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Emerging Technology Bulletin

Bioscrubber

Aluminum Company of America

Technology Description: Biofiltration is an established economical air pollution control technology for removing organic contaminants from air. The existing filters using natural media, such as peat and compost, have been demonstrated in the field for degrading up to several thousand ppm of contaminants. An engineered biofilter using synthetic media, such as activated carbon, has been developed that shows improvements in removal efficiency, biodegradation, and space requirements over existing filters.

Biofiltration, in general, is the removal and decomposition of contaminants present in gaseous form into nonhazardous substances through the use of microorganisms. Biofiltration has been used in European countries for wastewater treatment and odor control. The technology is used in Germany and The Netherlands as an air pollution control technique. An engineered bioscrubber to digest hazardous organic emissions from soil, water and air decontamination processes was developed under the SITE Emerging Technology Program. It contains a unique Aluminum Company of America (Alcoa) granular activated carbon medium which supports increased microbial growth, enhances bioactivity, and converts diluted organics into carbon dioxide, water, and other nonhazardous compounds. Bioregeneration allows constant maximum adsorption capacity and a complete degradation of pollutants. A schematic of the bench scale bioscrubber is shown in Figure 1.

The Alcoa bioscrubber, a carbon-based biofiltration module, addresses the current deficiencies of composting and other naturally occurring media-based biofilters in the areas of pressure drop, bed requirements, biomass removal, and water retention. The activated carbon beds adsorb gases onto the carbon which increases surface concentration of contaminants and removes hydrophobic gases that would not normally be adsorbed into the aqueous phase. These qualities result in enhanced biodegradation of typical organic contaminants, as well as substances (i.e., refractory compounds, low concentration, operating concentration fluctuations) that would not be efficiently degraded in commercially available biofilters.

Waste Applicability: The bioscrubber technology removes organic emissions from soil, water, or air decontamination processes. It can be utilized for treatment of streams containing trace aromatic solvents, such as benzene, toluene, and xylene. The technology can be adapted to treat halogenated hydrocarbons and other contaminants.

Test Results: Some problems with composting are the huge space requirement, continual loss of effective surface area during biomass build up (slothing), and inefficient biodegradation of particularly refractory contaminants. The Alcoa biofilter demonstrated progression over existing commercially available filters.

Bench scale bioscrubbers were operated continuously for more than 11 mo to treat an air stream with trace (10-20 ppm) concentrations of toluene. Greater than 95% removal efficiency was accomplished throughout the test period. According to the literature, the degradation rate for toluene by existing biofilters is 0.1-0.2 g/M^3/hr for the selected concentration. The Alcoa unit, using granular activated carbon as media, demonstrated 40 to 80 times higher biodegradation rate than existing filters under the conditions tested, resulting in decreased space requirement. This enhanced degradation is at least partially attributed to the adsorption function performed by the activated carbon medium. The active media also allows for removal of excess biomass and prevents the compaction of the media experienced in existing technology. This is one of the advantages of the engineered filter over the existing compost-type filter, because compaction of the bed eventually develops and replacement is required in available filters. The removal of excess biomass accumulation in the filter also ensures minimal pressure drop. As a result, pressure drop from excess biomass was minimal (0-20 in. of water) for a flow rate of 0.5 liters/min during the 11-mo operation. The pressure drop did not increase dramatically when the flow rate was increased from 1 to 2 and then 4 liters/min. The pressure drop is believed to be primarily attributed to (1) bio-mass build-up, which can be reduced via washing of the carbon, and (2) poor flow distribution and channeling in the narrow column, which can be eliminated in a full-scale engineered filter. An automatic device for biomass removal can be designed for a field unit.

The unit was kept in a humid environment and supplemented with inorganic nutrients to stimulate biogrowth. The humidified air stream was prepared by passing pressurized house air through a Balston cleaner/dryer (type A, BX, DX), splitting the flow into three streams through a sparging bottle containing deionized water. An air stream containing toluene at ca. 500 ppm was split into three streams with individual mass flow controllers and mixed with the humidified toluene stream containing a target concentration of 10 ppm at room temperature. These streams were designed as "influent" to each scrubber. The mass transfer zone remained stationary during the entire operating period, indicating no accumulation of contaminants and/or their metabolic byproducts. To insure that toluene reductions were due to biodegradation versus carbon adsorption, the columns tested were presaturated with ca. 10 ppm of toluene in air prior to inoculation. The reduction of toluene in the effluent observed immediately after start-up was attributed to degradation by the microorganisms inoculated on the carbon support.

A portable pilot-scale bioscrubber designed and constructed based on lessons learned from the bench-scale studies, is available for field-

testing at a hazardous waste site. The unit incorporates automatic nutrient supply and biomass removal systems; thus, an unattended mode of operation can be accomplished.

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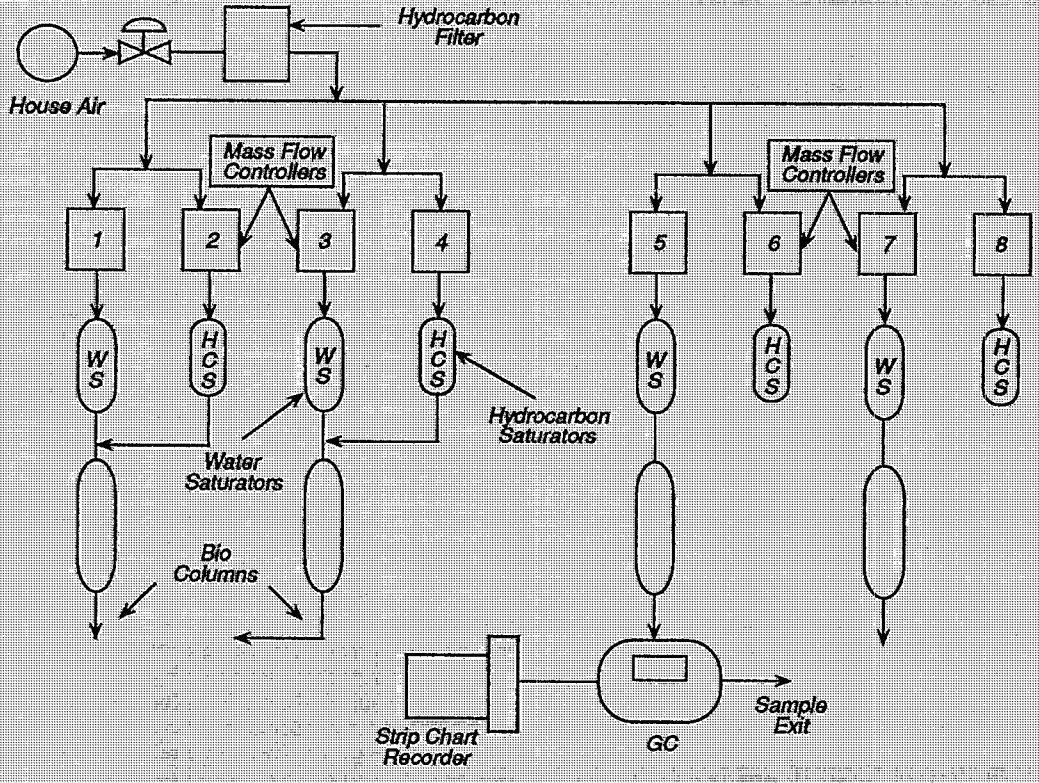

Figure 1. Bench-scale unit showing four bioscrubbers in parallel operation.

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