of molecular weight 22 kDa. All isolates had a major protein of MW 43–45 kDa. The specific band (22–24 kDa) was not detected if the isolates were grown on the agar media.

Discussion

Deep groundwater normally has very low heterotrophic and Aeromonas counts (Schubert 1991). The presence of Aeromonas thus indicates surface water contamination and the existence of an external environment that supports colonization and multiplication of the organism on limestone surfaces. Aeromonas spp. need simple sources of nutrients for multiplication. The slightly alkaline pH of the environment, pH 7.1 to 8.1, enhanced the survival of the organism. The CFUs of A. hydrophila and the heterotrophic counts decreased significantly following the construction of the new water collection pipeline inside the mine, indicating the importance of surface colonization.

To fully understand the epidemiological links between environmental and clinical aeromonads, both phenotypic and genotypic typing methods must be used to properly fingerprint the strains. This investigation confirmed results reported in some other studies (Havelaar et al. 1992, Moyer et al. 1992). The strains that have been isolated from drinking water are probably rarely similar to those in clinical samples. Biochemical methods and by SDS-PAGE of whole proteins showed that A. hydrophila isolated from water resembles genospecies 3, which is uncommon in clinical samples. DNA-DNA hybridization studies confirmed the relatedness of the water strains to the genospecies 3 (results not shown).

References


Bacterial Removal over Time in Experimental Up-flow and Down-flow Slow Sand Filters in a Tropical Climate

H.A. Minnigh
Vice President, BORQUIIS Environmental
San lnterbeck, PR

G.I. Ramirez-Toro
Catedracta Auxiliar, Interamerican University
San Germán, PR

C. Morales
Puerto Rico Department of Health, San Juan, PR

W.O. Pipes
Department of Civil Engineering
Drexel University

C.O. Vásquez
Interamerican University, San Germán, PR

Slow sand filters provide water treatment advantages by reducing the amount of chlorine necessary to achieve target disinfection goals and in turn possibly reducing the concentration of chlorination by-products in the treated water. These advantages include 1) removal of organisms from the water before disinfection, 2) removal of turbidity particles, some of which may interfere with disinfection, and 3) reductions in the concentrations of dissolved organic compounds that react with chlorine to form the by-products. This study is designed to determine if satisfactory filtration occurs by using a shallow depth of sand and to investigate the use of up-flow filters, which may be adapted for small water systems in Puerto Rico.

Slow sand filtration is a discontinuous process that depends upon biological activity in the sand to remove microorganisms and organic matter from the water. A normal operational cycle consists of 1) an acclimation period during which the biological activity is established, 2) a long period of steady-state removal of microorganisms from the water, and 3) clogging, which requires interruption of the filtration
process for removal of the clogged sand. Once the clogging is eliminated, the operational cycle and another acclimation period are started. To achieve the best overall performance, all phases of the operational cycle must be controlled. Microorganism removal may be limited during the acclimation period and a safe supply of water must be provided during that time. Also, clogging may occur over a short period and interrupt the water supply at an inopportune time.

Small public water systems may lack skilled operation. Thus, the provision of two filters may provide a satisfactory solution to problems presented by the discontinuous nature of the slow sand filtration process. One filter may be acclimated while the other is used for supplying properly treated water. If the filtration rate can be doubled without decreasing the microorganism removal during the steady-state phase, using two filters alternately may not require any greater amount of filter area than a single normal rate filter.

Increasing the filtration rate could result in shorter periods of steady-state removal before clogging occurs. This may be overcome, at least partially, by up-flow operation of filters that are hydraulically stratified. The large sand grains on the bottom of the stratified bed provide larger spaces for the biological growth that is responsible for removing microorganisms and other particles from the source water.

Previous studies of slow sand filtration have failed to provide detailed information on the nature and length of the acclimation period. Up-flow operation of slow sand filters has not been investigated to any great extent, either. Information is being sought on all three operational phases, on the relationship between the filtration rate and the length of the steady state removal phase, and on the feasibility of up-flow operation. This report is concerned with studies conducted during 1991 and 1992.

Experimental slow sand filters were constructed using a 38 to 50 cm depth of sand in an 86 cm glass chromatography column with an inside diameter of 5 cm. The filters have been operated in a water treatment plant in San Germán, Puerto Rico, for more than a year, using the source water for that plant. A diagram of the experimental setup is presented in Figure 1.

The time necessary for acclimation has been observed to be four to five weeks for either mode (up-flow and down-flow) of operation. As shown in Figure 2, locating the transition between acclimation and steady state phases was uncertain because bacterial removal was initially 10% to 20% and gradually increased to more than 95%. Removal of 90% was used as the transition point. Because the operational cycle is so long, only three observations on the length of the acclimation period have been made.

Safety of Water Disinfection
The results indicate that slow sand filters are suitable for use in small water systems in tropical climates such as Puerto Rico. Significant reductions in the bacterial content of the source water can be achieved so that the amount of chlorine needed for disinfection can be greatly reduced. Up-flow operation achieves bacterial reductions equivalent to those filters operated in the down-flow mode.

Acknowledgments

This study was supported by a Public Water Supply Program Grant from the US Environmental Protection Agency, Region II, to the Puerto Rico Department of Public Health, by an Undergraduate Research Participation Grant from the National Science Foundation to the Inter-American University of Puerto Rico, and by assistance from the Paul & Gabriella Rosenbaum Foundation and Borquis Environmental.