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# Slow flow Sand Filtration (SSF) for water treatment in nurseries and greenhouses

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**Slow sand filtration is a low-cost water disinfestation method that can be used as an alternative method of treating nursery irrigation water to control plant pathogens. It is a method that has gained popularity for use in treating recirculating nutrient solutions in greenhouse production yet can be adapted to large scale water treatment in nurseries.**

Slow flow sand filtration (SSF) differs from the ‘fast’ sand filters that are commonly used in conjunction with irrigation systems to filter out particulate matter. SSF is more appropriately called slow filtration as alternative materials besides sand are being used in the filter bed.

## How SSF works

Slow sand filtration relies on both physical and biological activity in controlling plant pathogens.

In a slow sand filter, the filter bed is constructed of a medium with high surface area which can be colonised by suppressive micro-organisms. This fine media also presents a physical barrier to the passage of spores of plant pathogens.

Bacteria, such as representatives of the genus *Pseudomonas* and *Trichoderma* have been demonstrated as biological control agents effectively controlling plant pathogens in hydroponics systems. In a SSF, plant pathogens recirculating in the irrigation water are captured in the filter media, and at slow rates of water filtration (100-200 l/hr/$m^2$ surface area of filter), are acted upon by the antagonistic micro organisms that colonise the filter bed.

The efficiency of SSF depends on the particle size distribution of the sand, the ratio of surface area of the filter to depth and the flow rate of water through the filter.

The finest grade sand fractions and granulated rockwool have been shown to be most efficient in controlling diseases such as *Phytophthora*, *Pythium* and *Fusarium oxysporum*, the most widespread nursery diseases.

# Advantages of SSF

There are several advantages of slow sand filtration over other methods of water disinfestation:

- there is no need for chemicals or technical instrumentation
- it is a low energy consuming process
- it has great adaptability in components and applications
- maintenance is minimal
- systems can be built and installed by laymen
- costs of building and running significantly lower than other disinfestation methods

Establishment of SSF in a nursery is similar to the installation of holding tanks and pumps to allow for batch treatments with chemical disinfectants. SSF requires no purchase of chemicals, there is no technical dosing equipment to service or replace and there is no chance of crop damage if dosing equipment or the operator miscalculates.

SSF used as a replacement for other forms of chemical, ozone or UV treatments would lead to significant savings in equipment upkeep and purchase of chemicals and avoid potential crop phytotoxicity.

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# Construction of a slow sand filter

The basic components in a slow sand filter are the housing, water layer, filter bed, drainage system and flow control. These are described below.

## Housing

Filters can be constructed in tanks with non-reactive surfaces such as plastic or fibreglass lined galvanised tanks, poly or concrete tanks of various sizes from 44gal drums (205 litres) up to 100,000 litre tanks. It may be advantageous to construct 2 smaller SSF units rather than one large unit so one can be shut down periodically for cleaning or repairs. Table 1 presents the volume of water filtered in a 24 hour period by filters of varying size. The capacity of the filter is determined by the surface area of the filter top and not the overall volume of the filter. Consideration must be made of the flow rate to be used when determining tank size (see Managing the SSF below)

## Water layer

The water layer above the filter bed provides the head to push water through the filter bed. It is convenient as a water storage zone and provides an effective temperature buffer to stabilise the filter and protect the biological activity occurring in the top layers of filter bed. A minimum depth of 0.5m up to 1.5m is most commonly used. Research in Australia suggests that this water layer should be maintained at a constant depth by the use of a small pump from an overflow tank or from the filtered water reservoir. This is particularly important if nutrient solution or recycled water is introduced into the filter in pulses and not continuously. The filter should never stand with an exposed dry top layer, or stagnant water which would accumulate only if the filter outlet was closed at the bottom. Continuous filtering assists in the development and maintenance of a healthy filter.

## Filter bed

The filter bed consists of a uniform fine particle sand mixture as specified (see Sand Specifications). The most critical design feature of the SSF is using a correct sand or alternative media. The filter bed is built to a depth of 1-1.5 m (or more) with a minimum of 0.8m on smaller filters. This depth of sand will allow for losses which will occur if the top portion of the sand is removed when particulate matter and algae is cleaned from the top of the sand.

**SAND SPECIFICATIONS**

**Sand is characterised by the diameter of the individual sand grains (eg 0.15-.35mm) and the effective size of the composite sand, the ES or $d_{10}$. $d_{10}$ is defined as the sieve size in millimetres that permits passage of 10% by weight of the sand. The uniformity coefficient (UC) of a sand is defined as $d_{60}/d_{10}$.**

**Sand needs to be of a fine grade ( 0.15-.35mm is recommended), uniform (the UC should always be less than 3 and preferably less than 2) and be washed free of loam, clay and organic matter. Fine particles will quickly clog the filters and frequent cleaning will be required. A sand that is not uniform will also settle in volume, reducing the porosity and slowing the passage of water. Sand manufacturers should be able to supply or blend sand to these specifications.**

## Drainage system

A gravel drainage system is provided at the bottom of the filter to prevent movement of the fine sand into the filter outlet. In European specifications this has consisted of 3 graded layers, 2-8mm, 8-16mm, 16-32mm. The use of a geo-textile fabric may be considered to support the sand as an alternative to some gravel layers. The bottom layer of gravel supports perforated drainage pipes which may simply bisect the filter or in a large filter form a network of connecting pipes across the base. The use of granulated rockwool as an alternative media to sand can reduce the requirement for the gravel drainage system and thus reduce the depth of the filter. A fine screen over the outlet would still be recommended to prevent rockwool granules from passing into the outflow.

### Flow control

A regulating tap should be connected to the filter outlet to control the flow rate. On large filters a flow meter is sometimes installed for use in monitoring the flow rate. The flow rate is specified in terms of litres/hour per unit area of the *surface* of the filter ( $m^2$). The flow rate through the filter is less than gravitational fall. Keeping the water level above the filter bed constant assists in maintaining an even flow. The flow rate will drop off with the build-up of material on the surface of the filter bed. An open clear pipe (poly tube) fixed to the exterior of the filter can be used to monitor head loss.

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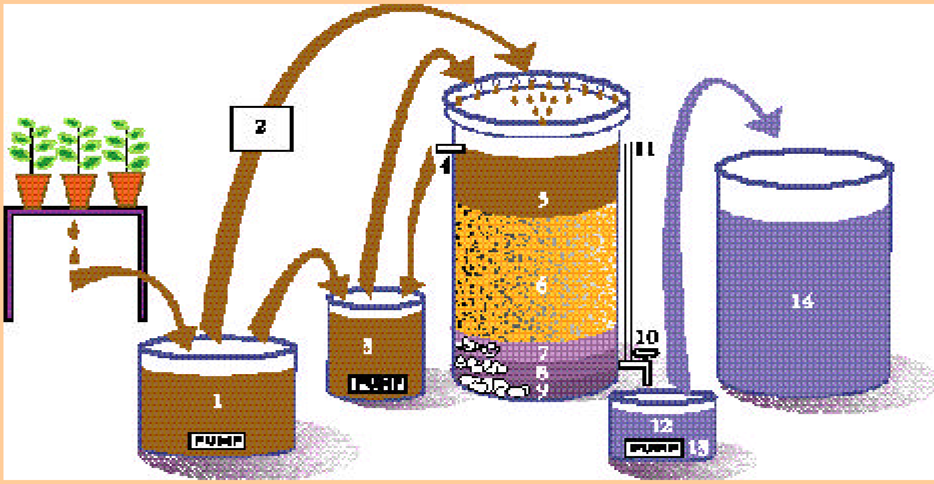
## Managing the SSF

#### Water flow

Water flow rates are relevant in relation to the disease load of the irrigation water. A slow flow rate of 100 l/hr per $m^2$ of surface area have been found to be preferable in high risk situations such as the control of *Fusarium* or viruses in tomato crops. In German research, the rates of 200 or 300 l/hr per $m^2$ are recommended for control of *Pythium* and *Phytophthora* in general nursery use. These rates are very important to consider when the SSF is being designed and a disease risk assessment should be conducted to determine the size of filters that will be required.




**Nutrient solution or recycled water drains from the crop and is collected in a catchment tank or dam (1).**
**Water is pumped to the SSF via a holding tank (3) or through a fast particle filter (2) to remove sus-pended organic matter, algae etc. Overflow outlet (4) back to holding tank maintains constant depth to water layer. The SSF consists of: a water storage layer (5), a sand or media filter bed (6) and gravel layers (7-9) to support filter bed. The outflow (10) may be fitted with a flow regulator valve and an open tube (11) to measure filter head loss. A small collection tank (12) lower than the SSF collects filtered water for distribution by pump (13). An optional holding tank (14) is used for the filtered water.**

As a guideline, where high volumes of water are being treated and the disease pressure is low (e.g. container nursery), then the higher flow rates may be most appropriate. There is no reported demonstration of filter effectiveness against plant diseases above the rate of 300 l/hr/$m^2$. If there is a high disease presence in the crop or the disease of most concern is a disease with small spores such as *Fusarium*, low rates of flow would be recommended.

**Volume of water filtered in a 24 hour period by filters of varying size surface area**

| **$M^2$ surface area** | **Flow rate (litres/hour)** | | |
|---|---|---|---|
| | **100** | **200** | **300** |
| 0.25 | 600 | 1200 | 1800 |
| 0.5 | 1200 | 2400 | 3600 |
| 1 | 2400 | 4800 | 7200 |
| 2 | 4800 | 9600 | 14400 |
| 5 | 12000 | 24000 | 36000 |
| 10 | 24000 | 48000 | 72000 |
| 15 | 36000 | 72000 | 108000 |

## Cleaning

All forms of water disinfestation may need to use traditional sand filters to pre-clean recycled water if many particulates are present. Similarly, irrigation water from dams with a high algal or silt content will need pre-filtering prior to SSF. The photo on page 1 shows a large SSF in California which recycles all the greenhouse nutrient solutions into an outside holding dam. The fast sand filter ( which can be easily backflushed) pre-filters all this dam water before it reaches the SSF.

When the flow rate through the filter slows (as indicated by head loss) the water layer above the sand bed can be drained and the top layer of sand scraped off. This layer should contain most of the suspended organic matter and silt that was slowing the water flow. In a granulated rockwool filter, some settling may occur over time and cleaning may also involve topping up with more rockwool at this stage.

### Biological activity

Microbial activity builds up very quickly in greenhouse nutrient solutions and slow sand filters will become active in biological suppression without any special inoculation. Some researchers suggest a four week period to fully 'establish' the activity of filters, however, the filters are physically active immediately and water needs to circulate through them to establish a microflora. In the future, the potential exists to inoculate the filters with specific biologically suppressive preparations as more of the complex microbial interactions occurring in the filters are understood.

Australian research has demonstrated that the majority of biological activity is occurring in the top 20 cm of the sand filter, when a modifying layer of water (nutrient solution) is passed continually over the filter head.

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## Australian research - summary

Direct inoculation of diseases into a range of ornamental host plants has demonstrated the effectiveness of SSF in reducing disease propagules to low levels where the chances of re-infection of a crop is negligible. Our experience with inoculations and monitoring can provide confidence to the nursery/greenhouse manager that SSF is appropriate for water disinfestation programs and can safely be used in nursery recycling and water treatment programs.

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## Further reading

Barth, Gail E. 1997. *Investigation of slow sand filtration for nursery recycling systems*. HRDC Final Report NY413 32p. $20 from HRDC. For copies phone: 02 9418 2200

Barth, Gail E., B. Hall and S. Chinnock. 1997. *The use of slow sand filtration for disease control in recirculating hydroponics systems*. Proceedings of the 4th National Conference of the Australian Hydroponics Association.

Rolfe, Chris, et al. 1994. *Managing water in plant nurseries*. HRDC manual. NSW Agriculture.163p.

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