‘Biofilters’ and more for water treatments in soilless cultures

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‘Biofilters’ are nowadays commonly used in several countries for treating water for soilless cultures. It started with slow sand filters. The majority of biofilters still has sand as the filter medium, but alternative filter materials such as lava and rockwool are tested and applied here and there. The previous article discussed slow sand filters, especially the construction, required flow rate and filter area. The present article discusses the efficacy of biofilters and some special features.

Testing slow sand filters
Two researchers in the Netherlands (Van Os in Wageningen and Runia in Naaldwijk) carried out extensive research on slow sand filters over several years. They investigated the performance of slow sand filtration in twelve separated closed systems with tomatoes growing in rockwool. They compared three types of sand (fine, medium and coarse) combined with two flow rates (100 and 300 $l/m^2/h$). The test was done with three pathogens: Phytophthora cinnamomi, Fusarium oxysporum and Tomato Mosaic Virus (TMV). In a separate experiment they also used the nematode Radopholus similes. The sand filters were allowed a four-week maturation period. This would be enough time for the development of ‘microlife’ or ‘biological activity’ (beneficial bacteria). They did not add any products for stimulating microlife.
Phytophthora appeared to be removed by the fine sand (0.15-0.35 mm sand) as well as by the medium size sand (0.2-0.8 mm) but only in combination with a low flow rate (0.1 m/h). Fusarium was not completely removed (99 % removal, which is not satisfactory). Some Fusarium spores came out of the filter three months later, and were still alive and pathogenic. For TMV the removal percentages were low (60-90 %) and living virus trickled through the filter over a period of weeks. The nematodes were filtered out for 90-95 %. But even after seven weeks some nematodes came through and were able to infect plants. The pH, CF and other factors where hardly affected by the sand filters.

Biological action?
The same researchers also investigated the difference between new and mature sand filters. The fresh filter had not had time to develop microlife. Overall there were no great differences in efficacy between mature and immature filters. Apparently the biological action in their filter was minimal and thus the need for maturing the filter was questionable.
Other scientists however (Postma in Wageningen and Brand in Sweden) studied the biological activity in slow sand filters. They found a totally different range of creatures in the effluent (water coming out of the filter) than in the influent (water going into the filter). For instance lots of harmless bacteria came out of the filter. Apparently some micro-organisms die and others thrive in a biofilter. The scientists thought that the biological activity in the slow sand filter may play a role in the control of some diseases. They found that a temperature of 15 °C or more is needed to maintain an active microlife in the biofilter. Therefore in cold countries slow sand filters are placed in the greenhouse or in a shed to keep the temperature up.

Alternative filter materials
Slow sand filters have some disadvantages: they are huge in area and heavy. They may get clogged and then the crust has to be scraped and removed. Hence it would be handy if other filter material could do the job. A German researcher (Wohanka in Geisenheim) tested four filter materials: rockwool, porous clay, pumice and sand (with a sand grain size of 0.2 – 2 mm, which is rather coarse).

This researcher reported that the rockwool granules performed as good as his sand filter, and significantly better than porous clay and pumice. Pythium and Phytophthora were removed completely, while Fusarium was removed to a great deal (just as with standard slow sand filters). The advantages of rockwool are: much lower weight and easier to handle, not prone to clogging, and no requirement for a gravel drain bed under the filter bed.

Lava filter

One particular biofilter worth mentioning is a lava filter produced by Shieer in the Netherlands. A tank contains lava granules, submerged in a layer of water that is to be treated. The lave granules are being moved around continuously by a strong air stream bubbling through the water. Lava granules have much more pores than sand. They give shelter to bacteria that are introduced or appear naturally in the lave filter. The manufacturer recommends adding a certain mixture of plant extract called BioWaterClean. This stimulates the development of micro-organisms, and helps protecting plants against root diseases, as well as cleans the irrigation system. The bacteria break down fungal spores, algae and slime. The airflow provides the bacteria with lots of oxygen.

The Research Station in Naaldwijk has investigated this biofilter and found that it completely removes Pythium and Phytophthora, and removes over 98% of tomato mosaic virus and Fusarium. (However 98% removal is considered insufficient). The advantages of this system are: the CF, pH and nutrients are not changed, the biological balance is maintained, the filter cleans itself and requires little maintenance, it can treat all sorts of water including nutrient solution.

Biofilter + UV

The slow sand filters were designed for a slow flow rate of 100 $l/m^2/h$, to control Pythium and Phytophthora. But many growers ran their biofilter at a much higher speed, so that even Pythium and Phytophthora were not properly controlled. Other growers decided that they needed protection against viruses and/or nematodes as well, which could not be achieved with a slow sand filter alone. Therefore many growers in the Netherlands added a UV installation to their biofilter. Some say that this is over the top, because a simple (back-washable) sand filter could do the job as well. However, a slow sand filter does more. It greatly improves the clearness of the water, so that the UV transmission improves. This makes the UV treatment more effective. An Israeli research group (Silverman and others) tested different disinfection systems on a large commercial capsicum operation over five seasons. They found that UV was only effective when it was combined with a slow sand filter.

Practical implications

Although some researchers found some evidence of a biological effect, it seems that the principle effect of the slow sand filter is the physical sieving of the pathogens. Runia and Van Os found that the bigger organisms are retarded more. Virus is very small and hence not well stopped, Fusarium spores are bigger, while Phytophthora spores are the biggest. But even more important than the size, is the hardiness of the pathogen. Pythium and Phytophthora zoospores are weak and die quickly. Fusarium conidial spores are very sturdy; they easily survive a long period in a slow sand filter. Nematodes can stay alive for several weeks in a slow sand filter. Moreover, with nematodes it is known that a very small number can cause an infection. In contrast, with some other diseases, an infection only happens when there are many spores.

The above explains why biofilters can control Pythium and Phytophthora, and to some extent Fusarium, but no viruses or nematodes. Since modern plant varieties have resistance against diseases (e.g. many tomato varieties are resistant against Fusarium), it is not needed to completely remove those spores. So a biofilter that removes Pythium and Phytophthora can be sufficient, depending on the circumstances. If the requirements are more stringent then it may be necessary to add a UV installation behind a biofilter. Another practical recommendation is to have two smaller slow sand filters, rather than one huge one. The two are used parallel. In case one is clogged, the other can be used at higher speed.

Further research

A large European research project is now underway that aims at further development of biofilters. Researchers in various countries will test a range of filters and use different diseases. The tests are large-scale and practical: a few diseased plants are placed in a recirculation system with a biofilter in it, and it is tested if the disease spreads to other gullies. They hope to come up with biofiltration systems that are effective, reliable, practical and economic.