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Project Summary

Powdered Carbon-Activated Sludge—Filtration Processes for Petroleum Refinery Wastewater

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The purpose of this research program was to determine the effect of the addition of powdered activated carbon (PAC) to petroleum refinery activated sludge systems. Both bench-scale and full-scale tests were performed. A wide range of PAC concentrations and sludge ages were evaluated.

Bench-scale activated sludge systems were designed and constructed. The bench-scale units were initially operated to determine the conditions for the full-scale test. Additional bench-scale tests were carried out to evaluate conditions impractical to meet during the full-scale testing.

Similar results were obtained during the full-scale and bench-scale tests. A moderate enhancement of COD removal was observed. PAC addition had little effect upon the removal efficiency of other contaminants or the toxicity of undiluted effluents. An economic analysis of PAC addition was carried out.

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

The 1974 EPA effluent limitations guidelines for the petroleum refining industry proposed that best available treatment economically achievable (BATEA) be secondary treatment followed by filtration and granular activated carbon (GAC) treatment. GAC adsorption equipment and operations including regeneration are costly; consequently, cost-effective BATEA alternatives to GAC have been of considerable interest to both EPA and industry. The addition of powdered activated carbon (PAC) to the activated sludge treatment system is such an alternative for improving performance and effluent quality.

The purpose of this study was to establish the effectiveness of adding commercially available PAC to a full-scale refinery activated sludge treatment system which was currently meeting effluent permit limitations. Both bench-scale and full-scale studies were carried out. The main purpose of the bench-scale studies was to establish the conditions to be evaluated during the full-scale test. In addition, bench-scale reactors were operated at conditions that were impractical to meet during the full-scale testing.

Conclusions

1. The results from the bench-scale units were similar to those obtained from the full-scale units when operated under similar conditions.
2. PAC addition resulted in the moderate enhancement of COD removal. During the bench-scale

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testing, the effluent COD from the PAC units was 11-33 percent less than from the control units. This corresponds to a 2-6 percent improvement in COD removal efficiency in the PAC units based upon the overall COD loading. During the refinery test, the effluent COD from the PAC unit was 18 percent less than from the control which corresponds to a 2 percent improvement in the overall removal efficiency of COD.

3. PAC addition resulted in a small, but statistically significant, enhancement of the removal of oil and grease. During the bench-scale tests, the oil and grease in the effluents from the PAC units were 0.5 to 2.0 mg/l less than in the control effluents. During the refinery test, the oil and grease concentration was 0.6 mg/l less in the PAC effluent than in the control effluent.
4. PAC addition had little effect upon the removal efficiencies of TOC, phenol, or phosphorus.
5. PAC addition resulted in higher effluent suspended solids and ammonia concentrations during the refinery test.
6. PAC addition had little effect upon the removal of priority pollutants or the fish toxicity of the undiluted effluents during the refinery test.
7. PAC addition did result in increased sludge compactability and sludge settling rates.
8. PAC is abrasive and its use during the refinery test resulted in increased wear of sludge recycle pumps. It may be necessary to modify sludge handling equipment to prevent the adverse effects of abrasion when PAC addition programs are implemented.
9. The mixing requirements of PAC sludge are greater than conventional sludge. As was demonstrated during the refinery test, it may be necessary to provide additional mixing to maintain the PAC sludge in suspension.
10. The mechanism of PAC enhancement appears to be simple adsorption. Biological regeneration of the PAC surface did not seem to occur.
11. If the PAC addition program that was evaluated during the refinery test were implemented, the annual cost is estimated to be $603,500. This corresponds to a cost of $7/additional lb COD removed and $104.95/additional lb oil and grease removed.
12. In comparing the results of this study to results obtained in other recent refinery wastewater PAC studies, it becomes apparent that the effect of PAC addition depends upon the circumstances of the particular application. It should not be assumed that PAC addition will have a similar effect at all refineries. The suitability of PAC treatment should be tested in a bench-scale or pilot-scale study prior to adoption of a full-scale PAC program.

Recommendations

1. Since all refinery systems are not equally amenable to PAC treatment, future work should focus on what influent characteristics or operational factors control the effectiveness of PAC addition.
2. No evidence was found for the bio-regeneration of the PAC surface. Since other workers have claimed that bio-regeneration does occur, future work should focus on the mechanism of PAC enhancement to determine under what conditions bio-regeneration occurs.

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The complete report, entitled "Powdered Carbon-Activated Sludge—Filtration Processes for Petroleum Refinery Wastewater," (Order No. PB 82-252 933; Cost: $10.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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