Performance Evaluation Using a Perlite Filter[1]

Aqua-Tech Report 7.3

Background Information

AquaShield™ utilizes various filter media for the treatment of stormwater and industrial runoff in the Aqua-Filter™ Stormwater Filtration System, the Go-Filter™ Mobile Treatment System, and the Aqua-Guardian™ Catch Basin Insert. The media is packaged in flexible cartridges that are fixed within the different patented technology devices. While each of these systems are custom-engineered facilities, the Aqua-Filter™ and Go-Filter™ systems utilize a two stage treatment train configuration. Treatment begins with the removal of gross pollutants and free-floating oil by the swirl concentrator (Aqua-Swirl™), followed by the removal of fine sediments and other waterborne pollutants by the filtration chamber. The Aqua-Guardian™ does not rely on a treatment train approach.

Perlite is the most common filter media used in the AquaShield™ stormwater treatment systems. Perlite (CAS: 93763-70-3) is an amorphous, hydrated glassy volcanic rock of rhyolitic composition, consisting primarily of fused sodium potassium aluminum silicate. Perlite has long been recognized as an effective filter medium for the removal of sediment and hydrocarbons contained in stormwater runoff.

Purpose of Performance Evaluation

In order to evaluate the performance level of a perlite filter medium, a laboratory simulation was performed using known concentrations of common contaminants associated with stormwater runoff.

Laboratory Methods

Independent laboratory testing was performed on behalf of AquaShield™ by Analytical Industrial Research Laboratories, Inc. (AIRL) of Cleveland, Tennessee.[2] AIRL is accredited with the National Environmental Laboratory Accreditation Program (NELAP).

A 50 gallon stock solution of laboratory reagent water containing known concentrations of total suspended solids (TSS) aluminum, copper, zinc and phosphorus was gravity fed from a 50-gallon sterile polypropylene holding tank. The container was gently stirred with an electric motor turning a paddle at approximately 25°C (77°F). The container was fitted at the base with a manually operated PVC flow discharge nozzle. An open ended, tube shaped, PVC filtration cartridge was held in place below the discharge nozzle by the use of standard laboratory clamp devices. A three inch (7.62 cm) head space was maintained between the discharge nozzle and the top of the filtration cartridge. The filtration cartridge dimensions were six inches (15.24 cm) in diameter and eight inches (20.32 cm) in length, and occupied a volume of 226 cubic inches (3,705 cubic cm). The cartridge contained 370 grams of consolidated (not packed) perlite. Both ends of the cartridge were covered with a thin flexible nylon screen having one millimeter (0.0394 inch) square openings to retain the perlite filter media.

Target influent concentrations were based on the maximum concentration from two years of sampling a commercial parking lot (Table 1).

Table 1: Target Influent Concentrations

Contaminant	Maximum Concentration
TSS	44 mg/L
Aluminum	786 µg/L
Copper	21.9 µg/L
Zinc	118 µg/L
Phosphorus	50 mg/L

All test constituents were insoluble forms. The simulation used sediment (TSS) particle sizes of 19, 45 and 75 microns, ranging from silt to very fine-grained sand. Particle sizes for the aluminum, phosphorus and zinc were <10 microns, while the copper particle size was <5 microns.

Water passed through the filtration cartridge at an assigned flow, or loading rate of approximately 17.8 gpm/ft^2 and at five gallon increments. One gallon effluent (filtered) water samples were collected in new, sterile polypropylene containers at the terminus of the filtration cartridge at pre-determined discharge volume intervals between the 4th and 5th, 24th and 25th gallon, and 49th and 50th gallon. Each effluent water sample was analyzed for the contaminant constituents and within their established holding times. Prior to testing, the filtration cartridge was rinsed with five gallons of reagent water to establish background levels for each constituent. The sampling for the "blanks" occurred between the 4th and 5th gallon.

Laboratory analytical methods for influent and effluent water samples followed EPA Method 160.2 for TSS and EPA Method 200.7 for the other contaminants.

Simulated Test Parameters

The use of simulated test parameters allows for the laboratory test parameters to be extrapolated in order to evaluate removal efficiency for a larger scale filtration cartridge. By using the laboratory test parameters of test gallons (50 gallons), test cartridge volume (226 in^3) and loading rate (17.8 gpm/ft^2), the extrapolated flow rate over a 24 hour period using a larger simulated filtration cartridge can be calculated.

Based on the laboratory test parameters cited above and a simulated filtration cartridge measuring 2 feet x 2 feet x 1 foot thick (4 ft^3, or 6,912 in^3), the laboratory test simulated approximately 102,400 gallons of contaminated water continuously passing through a 4 ft^3 filtration cartridge over a 24 hour period.

Analytical Results

Table 2 summarizes the average influent and effluent concentrations of the contaminants, and the calculated removal efficiencies that were achieved during the performance test. Removal efficiency (RE, %) is calculated as follows:

$$RE = 100 \times \frac{\text{Influent Concentration} - \text{Effluent Concentration}}{\text{Influent Concentration}}$$

A removal efficiency of 100% is not calculated for a recorded concentration that is below the method detection limit (MDL). While it is possible that a very small fraction of the contaminant could be contained in the effluent water below the MDL, the use of a reported effluent value of zero is not realistic. If the concentration is reported as less than the MDL, then one-half the MDL value is the reported concentration

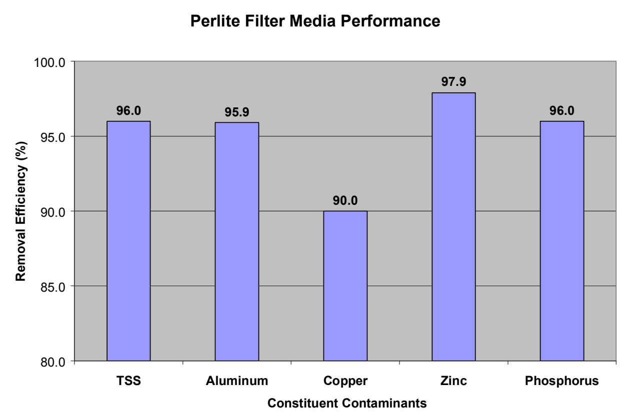
Table 2: Perlite Filter Performance Summary

Contaminant*	Average Influent	Average Effluent	Removal Efficiency (%)
TSS	50	2**	96.0
Aluminum	800	33	95.9
Copper	25	2.5**	90.0
Zinc	120	2.5**	97.9
Phosphorus	50	2	96.0

* TSS, P in mg/L; Al, Cu and Zn in µg/L
** Listed value = ½ MDL

It should be kept in mind that the average effluent concentrations for TSS, copper and zinc were recorded below their respective MDLs.

The following graph illustrates the high removal efficiencies achieved by the perlite filter medium during the performance evaluation:



Conclusion

Laboratory performance testing using approximately 100,000 gallons of simulated stormwater passing through a 4 ft^3 filtration cartridge in a 24 hour period demonstrates that the perlite filter medium provides outstanding water quality treatment against the tested contaminants. The TSS removal efficiency is calculated to be 96%, while excellent treatment was also achieved against aluminum, copper, zinc and phosphorus with removal efficiencies ranging from 90 to 97.9%.

[1] Jan. 2003, Updated Nov. 2007

[2] AIRL, 1550 37th Street, NE, Cleveland, TN 37312, (423) 476-7766.