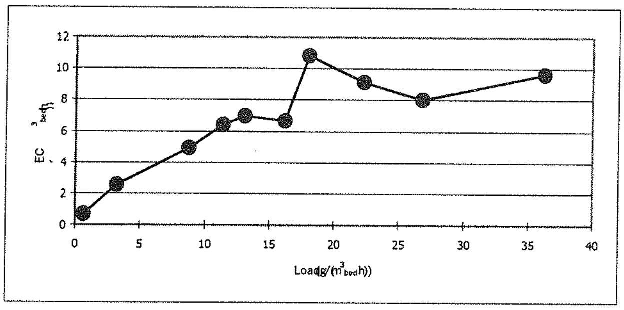


Figure (3) Elimination capacitiy of the biofilter in different loading rates, flow rate 2lmin^{-1}.

Table (1) Performance of the biofilter at high residence times and inlet concentrations.

Flow rate liter/min	Inlet Conc. mg/m^3	Outlet Conc.	Loading rate g/(m^3.h)	Elimination Capacity g/(m^3.h)
0.5	3461.39	1127.91	22.09	14.89
0.5	3775.85	1754.05	24.09	12.90
0.5	1084.57	331.42	6.92	4.80
0.5	1093.95	296.43	6.98	5.09
1.0	2439.23	963.74	31.14	18.84
1.0	2486.43	1243.84	31.74	15.86

References

[1] Groenstijin, J. W., Lake, M. E, Elimination of alkanes from off-gases using biotrickling filters containing two liquid phases, Environmental Progress, Vol.. 18, No. 3, pp. 151-154, 1999

[2] http://www. epa.gov/ttnatwo1/h1thef/hexane.html

[3] Morgenroth, E., Schroeder, D. P. Y.,Chang,K. M., Nutrient limitation in a compost biofilter degrading hexane, J. Air&Waste Management Assoc.,Vol. 46, 300-308, 1996

[4] Johnson, C. T., Deshusses, M. A., Quantitative structure activity relationships for VOC biodegradation in biofilters, in Proceeding of the Fourth International In Situ and On-site Biorecalmation symposium,vol. 5, Battelle Press, Columbus, OH, p. 175,1997

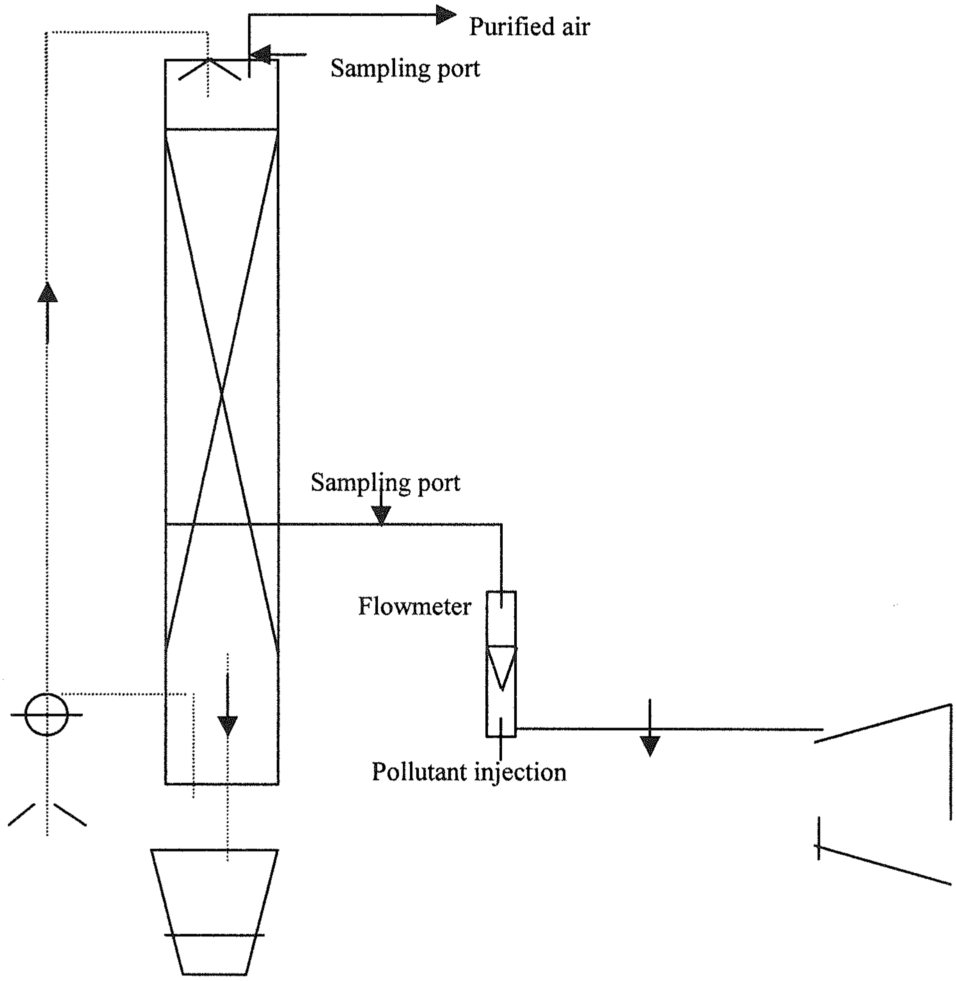
[5] Budwill, K., R. N. Coleman, Effect of silicone oil on biofiltraton of n-hexane vapors, In 11th forum for applied biotechnology, Med. Fac. Landbouw. Univ. Gent, 62/4b,pp. 1521-1528, 1997

[6] Bohn, H. L., Bohn, K. H., Moisture in biofilters, Environmental Progress, Vol. 18, No. 3, P. 156 –161, 1999

biodegradation also should be considered for successful biofiltration of mixtures. Optimization of the biofiltration process for n-hexane removal and finding some ways for reducing toxic effects of hexane on microorganisms are our future work in this research area.

Acknowledgments

The authors would like to acknowledge Dr. Ebrahim Vasheghani Farahani and Dr.Jafar Towfighi Darian (Tarbiat Modarres University) for their comments during the experiments. The financial support of this research was received from Tarbiat Modarres University of Iran



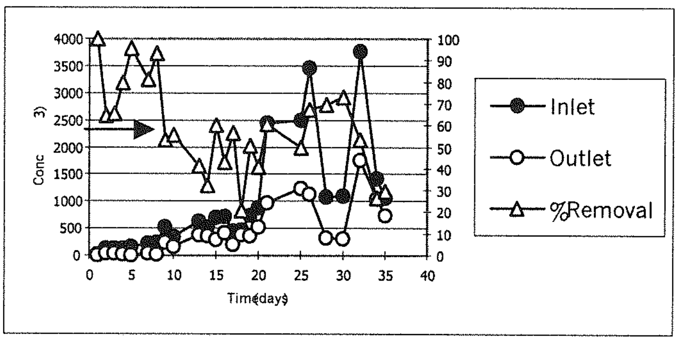


Figure (2) Inlet and outlet concentrations in the biofilter during investigation.

Analysis

Gas samples were taken from the sampling ports using a gas-tight syringe and the concentration of the total hydrocarbon was determined by gas chromatography.

Result& Discussion

Continuous operation of the biofilters

The process started at the air flow rate of $2 l min^{-1}$ and inlet concentration of $1 g m^{-3}$.As investigation of the performance in a well developed system was planned, the process was continued for two months without changing in the operating conditions. During this period occasional samples were taken to ensure the system was active. During the process 1 liter of fresh mineral medium was added once in every two days to offset the evaporation. After this period performance of the biofilter was investigated under different airflow rates and concentrations. In the most of the cases removal efficiency is more than 50% and except for the very low inlet concentrations hydrocarbon were detected in the effluent air due to existence of some hydrocarbons that were not degraded by inoculated microbes (Fig2). This indicates that enrichment of the activated sludge microbes in the presence of a mixture of the pollutants does not guarantee the effective removal of all components. The performances of the biofilters are rather variable during the investigation period. The reason for this variation is believed to be due to the method used for providing the moisture. It was mentioned that direct trickling was used for providing moisture. During the continuous process liquid medium was circulated in each biofilter at two-hour intervals. Although this method is a good way to ensure even distribution of moisture in the bed, it causes a high saturation of the bed that decreases performance of the bed temporarily (high moisture content of the bad is a barrier for mass transfer of reactants from the gas phase to the biofilm [6]).

Performance of the biofilter in different loading rates

The performance of the biofilter in different loading rates (constant flow rate of $2 l min^{-1}$) is depicted in Fig.4. Elimination capacity increased with loading rate and slightly decreased in higher loads probably due to toxic effects of hexane on microorganisms .To obtain the maximum elimination capacity a series of experiments were conducted under greater residence time and concentrations. Results presented in table 1.

Conclusions

Biofiltration is a feasible way for removing n-hexane from the polluted air.Maximum elimination capacity of $18.83 g/(m^3_{bed}.h)$ was obtained in this research work that it is a good capacity for practical purposes. Optimizing the operation parameters like moisture content of the bed and using more tolerant species can improve maximum elimination capacity of biofilter. For effective removal of a mixture of pollutants it is necessary to ensure proper strains exist in the bed for degradation of each of the pollutants. Competition among the pollutants for elimination capacity of 8.2 g/(m^3_{bed}.h) in a peat biofilter[5] .The objective of this research work is obtaining biofiltration data for a mixture of hydrocarbons (which hexane is the main component) in a defined biofiltration system in the cases of packing medium, microorganism and nutrients

Materials and Methods

Chemicals:
All the chemicals mentioned below are of analytical grade except for hydrocarbon mixture. This mixture contained n-hexane (80%)and some unidentified hydrocarbons.
Medium
The following medium was used for enrichment of hydrocarbon degrading microorganisms and also in biofiltration experiments.
KH_2PO_4; 3.4gl^{-1}, K_2HPO_4; 4.3gl^{-1}, $(NH_4)_2SO_4$; 2gl^{-1}, $MgCl_2.7H_2O$; 0.2gl^{-1}, $CaCl_2.2H_2O$; 0.04gl^{-1}, $FeSO_4$; 0.03gl^{-1}
Trace element solution:
$MnCl_2$;0.04gl^{-1}, $NaMoO_4$; 0.08gl^{-1}, $CuSO_4$;0.006gl^{-1}, H_3BO_3; 0.013gl^{-1}, $ZnSO_4$;0.06gl^{-1}
Each liter of the culture medium contained 25 ml of the trace element solution

Isolation of hydrocarbon degrading bacterium

A sample of activated sludge from a petrochemical wastewater treatment was used for the enrichment of hydrocarbon degrading bacteria. Fifty milliliters of the above medium was poured in a 500ml flask, 1ml of activated sludge was added and a test tube containing 1ml of hydrocarbons was placed in the flask (for avoiding probable toxic effect of direct contact between microorganisms and hydrocarbon droplets), and the flask was sealed. The space above the medium in the flask was enough to provide oxygen for microbial growth. After 24 hour, growth of microorganisms was evident in the medium. This culture was transferred to the fresh medium several times to obtain pure culture. The final culture contained two bacteria out of which one could grow on hydrocarbon mixture as the sole source of carbon and energy. This bacterium was used for inoculation in biofilters.

Biofiltration system

A biofiltration system was designed and constructed (Fig.1). The column was made of glass with the height and inner diameter of 1.0and 0.1m respectively. It was jacketed and passing water through the jacket controlled the column temperature. The air supplied by a compressor, contaminated with hydrocarbons by a syringe pump and entered the column. The column packed with 680 g of sieved perlite (Rose Granite, Iran, 2<size particles<4). The bulk volume of packing material in the reactor was 4.7 liters. Before starting the process, the packing material was inoculated with 1 liter of the hydrocarbon-degrading bacterium culture. The mineral medium was recirculated through the bed of biofilter for 10 minutes in 2 hours intervals with the flow rate of 2$lmin^{-1}$throughout of the continuous experiments. Ports were provided for sampling the entering and exiting air from the biofilter.

Biofiltration of n-Hexane from Airstreams

M. H. Fazaelipoor

Ph.D. Student

S. A. Shojaossadati

Professor

Biotechnology Group, Chemical Engineering Department,
Tarbiat Modarres University

Abstract

An-hexane degrading bacterium was isolated and used in a biofiltration system for removal of n-hexane from polluted air. Performance of the system under different pollutant concentrations and airflow rates was investigated. Three months of continuous operation showed that biofiltration is a practical method for reducing emission of pollutants into the atmosphere. Maximum elimination capacity for the biofilter obtained in this research was 18.83g/($m^3{}_{bed}$.h)

Key words

Biofiltration, n-hexane, Performance

Introduction

The volatile organic compounds (VOCs) emitted from chemical industry, if left untreated can pose potential health risks in addition to causing severe environmental problems. An emerging technology for the treatment of VOCs is biofiltration. Biofiltration is a process in which the polluted air passes through a packed column that consists of specific microorganisms immobilized on the surface of packing materials. The pollutant and oxygen diffuse from the gas phase into the biofilm (thin wet layers of microorganisms on the solid surface) where they undergo biological reactions. Proper selection of microbial culture and size of biofilter would result in pollutant free airstreams.

Alkanes are emitted by various industries. Petrochemical industry, edible oil producers (n-hexane) and polystyrene foam producers (pentane) are examples of those industries. Vegetable oil production involves extraction of the oil from the seeds by hexane. Although hexane is recovered after using, a 100% recovery is not feasible and a few percent of the solvent is emitted to the atmosphere. A typical oil factory emit about 1000m^3gas/h containing 30g hexane/m^3 [1]. Inhalation of hexane causes some adverse effects on human body. Health organizations recommended 180mg/m^3 as maximum permissible concentration of hexane in work places [2].

Several attempts have been made to eliminate hexane from waste gases using biofilters. Morgenroth *et al.* used a laboratory scale compost biofilter and obtained hexane elimination capacity of 21g/($m^3{}_{bed}$.h) [3] and Johnson and Deshusses reported maximum elimination capacity of 5g/($m^3{}_{bed}$ .h) for a compost biofilter[4].Coleman and Budwill obtained maximum