2003년 한국산학기술학회 춘계 학술발표논문집

담체 변화에 따른 Labscale 바이오 필터의 성능 실험

조대철, 권성현
순천향대학교 공과대학 환경공학과
경상대학교 해양환경공학과

Operation of biofilters with different packing material

。D. Cho and Sung Hyun Kwon*
Department of Environmental Engineering, College of Engineering, Soonchunhyang University
*Department of Marine Environmental Engineering, Gyeongsang National University

ABSTRACT

The low-pH biofiltration system in laboratory experiments demonstrate defectiveperformance for treating H2S. When leachate pH was in the range of 1.5 to4, the biofilters in three different media removed H2S with efficiencies greater than 99% while it was treated as a single contaminant.

The posibility of using a single-stage low pH biofilter depends on its performance in treating VOCs. During Phase 2, a single-stage biofilter was effective for treating mixtures of H2S and toluene with toluene concentrations below 20ppm and leachate pH between 2 and 3.5.

Biofiltration of xylene was ineffective when pH was lower than 1.5. The treatment sysytem acclimated most slowly to benzene, and treatment of benzene was apparently subject to some competive inhibition from xylene and toluene. However, co-treatment was possible after some acclimation time. Xylene was not easily treated, with higher elimination capacities and no sign of competitive inhibition.

Introduction

Biofilter systems harness the natural degrading abilities of microorganisms to oxidize organic contaminants biochemically into environmentally benign end-products such as *carbon dioxide and water*. The simplicity of the biofiltration process has resulted in its emergence as a practical, cost-effective technology for the treatment of large volumes *of air contaminated with low concentrations as* biologically degradable compounds, as compared with other traditional VOC and odor control technologies, such as incineration and carbon adsorption.

Publicly owned wastewater treatment works(POTWs) have always struggled with odor problems, caused chiefly hydrogen sulfide(H2S). Recently there has been additional concern over release of hazardous air pollutants(HAPs). Regulators are concerned with aceton, benzene, carbon tetrachloride, chloroform, formaldehyde, methylene chloride, perchloroethylene, toluene, xylene, and others. These compounds enter wastewater collection systems through industrial discharges, illegal dumping, or as disinfection byproducts (Witherspoon, et al., 1993). While the concentrations are generally low, the large amounts of water handled by POTWs can make total emissions troublesome. Sulfide removal is commoly necessary for wastewater treatment plants and other industrial facilities, and it is most most economical to operate sulfide biofilters at low pH. However, the same waste air often contains VOCs that also should be removed. One approach is to use a second biofilter to remove these compounds, but this is inexpensive. Recently the stdies of sulfide-removing, low pH biofilters for their ability to simulataneously treat volatile organics demonstrated effective performace.

Compost is the most widely used for the biofilter medium. It is inexpensive, nutrient rich, and has substantial adsorption capacity. The microorganisms remaining from the composting process constitute an excellent inoculum and the medium rapidly becomes effective at removing air pollutants. Compost has been used in biofilter treating VOCs and H2S in many studies(Ergas et. Al., 1995: Hodge and *Devinny*, 1995: *Schroeder et al*., 1994). However, the life span of compost is limited to not more than 7 years(Van Lith et al., 1997), and is commonly much shorter. It decays over time, causing compaction, clogging, short circuiting and increased headloss across the bed.

Granular activated carbon, ceramic, and proprietary materials have been used in biofilter(Deshusess et al., 1995; Medina et al., Shinabe et al.,1995). Inorganic media are not prone to compaction or shrinking and will last indefinitely. If they dry out rewetting is not difficult. However, some are much more expensive than compost and all required nutrient addition.

Cork is not prone to compaction or shrinking and will indefinitely. If they dry out, rewetting is not difficult. The life span of cork is commonly much longer than that of compost. Cork does not decay over time, not causing compaction, clogging and increased headloss across bed. It is inexpensive, and has high surface area and substantial capacity.

The objective of this research was to demonstrate the feasibility of using cork for the treatment of VOCs and H_2S at a single stage biofilter and to compare removal efficiency and bed life to conventional media biofilter

Materials and Methods

Analysis

The concentrations of toluene, benzene, xylene were measured using gas chromatography(Hewellet Packard 6890) equipped with a flame ionization detector(FID). Response from the FID detector was immediate after sample injection, allowing for a large number of analyses in a short period of time. The carrier gas had a 10:1 ratio of air to hydrogen at flow rates ranging from 5 to 10ml/min. For full-chromatographic analysis, a 60m capillary column(0.53mm I.D., 5m df, manufacture by Restek Corp.) separated gas constituents before detection by FID.

Carbon dioxide concentrations were also determined with the gas chromatograph. A capillary column separated carbon dioxide from other constitutents in the gas sample. Because the FID cannot detect CO_2directly, a methanizer was attached in-line after the capillary column and before FID. With hydrogen supplied as the carrier gas, CO_2 is catalytically reduced to methane by passage through the methanizer. The methanizer column consisted of a 7.5cm long x 3.2 mm i.d. stainless steel tube filled with a special nickel powder which was heated to 375oC. The CO_2 is detectable by the FID to 1 ppm with this system.

Continuous Flow Column Studies

The bench scale column apparatus consistedof polyvinyl chloride plastic(PVC) column with an inner diameter of 8cm and height of 90.0cm(Figure). Columns were sealed at each end with PVC caps fitted with hose drilled in the PVC and covered by rubber sepa. Peristaltic pumps supplied air flow to thecolumns. One air stream passed through water to provide humidity while another passed through a liquid pollutant. Flow were independently measured by flowmeters. Backpressures were determined by a water manometer before the combined flow entered the column.

Air samples were taken with disposable syringe(5cm3 in volume). Three 0.25 cm3samples were taken per sampling port and injected into the GC. The average concentration of the three injections was used for data anaysis.

Saturation studies

Start-up conditions were monitored by determining concentration profiles in the columns. Loading conditions were held constant. During this period, concentrations were primarily controlled by the adsorptive capacity of the biofilter material. Profile and effluent concentrations rose as column material was saturated. Also during this period, microbial populations and activity increased until a steady state condition was reached where contaminant loading equaled biological degradation plus discharge.

Water Content Measurement

The water content of the biofilter material was measured as weight loss on heating to 105oC for 24 hours and expressed as percent wet weight. Prior to sample collection, crucibles were iginited at 550oC to dry them and remove all volatile matter. The crucible were weighted on analytical balance to an accuracy of 0.0001g. Media samples were added and weighted. The material was then dried in an oven at 103oC for a minimum of 8 hours and a maximum of 30 hours. The sample was reweighted and the water content calculated.

PH Determination

The pH values for samples were determined with the use of a pH meter(Orion Research Inc.). Samples were saturated with distilled water, covered with parafilm paper to prevent equilibrium with ambient CO_2, allowed to stant for roughly one hour, and measured with the pH meter.

Results and Discussion

Bench-Scale Low-pH Biofilters

Sludge from municipal wastewater treatment plants is used as inoculum. Because the organisms in the sludge have been exposed to the mixture of sulfide and organic gases, sludge is a logical choice as an inoculum. Sludge also is easily available source of dense biomass and diverse microbial populations. Thus, sludge is potential useful as an inoculum for virtually and biofilter application. Sewage sludge inoculum improved the performance of compost biofilters treating sulfide gases, presumably because it contained suitable sulfide oxidizing organisms (Clark and Wnorowski, 1992).

Removal of Hydrogen Sulfide(Phase 1)

Biofilter were operated with three different media(cork for column1, zeolite for column2, and granular activated carbon for column3) for two month, treating an air stream containing hydrogen sulfide. The removal efficiencies of cork, zeolite, GAC biofilters were 99.2%, 98.3%, and 94.0% with average inlet sulfide concentration of 30ppm, , and an empty bed residence time of 30sec. This initial two month experiment for hydrogen sulfide treatment showed that biofilters were readily applicable to wastewater plant.

Removal of Toluene vapor(Phase2)

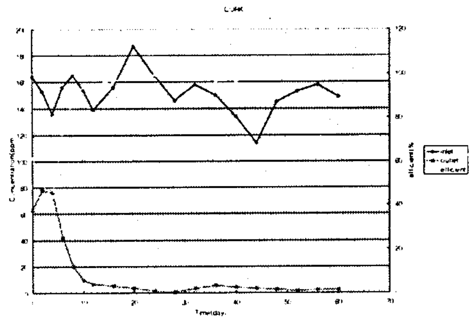
After two months of operation, biofilters were washed with nutrient minerals to lower the pH of filter media, and toluene vapor was added to the reactors in concentration up to 200ppm, while the inlet sulfide concentration was maintained at 30ppm(Figure).

When toluene inlet concentration were less than 100ppm, the removal efficiencies for cork, zeolite, and GAC biofilters were 81%, 92%, 65%.

Conclusion

Dynamic adsorption models have been developed to describe the oscillating-area data. The models show that even the simple planar diffusion-controlled model can predict the important qualitative features of the dynamic tension behavior under pulsating-area conditions. As the area amplitude decreases, the calculated tension amplitude decreases and the tension response is closer to sinusoidal.

The mixed kinetics model with the parameters obtained from constant-area experiments describes well the qualitative behavior of the data and predicts the low equilibrium tension minima.



References

1. Witherspoon, J.R., Bishop, W.J. and Wallis, M.J., "Emissions Control Options for POTWs," Environmental Protection, 4(5):pp59-66(1993)

2. Ergas, S.J., Schroeder, E.D., ChangD, P.Y. and Morton, R.L., "Control of Volatile Organic-Compound Emissions Using a Compost Biofilter."Water Environment Research, 67(5), pp816-821(1995)

3. Hodge, D.S. and Devinny, J.S., "Modeling Removal of Air Contaminants By Biofiltration," J. Environmental Engineering-ASCE, 121(1), pp21-32(1995)

4. Schroeder, E.D., Ergas, S.J., Chang, D.P.Y. and Morton, R., "Control of VOC Emissions from a POTW using a Compost Biofilter."Proceedings of the Water Environment Federation 65th Annual Conference & Exposition, New Orleans, Louisiana, (September20-24)

5. Medina, V. E., Webster, T., Ramaratnam, M. and Devinny, J.S., "Treatment of Gasoline Residuals By Granular Activated Carbon-Based Biological Filtration." J. Environmental Science and Health Part A-Environmental Science and Engineering, 30(2):pp407-422(1995)

6. Lesson, G., M., Winer, and D.S. Hodge, "Application of Biofiltration to the Control of Toxics and Other VOC Emissions. Presented at the 84th Annul Meeting and Exhibition of the Air and Waste Management Association. June16-21. Vancouver, BC, Canada.