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COMPARISON OF INTEGRATED AOP SYSTEMS FOR BTEX REMOVAL FROM SOLUTION

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This paper investigates the removal of BTEX compounds (benzene, toluene, ethylbenzene and xylene) from water using different advanced oxidation processes (AOPs) used singly or in combination with one another. This research is an extension of our work performed under the Environmental Management Science Program (EMSP) which addressed treating chlorinated organic contaminated water using sonication, vapor stripping and combined sonication + vapor stripping. In our current study, various AOP processes were investigated for their ability to remove BTEX compounds from solution, including the following.

- Ultraviolet (UV) light alone
- UV light + hydrogen peroxide (H_2O_2)
- Sonication alone
- Air sparging alone
- Air sparging + sonication
- Air sparging + UV light
- Sonication + UV light
- Sonication + H_2O_2
- Sonication + air sparging + UV light

- Sonication + air sparging + H_2O_2
- Sonication + air sparging + H_2O_2 + UV light
- Sonication + air sparging with O_3
- Sonication + O_3 + H_2O_2
- Sonication + O_3 + H_2O_2 + UV light

Data are presented from the various AOP treatment systems. Results from our current study have been presented at various conferences [Mohammad and Peters, 2003a-d]. Several examples of the results obtained from our research investigation are presented in Figures 1 to 3. Figure 1 shows the data used to determine the optimal air flow rate in the air sparging experiments for removal of benzene from solution. Figure 2 shows a comparison of the residual concentration of benzene in solution employing various AOP processes. Figure 3 summarizes the benzene removals achieved using the various AOP processes, while Table 1 summarizes the first-order rate constants obtained for the petroleum hydrocarbon contaminants using sonication alone (operated at 20 kHz, 38 W/cm^2), air sparging alone (at 500 mL/min) and the combined sonication + air sparging system. For these experiments, an optimum air flow rate for air sparging was observed (~500 mL/min) for BTEX removal. Two systems, sonication + air sparging and sonication + air sparging + UV light consistently removed more than 90% of the petroleum hydrocarbon contaminant from solution for a treatment time of 10 minutes. The sonication + air sparging + UV light system provided excellent removal efficiencies. The Henry's law constant affected the contaminant removal efficiency and rate. The hybrid (integrated) treatment systems resulted in process performance enhancement.

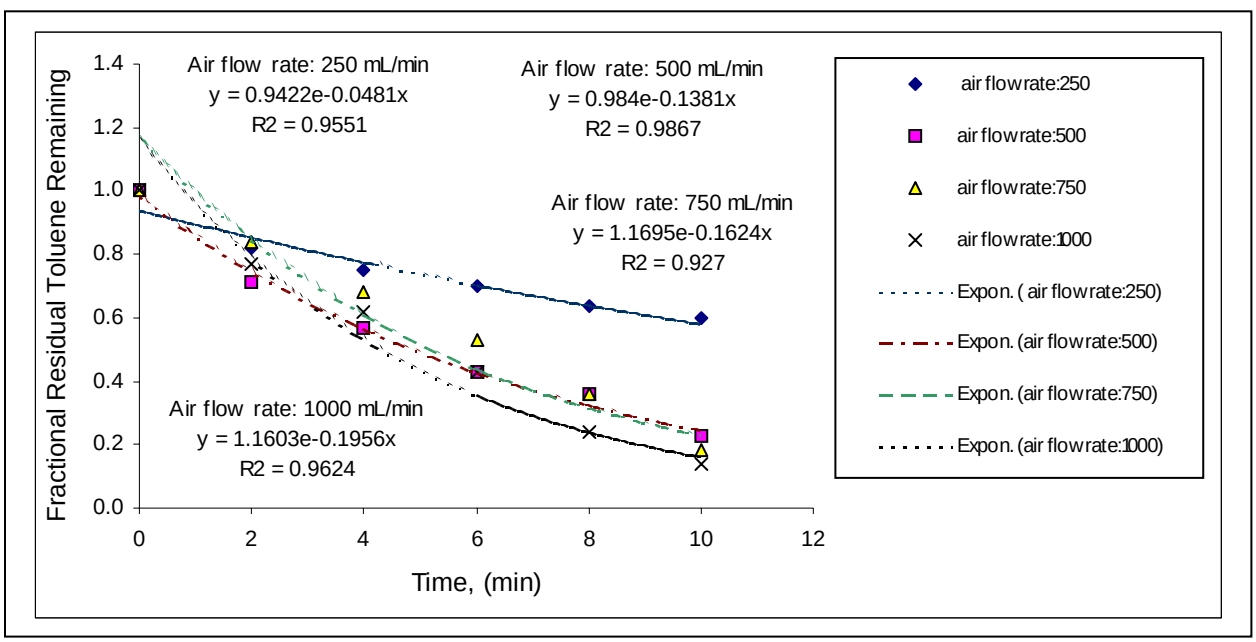

Figure 1. Comparison of Removal Efficiency of Toluene Using Air Stripping Employing Different Air Flow Rates.

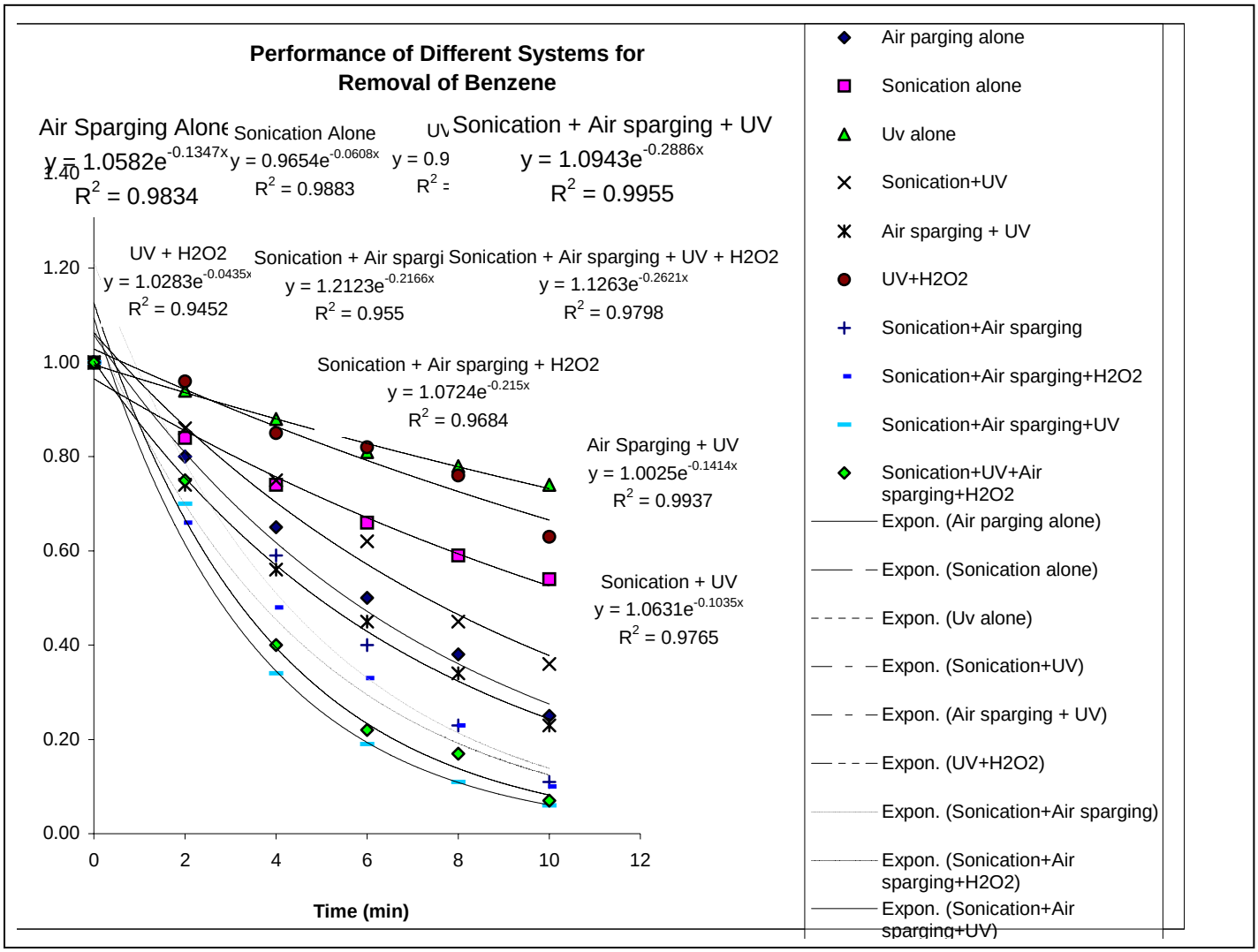

Figure 2. Comparison of System Performance for Various AOP Processes for Removal of Benzene from Solution.

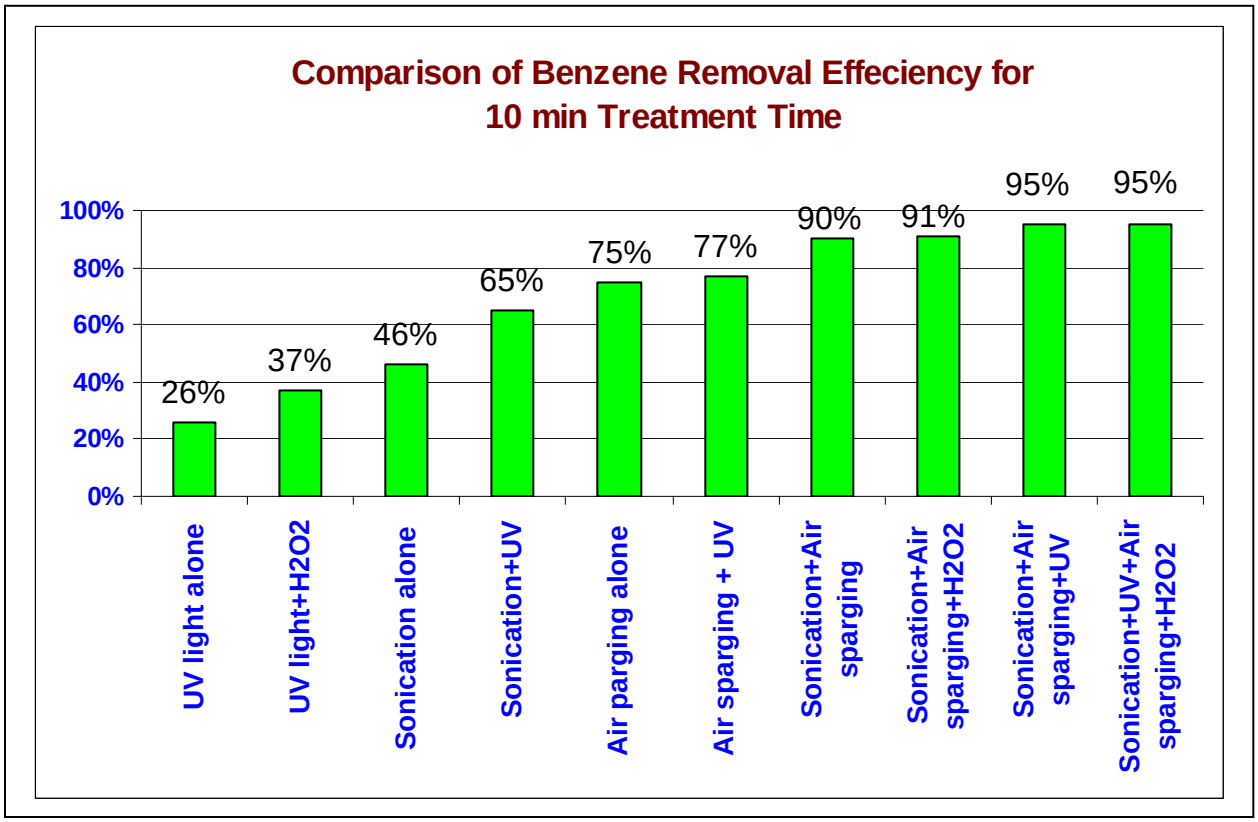

Figure 3. Comparison of Benzene Removal Efficiency for Various AOP Processes Using a 10-minute Treatment Time.

Table 1. Comparison of Rate Constants Using Sonication Alone, Vapor Stripping Alone and Combined Sonication + Vapor Stripping for Removal of Benzene, Toluene, Ethylbenzene and *o*-Xylene from Solution.

Compound	1st –Order Rate Constant k, (min^{-1})		
	Sonication alone	Air sparging alone	Sonication + Air Sparging
Benzene	0.061	0.135	0.223
Toluene	0.064	0.138	0.244
Ethylbenzene	0.070	0.166	0.268
o-Xylene	0.050	0.138	0.213

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