1. INTRODUCTION

1.1. PROBLEM STATEMENT

Current Federal drinking water (chemical) standards are primarily based on associated ingestion exposure. However, other exposure routes—inhalation and dermal contact—may be as or more important in terms of human health risk (McKone, 1987). Contaminated tap water can enter a home through several sources, including showers, bathtubs, washbasins, dishwashers, and washing machines. For each of these sources, chemicals have the potential to volatilize to indoor air and thus provide an inhalation risk to humans. Previous studies on volatilization of chemicals from drinking water to indoor air have been narrow in focus and have failed to close several "knowledge gaps." These knowledge gaps currently hinder accurate inhalation exposure assessments.

To date, research on volatilization of chemicals from drinking water has focused on one household source, showers. Despite the relatively large number of shower experiments, previous studies have focused on stripping efficiencies for a narrow range of chemicals, primarily radon (Rn-222), trichloroethene (TCE), and chloroform ($CHCl_3$). Thus, current methods for estimating inhalation exposure related to contaminated tap water are based on simplifying assumptions and/or extrapolation techniques that fail to capture the mechanistic behavior of the volatilization process. For example, these extrapolation techniques are limited by the lack of specific mass transfer coefficients for chemicals that vary significantly in their volatility. Thus, there is an important need to expand current knowledge about to chemical volatilization from tap water.

This research project was completed in two phases. The first phase was dedicated to an extensive literature search to establish the current knowledge base regarding mass transfer of volatile chemicals from household water sources. This literature search has been documented elsewhere (Corsi et al., 1996). Results of Phase I led to the conclusion that there was a significant need for experiments to estimate chemical volatilization for all household consumptive water uses. Four sources were chosen for further study (Phase II). The four sources were showers, dishwashers, washing machines, and bathtubs, all of which were chosen based on predicted significance of chemical emissions.

A series of experiments was completed to determine chemical volatilization rates for each of the four sources. Results from this work have been used to develop and evaluate improvements to existing extrapolation models for relating rates of volatilization and mass transfer coefficients between chemicals.

1.2. RESEARCH OBJECTIVES

The research objectives of Phase II were as follows:

1. Use a series of well-designed laboratory experiments to expand the general knowledge base associated with chemical volatilization to indoor air.

2. Develop and evaluate improvements to existing models based on empirical and mechanistic accounting for source operating conditions and contaminant physicochemical properties.

3. Compile and organize these experimental data in a database that may be easily used by regulators, consultants, academics, and others.

1.3. SCOPE OF RESEARCH

A two-phase mass balance model was developed for each of the four sources described in Section 1.1. Laboratory experiments were designed such that the mass balance model was solved to back-calculate mass transfer coefficients for each chemical and source. These experiments were completed using a water supply spiked with a cocktail of chemicals representing a wide range of Henry's law constants. For each source, chemical stripping efficiencies and mass transfer coefficients were determined for several applicable operating conditions (water temperature, liquid flowrate, presence of detergent, etc.). A total of 113 mass transfer and air exchange rate experiments were completed.

1.4. ORGANIZATION OF RESEARCH REPORT

Mass balance models used for each experimental source are presented in Section 2. General experimental methodologies and analytical techniques are described in Section 3. Sections 4 through 7 include presentations of each experimental system, experimental design, source-specific methodologies, and experimental results for the respective sources. A model application for each source is presented in Section 8. Conclusions and recommendations based on this research are presented in Section 9. All applicable references are included in Section 10. Finally, the data from the experimental database are provided in the Appendix.