Report for 2002AL5B: Use of Sonication/Acoustic Cavitation with Advanced Oxidants to Treat Petroleum Hydrocarbons Contaminated Surface Waters and Groundwaters

There are no reported publications resulting from this project.

Report Follows:

"USE OF SONICATION/ACOUSTIC CAVITATION WITH ADVANCED OXIDANTS TO TREAT PETROLEUM HYDROCARBONS-CONTAMINATED SURFACE WATERS AND GROUNDWATERS"

a. A statement of the problem and research objectives:

This project seeks to treat petroleum-hydrocarbon contaminated groundwater using a combination of sonication, vapor stripping, and advanced oxidants as a means to cleanup contaminated groundwater.

b. A brief explanation of methodology:

Four separate tasks are to be performed in this study. Batch and continuous flow experiments will be performed using sonication alone, vapor stripping alone, and combined sonication/vapor stripping. The study focused on treatment of benzene, toluene, ethylbenzene, and *o*-xylene (BTEX). Initial contaminant concentrations were generally held constant at 100 mg/L. The sonicator had an ultrasonic frequency of 20 kHz, and the power intensity was ~38 W/cm^2. For those experiments involving air stripping, the air injection rate was normally held constant at 500 mL/min. Additional experiments were conducted for removal of benzene, toluene, ethylbenzene, and *o*-xylene, using different air flow rates, of 250, 500, 750, and 1,000 mL/min. Batch reaction treatments were operated for up to 10 minutes, with samples drawn for gas chromatography analysis every 2 minutes. Experiments were performed both in the absence and presence of advanced oxidants such as ozone (O_3) and hydrogen peroxide (H_2O_2). The project determined the removal of the parent petroleum hydrocarbon contaminant and identified and quantified any degradation products formed during the advanced oxidation treatment. As a part of the project, preliminary economic and process performance assessments were performed.

c. Principal findings and significance:

Results from air stripping treatment for 10 minutes are summarized below in Table 1. The results indicate that little improvement in terms of contaminant removal is achieved for air flow rates exceeding 500 mL/min. This flow rate was deemed to be the optimum air flow rate for the other experiments performed in conjunction with sonication.

Table 1. Summary of Results from Air Stripping Experiments.

Compound	**Removal Efficiency, (%)**			
	Air Flow Rate, (mL/min)			
	250	*500*	*750*	*1000*
Benzene	37.46	75.69	76.96	88.00
Toluene	39.98	77.34	78.09	83.51
Ethylbenzene	53.00	80.65	81.63	89.82
o-Xylene	55.37	73.47	77.72	78.21

Table 2 summarizes the removal efficiency of benzene, toluene, ethylbenzene, and *o*-xylene obtained after 10 minutes treatment using various treatment technologies (sonication alone, air sparging alone, sonication+air sparging, sonication+UV light, and sonication+air sparging+UV light). The results are shown in Figures 1 and 2, below.

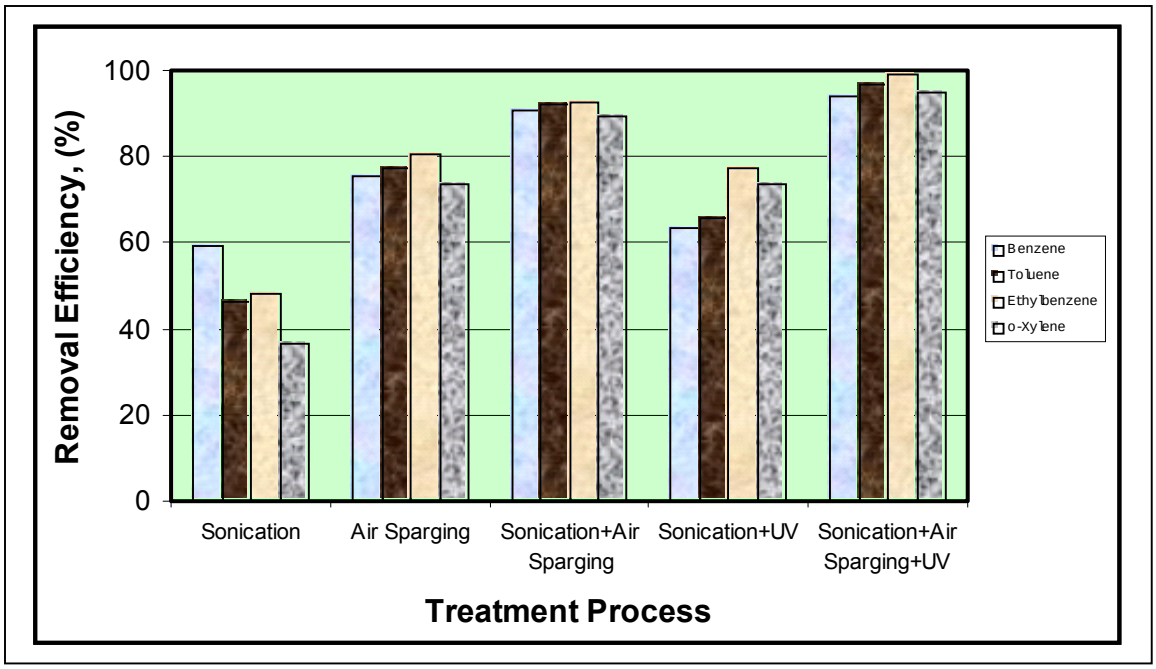

Figure 1. Comparison of Removal Efficiencies of BTEX Compounds Using Different Treatment Processes.

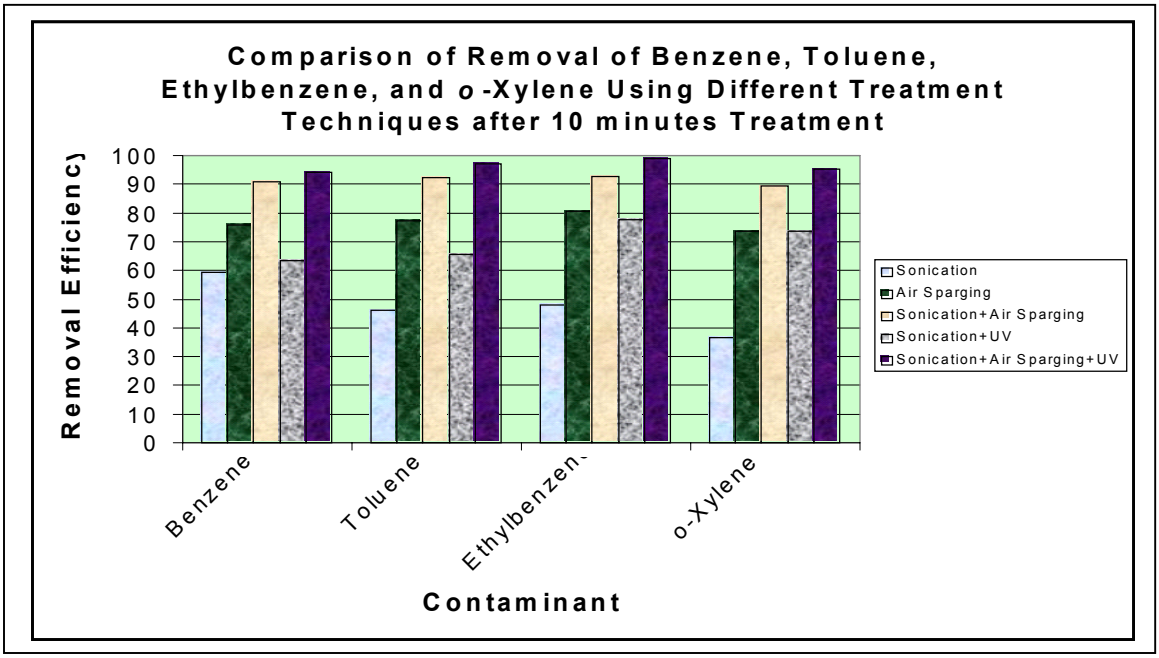

Figure 2. Comparison of Removal Efficiencies from Different Treatment Processes for BTEX Compounds from Solution.

The removals of benzene, toluene, ethylbenzene, and o-xylene obtained after 10 minutes treatment time using various treatment technologies (sonication, air sparging, combined sonication+air sparging, sonication+UV light, and sonication+air sparging+UV light) are summarized in Table 2. The removal of the BTEX compounds generally was in the order: sonication < sonication+UV light < air sparging < sonication+air sparging < sonication+air sparging+UV light. The highest removal efficiency was generally achieved for ethylbenzene, while the poorest removal efficiencies were achieved for benzene and *o*-xylene.

Table 2. Summary of Removal of BTEX Compounds Achieved after 10 minutes Treatment Time Using Various Treatment Technologies.

Compound	**Removal Efficiency, (%)**				
	Sonication	Air Sparging	Sonication+Air Sparging	Sonication+UV Light	Sonication+Air Sparging+UV Light
Benzene	59.170	75.685	90.765	63.469	94.029
Toluene	46.085	77.344	92.322	65.690	96.922
Ethylbenzene	48.020	80.647	92.755	77.521	98.889
o-Xylene	36.598	73.465	89.236	73.636	95.068

The effect of hydroxyl radical scavengers was addressed by adding 50 mg/L each of sodium carbonate and sodium bicarbonate to the solution containing 50 mg/L of benzene. After 10 minutes treatment employing sonication + air sparging, the removal efficiency of benzene decreased from 90.765% to 86.758% in the presence of the •OH scavengers, indicating the •OH scavengers had a minimal effect on removal of benzene using sonication + air sparging.