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Managing waste water from intensive horticulture: a wetland system

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WHAT IS WASTE WATER?

Waste water or 'run-off' from intensive horticulture usually contains a high level of nutrients - and possibly some sediments and plant pathogens. Described as nutrient-loaded, this waste water is defined as effluent.

WHY IS WASTE WATER A PROBLEM?

Responsible land use is about preventing waste water from entering the environment. High nutrient and sediment loads can cause environmental problems, such as algal blooms and fish kills.

Solid matter and sediment

Solid matter and sediment in waste water originate from soil based production systems and may include organic matter as well as sand and clay particles. Hydroponic media can also be a source of solid materials carried in waste water - for example, commonly used growing media such as sawdust and perlite.

Turbidity

Turbidity can be used as a measure of how much sediment is in the water. As the level of sediment increases, so does the turbidity of water. Water appears cloudy or muddy when turbidity exceeds 5 NTU*.

Sediments can result in blockages in irrigation equipment and, in the environment, can be harmful to some aquatic animals. Furthermore, if the water is being reused and requires disinfection, turbidity needs to be less than 1 NTU. This is because sediment and organic matter in the water impair some methods of disinfection.

* NTU - Nephelometric Turbidity Unit is a unit for measuring suspended matter in water

Nitrogen and Phosphorus

Nitrate and nitrite are naturally occurring forms of nitrogen. In the natural water systems, total nitrogen levels of 0.1-0.75mg/L contribute to algal blooms, though the level of phosphorus in water is often the key factor causing algal blooms. Total phosphorus levels of 0.01- 0.1mg/L contribute to algal blooms. Growth of algae in irrigation systems can also lead to clogging of drippers and filters.

Total Dissolved Solids (TDS)

TDS is a measure of the inorganic salts and small amounts of organic matter that are dissolved in water. Electrical conductivity (EC) can be used as an approximate measure of the TDS, where:

$$\text{EC (mS/cm)} \times 670 \approx \text{TDS (mg/L = ppm)}$$

High salt levels in water can impact on other agricultural activities. For example, while crops have varying degrees of tolerance to salt, yields of all crops ultimately decline as salt levels increase. Also, relatively low levels TDS in overhead irrigation can result in crop damage. In the environment, high levels of TDS can impact on aquatic organisms.

SOIL PRODUCTION

In field production and soil based greenhouse production, waste water is often not even noticed as it drains away through the soil profile, moves off-farm as run-off and evaporates. As a result, the contaminants can be carried in the waste water.

Market gardens and intensive soil-based horticultural operations can address the problem of waste water by containing run-off. Erosion of soil is a bigger concern in this industry than nutrient run-off. Nutrients and sediments should be removed. Leaching of nutrients through the soil and into the ground water can be minimised by matching fertiliser and irrigation application to plant needs.

Drainage water from greenhouses and run-off from orchards and market gardens can be directed to a holding dam or tank. It can then be contained until the nutrients and sediments are removed.

IS THERE WASTE WATER FROM HYDROPONICS?

There are two types of waste water

Run-to-waste. The first type of waste water comes from flow-through hydroponic systems - often called 'run-to-waste' - which use a soilless growing medium. It is possible to have no excess water from these systems. However most growers will have waste water because it makes the management of plants and nutrients easier. For example, applying more water than the plant uses can prevent the build up of salts around the plant roots by washing them out of the growing medium.

Dumped. The second type of waste water is the residual nutrient solution that is periodically replaced - dumped - in recirculating systems or when a nutritional or disease problem arises. In the latter situation, discarding the nutrient solution and starting again is often the most economic option.

WHAT TO DO WITH WASTE WATER

Contain. The first step in managing waste water is to contain it on-farm so that nutrients and sediments can be removed from the water.

An advantage of hydroponics is that the nutrient solution is a known quantity and concentration and is readily collected from the hydroponics system. As a result, it is easier to manage waste water responsibly in a hydroponics system.

Clean. Cleaning the waste water means removing or reducing the sediment and the nutrient load. A number of methods can be used to stop nutrients and sediments being carried into water courses including bio-filtration (wetlands), filtration, evaporation and reverse osmosis.

Soil production systems will have a lot more sediment than hydroponics systems, while both systems may have relatively high amounts of nutrients.

The two key nutrient pollutants found in waste water are phosphates and nitrates. Phosphates tend to be attached to sediments, particularly clay particles, and can be removed through sedimentation.

Nitrates are highly soluble compounds, which can be removed by plant uptake and biological conversion to nitrogen gas. In wetlands, conversion to nitrogen gas is the main process of removal. The nitrogen gas is released into the atmosphere.

Nitrogen is also taken up by growing plants. The organic matter produced by the growing plants can be used as a mop to pull some of the nutrients out of the water. Weeding, mowing and otherwise removing plant material then removes nutrients from the system.

Green waste is much easier to manage than nutrients dissolved in water.

Plant material can be composted, used in the garden or orchard or disposed of through a local green waste collection service.

Check. Once you have a system in place to manage the waste water, you need to check that it works. Water samples should be taken from time to time and tested for the level of nutrients. Monitoring the system also includes carrying out routine maintenance.

PASSIVE WASTE WATER TREATMENT

An effective passive system can continually clean waste water with only minor maintenance and minimal running costs. A wetland-based system is such a system. It is passive, low cost and fairly low maintenance – needing only periodic removal of sediment and vegetation.

A wetland-based waste water treatment system uses lessons learned from nature. In normal natural processes, run-off water carries sediments, nutrients and plant material into water courses. These natural 'contaminants' are used (and removed) by the micro-organisms, plants and animals downstream. Intensive farming - along with other activities such as residential developments - can lead to a higher level of nutrients entering the water system. As a result, sometimes the natural system can not cope.

One option for the responsible farmer is to use naturally based systems to remove sediments and nutrients before the water leaves the farm. The wetland is nature's filter and has been shown to be effective in removing nutrients and sediments from water.

The use of wetlands has increased a lot in recent years as an effective and friendly method of treating waste water. The objective is to construct a simple wetland system that is effective and feasible for the small, intensive farm. Furthermore, even wetlands need maintenance so they need to be constructed with this in mind.

IS THERE A WORKABLE WETLAND SYSTEM FOR INTENSIVE FARMS?

Using some of the principles of wetlands, and testing the efficiency of the components of a wetland, it is possible to identify key elements to use in designing feasible systems for individual farms.

A feasible system must be compact, easy to build and flexible enough to incorporate existing components that might be found on a farm.

The key tasks of a passive water treatment system are the removal of sediments and litter, the removal of nutrients - particularly nitrates and phosphates - and a sustainable maintenance program. Four basic components of a system are sediment traps, filter beds, wetlands and retention ponds.

BASIC PRINCIPLES OF TREATING THE WASTE WATER

Sediment trap. The sediment trap removes heavy sediment and litter from the water. A sediment trap is built so that materials settle out of the water or are left behind when the water moves on.

The design needs to ensure that the trapped material can be easily removed for disposal. As phosphates tend to be attached to sediments, some of the phosphorus will be removed simply by capturing the sediment. Intensive farming systems however, often have a very high phosphate level in the run-off. To accommodate this, the sediment trap stage could possibly be modified to act as a strong phosphate filter using lime enriched sand.

Filter bed. A soil based, vegetated area is used as a natural filter bed. This section removes fine sediments and the primary nitrate load. To ensure no nutrients are leached to the water table, this area is contained with a water tight barrier such as a plastic sheet or dam liner. Grass is an effective user of nitrogen and is also easy to maintain, making it useful for the filter bed area. By removing grass clippings, nutrients are taken out of the system.

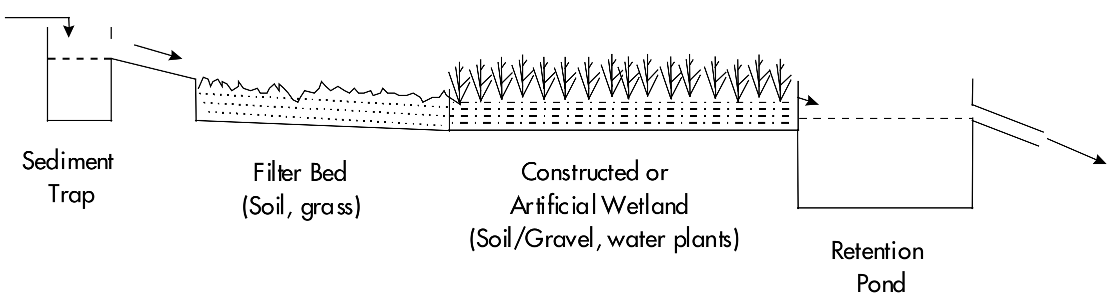
Wetland. The wetland stage of the system removes the remaining nutrients and gives the water a final 'polish.' This stage can either:

- use a vegetated gravel bed through which the water flows (separated from the water table with a plastic barrier), defined here as an *artificial wetland*, or
- use a soil based, vegetated area (ideally, separated from the water table with a plastic barrier), defined here as a *constructed wetland.*

Retention pond. The retention pond is a deep holding area for cleaned water, before disposal or re-use. This component may be either a deep water section of a constructed wetland or a separate pond. A tank can also be used.

HOW BIG MUST THE SYSTEM BE?

The size of the system is based on the desired retention time for the water in the system. That is, the time taken from when the water enters



the system to when it exits. The required retention time depends on the *nutrient load* of the waste water.

Nutrient load is a factor of both the **volume** of water and the **concentration** of nutrients in the water. A system with a five day retention period would have a total water volume 5-times the amount of water flowing into the system each day.

In a trial conducted at the National Centre for Greenhouse Horticulture, using part of the demonstration model wetland system, reductions in nutrient load were attained in line with Australian and international experiences. The system was highly effective with 87% of the nitrate and 95% of the free reactive phosphorus removed from the water in six days.

MAINTENANCE

The concentration of nutrients in the effluent should be checked when planning the maintenance program. Maintenance is an important task and it must not be overlooked. In a wetland treatment system, one problem - which can occur over time - is that the system can become saturated with nutrients. This is like a filter, which eventually clogs up if not cleaned.

There are two parts to this problem.

Net nutrient gain can occur. The system works by acting as a nutrient sink, that is, it uses more nutrients than it releases. Over time the plant material in the wetland system builds to a point where it actually contributes to the nutrient load in the water. While this is a natural result of a biological system, it is unwanted for obvious reasons. Maintenance of the system requires removal of plant material so that the system continues to use nutrients by growing more plants.

Phosphorus saturation. Phosphorus tends to stick to sediments, such as clay particles, but the sediment can only hold a limited amount of phosphorus. Eventually the system becomes full, and no more phosphorus can be removed.

The sediment trap could use sand and lime to increase the capture of phosphate. From time to time this sand is replaced to remove the phosphorus from the system.

An underlying basis of the passive, wetland-based waste water treatment system is that:

it is easier to manage solid green waste than invisible nutrients dissolved in water.

OTHER ISSUES TO CONSIDER

Fencing the retention pond

The final stage of the treatment system is a retention pond. Some councils may require you to fence the pond or dam. Check with your local council. For smaller systems, an alternative may be to install a tank as the retention pond.

Reusing water

Once you have a system in place to clean the waste water, you will no doubt start to think about reusing the water - especially as water is becoming more expensive. Reuse of water may still require more treatment. Plant pathogens (diseases) may survive in the system, though recent data has shown that *Phytophora* (a common plant pathogen) is removed in a wetland system.

If water needs to be disinfected, there are a number of treatments available including heat, chlorination, bromination, ultra violet radiation and ozone.

THE PROJECT

NSW Agriculture, in collaboration with the Natural Heritage Trust and supported by Wyong Shire Council and the Australian Hydroponics and Greenhouse Association, has funded a two year extension project: *Minimising the impact on the environment from intensive farming operations.* The aim is to assist intensive agricultural enterprises to address the issue of nutrient loaded waste water.

Natural Heritage Trust

This funding has enabled the construction of a demonstration system and production of a guide to building a system. The demonstration wetland model is located at the National Centre for Greenhouse Horticulture, at Gosford (Phone 02 - 4348 1900).

FURTHER READING

Managing Waste Water with a Wetland NSW Agriculture (in press). This booklet is a guide to constructing and installing a passive, waste water treatment system. It provides more detail on how to go about building a system.

PUBLICATIONS AVAILABLE

For a complete list of NSW Agriculture Agfacts, Agnotes and Farm Enterprise Budgets on the Web, please see this Web site:
www.agric.nsw.gov.au/publications

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