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Project Summary

Considerations in Granular Activated Carbon Treatment of Combined Industrial Wastewaters

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This project was initiated to investigate competitive adsorption phenomena and their potential impact on the feasibility of treatment of combined industrial wastewater effluents by granular activated carbon (GAC). Bench-scale laboratory and field site studies were conducted to evaluate the extent of competitive adsorption in GAC columns.

Laboratory studies examined competitive adsorption of toxic organic chemicals from simple deionized and complex combined industrial wastewater effluent matrices. Chemicals, selected from a list of those previously identified as occurring in the wastewater, were chosen to represent a broad range of structural and chemical characteristics. These compounds were spiked into the test matrices. Results indicated substantial suppression of adsorption, and, in some cases, the occurrence of desorption, of some components by other components of the test matrix.

Unspiked wastewater was run through scaled-up GAC columns in field studies. Fractionation of the columns and analysis of the fractions revealed a transport pattern through the column that, in general, reflected the observations made during the laboratory studies using spiked matrices.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

GAC column treatment has been under consideration by the U.S. Environmental Protection Agency (EPA) Effluent Guidelines Division as a feasible alternative for removing low levels of toxic organic compounds from complex industrial wastewater effluents. Although the effectiveness of GAC treatment has been clearly demonstrated in drinking water applications, questions remain as to the application of this methodology to considerably more complex matrices. Competition for adsorption sites between toxic organic components and other organics in the matrix could reduce the removal efficiency for compounds of concern. The result would be premature column breakthrough, and, consequently, more frequent carbon regeneration.

This study examined competitive adsorption and its significance in treating complex wastewaters. Bench-scale laboratory and field studies were conducted to evaluate the phenomena and to determine the suitability of conventional parameters for monitoring column breakthrough.

Conclusions

1. Competition for adsorption sites on the carbon surface results in certain organic solutes being retained on the column at the expense of other organics. In some

cases, low affinity organics were desorbed from the carbon resulting in effluent concentrations in excess of influent levels.

2. The success of certain organics in competing for adsorption sites is related to their aqueous solubility and their relative column influent concentrations. Low solubility components showed the highest affinity for the carbon although lower affinity compounds at higher relative influent concentrations are more effective competitors.

3. The presence of the nondescript organic matrix in the wastewater substantially lowered carbon capacity for spiked components when the latter were added to the wastewater at relatively low (5 μm) concentrations. At higher (100 μm) concentrations, little effect on carbon capacity, compared to deionized water systems, was observed.

4. The shape of the breakthrough curves for the organics studied varied considerably. Some components exhibited a sharp increase in column effluent concentration after initial appearance in the effluents while, at the other end of the spectrum, other components increased slowly in concentration as the column run progressed. Such diversity in column breakthrough patterns complicates the task of column monitoring.

5. The breakthrough patterns for chemical oxygen demand (COD) and total organic carbon (TOC) were similar, showing a rapid initial breakthrough to greater than 50 percent followed by a slow climb to total breakthrough.

6. The column breakthrough points of the spiked organics were not reflected by any inflections in the COD or TOC curves. Under these study conditions, TOC and COD reflected changes in the total organic content of the effluent, thus they were unresponsive to changes in specific compound concentrations.

7. Movement of components of interest within carbon columns receiving unspiked wastewater was generally in accord with predictions based on the results of the spiked components studies.

8. The complexity of adsorption from combined industrial wastewater effluents makes modelling of the system for specific component removal difficult if not currently impossible.

Recommendations

1. The competitive adsorption patterns observed in this study need to be generalized to all types of organic compounds requiring removal from wastewaters. Future studies should address structural and chemical property correlations to carbon column capacity as well as the magnitude of effects of influent concentration differences.

2. The magnitude of the effect of the nondescript background organic materials present in industrial effluents must be better defined.

3. Column monitoring when removal of specific toxicant organics is required will not be possible using TOC or COD. Unless more refined surrogate monitoring techniques are developed, monitoring of specific components by gas chromatography will likely be required.

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The complete report, entitled "Considerations in Granular Activated Carbon Treatment of Combined Industrial Wastewaters," (Order No. PB 83-164 475; Cost: $17.50, subject to change) will be available only from:
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