrogen; and other potential release sites (e.g. forestry) and other nitrogen absorption systems (e.g. constructed and harvested wetlands, coppicing trees for ethanol production or firewood, sawdust beds, nitrogen digesters).

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Appendix 1: Summary of recommendations for application to land

1. Have release sites identified at least one month ahead of intended application.

2. Estimate the volume of water and amount of N likely to be released.

3. If nutrient solutions are applied to land which is irrigated, deduct the release volume from the irrigation water volume to be added.

4. If nutrient solution is applied to land which also receives N-fertiliser or is grazed, deduct the weight of N in the solution from the weight of nitrogen in the fertiliser to be applied or the animal dung and urine to get the total nitrogen input.

5. Do not apply nutrient solutions to wet soils, wait until drains stop flowing.

6. Use local rainfall and evapotranspiration data (from tables and or local newspapers) to determine when leaching is likely to occur.

7. If more specific information is needed, use irrigation scheduling techniques (e.g. water holding capacity and water budgets) to estimate the ability of soil to retain the volume (or depth) of solution applied.

8. Identify the drainage and water infiltration characteristics of the soil of the discharge area. Be cautious when applying solutions to:
   - excessively drained soils
   - badly drained soils,
   - soils with a marked surface cap
   - dry soils with deep cracks.

9. Estimate the nitrate leaching index of the soil from drainage characteristics and local rainfall.

10. Assess leaching risks on the day before planned application.

11. Apply nutrient solutions to land with high plant cover (e.g. crop cover to be 75% or above)

12. Apply nutrient solutions in conditions with fast plant growth. (e.g. not to short grass after grazing or mowing or crops that are growing slowly in cold weather or are near to harvest)
13. Do not apply nutrient solutions to areas with just ploughed pasture or crops.

14. Consider methods to catch excess nitrate
    - Sowing a catch crop to take up nitrogen from the soil
    - Incorporating a high C:N ratio material such as cereal straw to soak up available nitrate in the soil
    - Sow crops in the autumn (e.g. winter-growing crops), to take up nitrogen before winter rains wash it through the soil
    - Ensure that actively growing crops are present when immobilised N is re-mineralised in spring.

15. When applying nutrient solutions to intensely grazed pasture
    - The grass must be at least 50 mm high
    - Wait for at least 2 weeks after stock is removed

16. Maximum nitrogen rates for application to pasture and crops
    - Total N application (from solution and other nitrogen sources e.g. both mineral or organic fertilisers) to be no more than 30 kg N / ha per application
    - Applications to be at least 3 weeks apart

17. Consider applying a nitrification inhibitor

18. Preferably apply nutrient solutions to deep-rooted crops such as wheat rather than to those with shallow or sparse root systems (potatoes, peas, spinach)

19. If applying solution to permanent plantings (orchard, amenity trees or forest) follow the general guidelines above.

20. Monitor the pH of soils receiving extra N, and apply lime when necessary.