Cleaning of Recirculating and Surplus Water in Container Plant Production

Volker Behrens
Research Station Geisenheim, Von-Lade-Strasse 1, 65366 Geisenheim, Germany

INTRODUCTION

A general water shortage, expensive or bad-quality water, or environmental pressures may force container plant growers to collect rain water and to use a closed, recirculating irrigation system. If done in a proper way, economic and ecological advantages can be achieved together. Utilizing such a water management procedure means two potential problems have to be taken into account. Firstly, re-used irrigation water should be free from pathogenic organisms that attack plants, because the risk of spreading diseases throughout the crop is increased. Secondly, with closed systems water may be collected in excess, and if leaving the nursery site it may not meet local or EC standards for quality and freedom from residues. Run-off water may need to be disinfected for recirculation and/or purified for discharging into ground or surface water.

RISK OF DISEASE SPREAD

In open (i.e., not recycled) irrigation systems single diseased plants within a crop can only infect the plants immediately next to them. Soilborne fungal diseases,

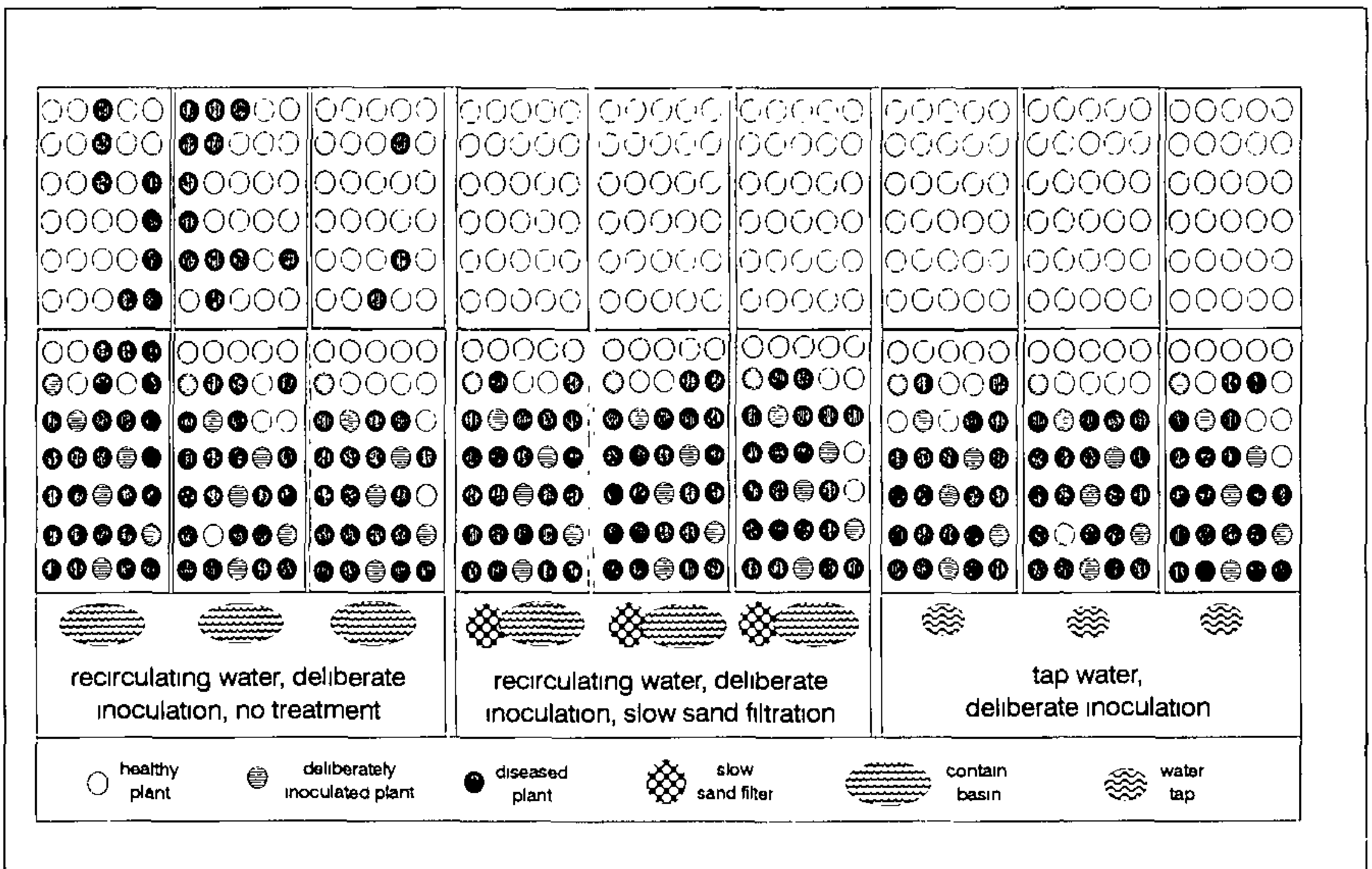

Figure 1 Spread of *Phytophthora cinnamomi* as influenced by water origin and water treatment. *Chamaecyparis lawsoniana* 'Columnaris' (syn. *Cupressus lawsoniana* 'Columnaris'), six plants per plot inoculated deliberately, overhead irrigation, poly film lined beds, 23 weeks after potting.

such as, *Phytophthora*, are spread by splashing and by the water running across the bed surface. When irrigation water is recycled, pathogenic organisms might be transported to all plants in the crop via the water. This may result in additionally infected plants everywhere in the bed.

Figure 1 shows the results of an infection trial with *Chamaecyparis lawsoniana* 'Columnaris' (syn. *Cupressus lawsoniana* 'Columnaris') (Kemp et al., 1992). The data were recorded 23 weeks after potting up and placing deliberately inoculated plants in the lower (downstream) end of the beds. On beds irrigated with mains water, two thirds of the initially healthy plants in the lower end were diseased or dead. All plants stayed healthy in the upper end of the beds. On the beds irrigated with untreated recycled water only a few more (71%) were infected at the lower end. But, at the upper end of the bed, 25% of the plants became infected.

Disease spread from plant to plant is faster and more extensive than spread via recycled water. The latter causes only minor problems, as long as no susceptible crops are cultivated or if the surplus water is stored in a biologically active, open pond. The risks can be reduced further by starting the crop with healthy young plants, by immediately taking out every obviously diseased plant, by diluting the spores via long ditches, and using large ponds to store the water accumulated from a number of beds.

SLOW SAND FILTRATION TREATMENT FOR IRRIGATION WATER

A slow sand filter can be included in the recycling system to protect plants from water-borne disease and is especially recommended when cultivating plants of the Ericaceae family, false cypress, or other susceptible crops. Spores of *Phytophthora* and other fungal diseases can be eliminated completely by using this simple and very old technique (Wohanka, 1992). Figure 1 shows that spores could effectively

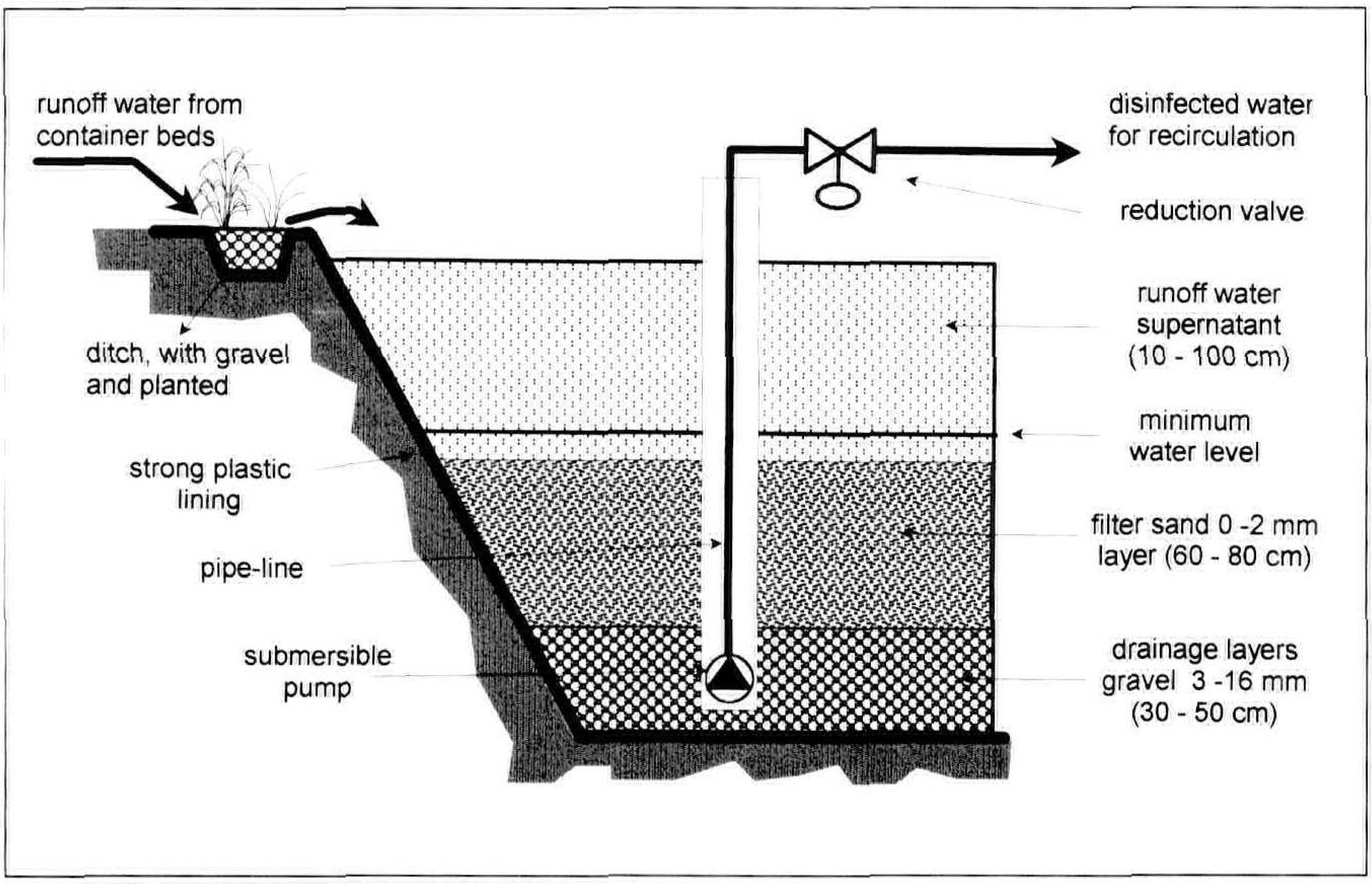

Figure 2. Cross section view of a slow sand filter, a pond-like construction in a commercial nursery with a capacity of 0.5 $m^3 h^{-1} m^{-2}$ (based on Wohanka, 1992).

be prevented from spreading via the recirculating water. No diseased plants could be found in the upper part of the beds 23 weeks after potting on beds using filtered recycled water. Filtered water was as good as mains water.

After vertical percolation through a 60 to 80 cm layer of biologically active sand within a barrel, no spores could be detected in the water, if a flow rate of no more than 200 to 500 litres h^{-1} m^{-2} filter surface was used. The elimination of spores does not only take place by a simple sieve effect, but mainly by beneficial fungi and bacteria living on the surface of the sand, within the so-called filter skin. There are many types of microorganisms breaking down organic matter.

This bioactive sand filtration system is an economic way to disinfect irrigation water or nutrient solutions, if a water-saving capillary or trickle irrigation system is used. A very simple, pond-like construction is currently working perfectly in a commercial nursery (Fig. 2). For irrigating the crop, water is directly pumped from underneath the sand layer. A capacity of 0.5 m^3 h^{-1} m^{-2} and a surface of 100 m^2 results in a capacity of 50 m^{-3} h^{-1}, sufficient to irrigate 1.5 ha of capillary beds.

In order to make the sand filter look more attractive, and to hold back rough organic matter like compost or leaves, a gravel-filled ditch was constructed around the filter and planted with marsh plants. Such plants will probably colonize the filter, too. Studies with different species of marsh plants growing on top of sand filters showed no negative influence on the disinfection effect. Even in the supernatant water no active spores could be found after several hours.

PLANTED GRAVEL FILTER TO REDUCE NITROGEN LOAD

During high rainfall, closed container units may lead to the collection of too much water. The most environment-friendly use of this surplus water would be to become groundwater. But nursery run-off may contain pesticide or fertiliser residues which may exceed official levels (currently a limit of 10 mg/litre nitrate-nitrogen per litre and soon a limit of 1 mg/litre phosphorus for drinking water in this part of Germany).

Various versions of planted sand filters are known under different names, such as, plant covered purification filter, reed bed treatment systems, root zone purification system, reposition plant filters, etc. (Börner, 1993; Schütte and Fehr, 1992; Wackerle and Gradl, 1993). They are known for purifying sewage from private households and wastewater (Gersberg et al., 1984, 1986; Geller et al., 1991; Soeder et al., 1986). Various microorganisms, living in the rhizosphere of plants, can break up organic and inorganic molecules. Under aerobic conditions some of them nitrify ammonium, although NH_4 is found in runoff water in very small amounts only. Under anaerobic conditions, however, others break down the nitrate for their oxygen supply and set free nitrogen. In addition they need a soluble carbon source which comes preferably from root exudations of marsh plants.

Another reason for growing plants on the filterbody is to prevent plugging. Moving stalks and growing rhizomes and roots avoid a deterioration of hydraulic conditions.

Basin-like sand filters planted with different species of marsh plants were used to investigate the influence of plants on cleaning nitrogen from run-off water. Generally the cleaning capacity of such filters is much lower than their microbial disinfection capacity. Depending on plant species, season, temperature, and salt concentration an inflow rate of 4 to 10 litres h^{-1} m^{-2} filter surface may not be exceeded. Because of transpiration the outflow rate varies.

Two years after planting, *Phragmites australis* proved to be the most efficient plant for this type of water treatment during the growing season. Concentrations of 240 mg nitrate per litre could be purified to drinking water quality at an inflow rate of 10 litres h^{-1} m^{-2}. In other words, the *Phragmites* filter eliminated 8 g nitrate per m^2 of filter surface per day from 160 mm of irrigation water.

Other species like *Iris pseudacorus* were less effective, only removing 25% of the material removed by *Phragmites* and were no more effective than unplanted filters. With these filters drinking water quality was only reached at very low inflow rates. In autumn, when growth and metabolic processes cease, the purification capacity of the *Phragmites* filter also fell to match the unplanted filter.

For eliminating phosphorus, filters containing iron are needed. Under aerobic conditions iron phosphate is formed, which is virtually insoluble and precipitates. After passing throught the planted gravel filter the water is passed through an iron wool filter. In the present study water contained 3 mg $litre^{-1}$ phosphorus which was completely captured by the iron.

A planted gravel filter, similar in construction to a reed bed, is presently working on a large scale in a commercial nursery in Germany. Figure 3 shows a cross section view of this filter. A filter body of gravel was chosen for hydraulic reasons only. Surplus water of a container plant unit flows horizontally and slowly through the root zone of different marsh plant species.

In the first year after planting it was not yet working perfectly, but it showed great promise. During summer a concentration of 150 mg nitrate/litre could be cleaned to drinking water standard, if the inflow rate was no higher than 4 litres h^{-1} m^{-2}. That is similar to the cleaning capacity of an unplanted sand filter. Possibly the root growth in the filter body was not yet well enough established. It takes some time

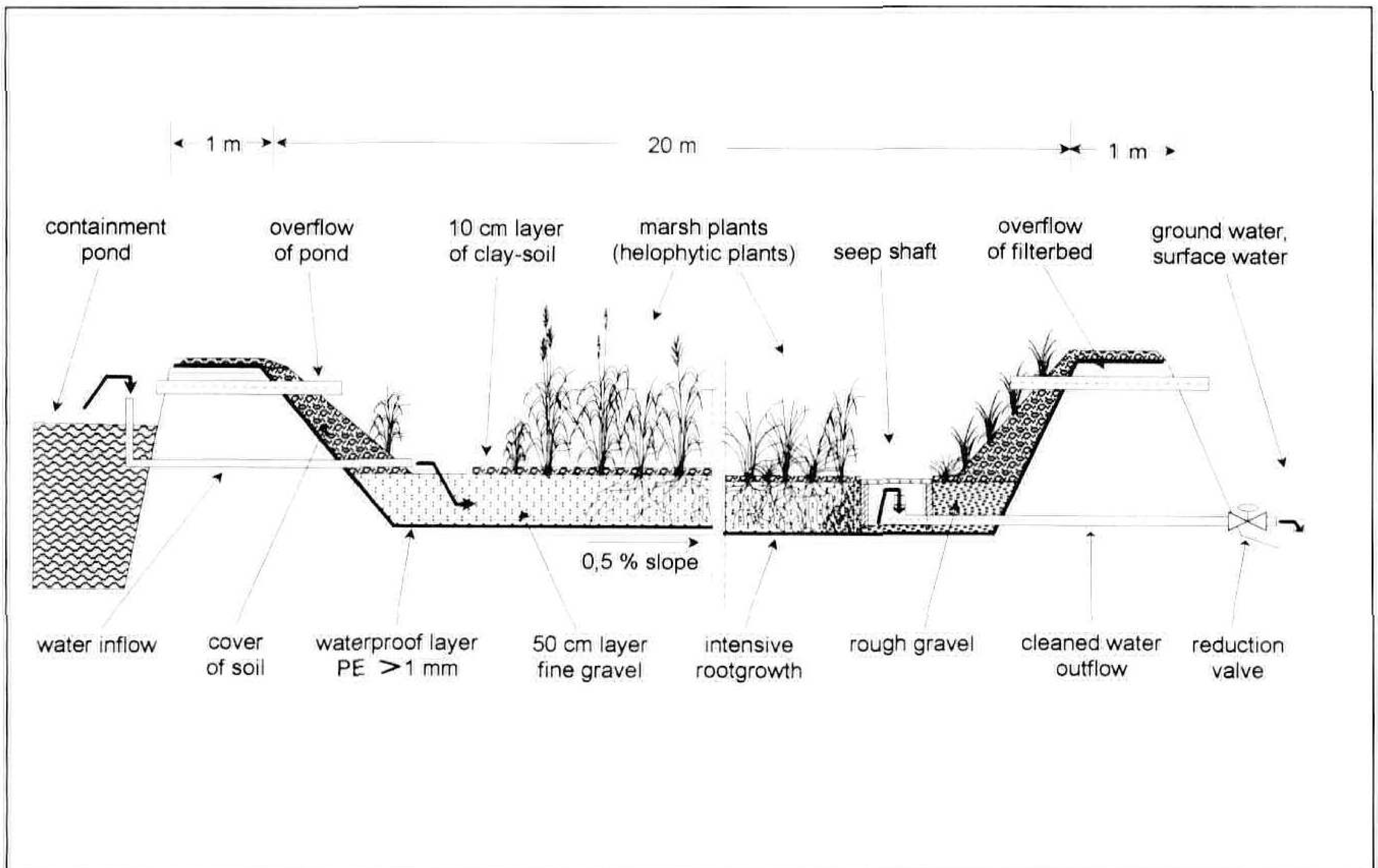

Figure 3. Cross section view of a planted gravel filter (reed bed type) for cleaning surplus water in container plant production.

before a proper environment for the micro-organisms develops and they might suffer from a lack of carbon sources during the establishment phase. Rotting straw or similar material added to the filter could only partly substitute for the plants and their root exudations.

Further investigations will concentrate on the elimination of pesticide residues, on the combination of cleaning and disinfesting, and on purifying all kinds of effluent from nurseries.

LITERATURE CITED

Börner, T. 1992. Haben sich pflanzenbeet-kläranlagen bewahrt? Deutscher Gartenbau 38:2430-2434.

Gersberg, R.M., B.V. Elkins, and **C.R. Goldman**. 1984. Use of artificial wetlands to remove nitrogen from wastewater. J. Water Pollution Control Federation 56:152-156.

Gersberg, R.M., B.V. Elkins, S.R. Lyon, and **C.R.Goldman**. 1986 Role of aquatic plants in wastewater treatment by artificial wetlands. Water Research 20:363-368.

Geller, G., E. Engelmann, W. Haber, K. Kleyn, A. Lenz, and **R. Netter**. 1991. Bewachsene bodenfilter zur reinigung von wässern - ein von abwasser beeinflußtes system von boden und pflanzen. Wasser und Boden 8:477-495.

Kemp, J., V. Behrens, and **W. Wohanka**. 1992. Langsamsandfilter verhinderten ausbreitung von *Phytophthora*. Gartenbau Magazin 5:58-60.

Schütte, H. and **G. Fehr**. 1992. Neue erkenntnisse zum bau und betrieb von pflanzenklaranlagen. Korrespondenz Abwasser 39:872-879.

Soeder, C.J., E. Stengel, P. Obermann and **G. Plum**. 1986. Aufbereitung von nitrathaltigem grundwasser mit hilfe denitrifizierender wasserpflanzen-boden-filter und nachgeschalteter grundwasserpassage. Neue Technologien in der Trinkwasserversorgung, DVGW-Schriftenreihe Wasser. 106:131-140.

Wackerle, L. and **T. Gradl**. 1993. Reinigung von sickerwässern aus altdeponien mit biologischen bodenfiltern. Müll und Abfall 4:253-264.

Wohanka, W. 1992. Slow sand filtration and UV radiation; low-cost techniques for disinfection of recirculating nutrient solution or surface water. ISOCS Proc. 8th Intl. Congr. on Soilless Culture 1992:497-511.