Characterization of Cancer Risk Associated with Measured Airborne Benzene Levels in the State of Florida

Abstract

Objectives: To evaluate the ambient airborne benzene exposures present in the State of Florida and to characterize the risk of developing leukemia as a result of these exposures.

Methods: This investigation uses historic air monitoring data from six counties in the State of Florida to characterize the cancer risk from airborne benzene concentrations utilizing current Federal and State regulatory risk characterization methodologies, and a comparative analysis based on occupational epidemiologic evidence. Airborne benzene samples were collected from 23 air toxics monitoring sites in Broward, Duval, Orange, Miami-Dade, Hillsborough, and Pinellas counties. From 2003 to 2006, samples (n = 37,914) were collected using 8, 12, and 24 hr sampling or with sub-ambient pressure canister methods consistent with EPA benzene sampling methodology.

Results: The mean benzene concentrations, by site, ranged from 0.18 - 3.58 ppb. The resulting cancer risk estimates ranged from 4.37 x 10^-10 to 8.56 x 10^-10, which exceed the FLDPE's acceptable cancer risk level of 1 x 10^-6 for all monitoring sites. The cumulative lifetime exposures were calculated from 2003 to 2006, and results of 0.04 - 0.70 ppm-years. A comparative analysis with available epidemiologic evidence revealed that the association between benzene exposure and cancer risk is related to cumulative exposures in excess of 1 ppm-years.

Conclusions: The results of this investigation indicate that it is unreasonable to expect additional cancer cases in Florida residents due to measured ambient airborne benzene levels, despite the fact that all regulatory risk calculations exceed acceptable cancer risk levels in the State of Florida.

Introduction

The United States Environmental Protection Agency (USEPA) Toxic Release Inventory (TRI) records indicate that 333,089 pounds of benzene were released into the environment in the State of Florida in the year 2005 (1). It is evident that the majority of environmental emissions of benzene are airborne, and consequently, the greatest opportunity for exposure to the general public is through inhalation. It is also generally accepted that the health risk of greatest concern from low level benzene exposures is cancer, specifically Acute Myeloid Leukemia (AML). The focus of research in the 21st century undoubtedly lies in the pursuit of establishing a clear dose-response relationship between low level benzene exposures and leukemogenesis, in both occupational and environmental settings, in order to maintain a level of benzene exposure that will ensure the safety of workers, as well as the safety of the general population. As a result, the primary objectives of this risk characterization are to:

1. Characterize the ambient airborne benzene exposures in the State of Florida;
2. Characterize the cancer risk that may exist using the USEPA Risk Assessment for Carcinogens methodology;
3. Extraplate the cumulative lifetime benzene exposure from the measured benzene concentrations;
4. Perform a comparative analysis between epidemiological studies evaluating cancer risk compared to the extrapolated cumulative lifetime benzene exposures.

Results: USEPA Risk Analysis

The resulting cancer risk estimates ranged from 4.37 x 10^-10 to 8.56 x 10^-10, exceeding the Florida Department of Environmental Protection's (FDEP) acceptable cancer risk level of 1 x 10^-6 for all monitoring sites. The risk probabilities for each monitor site are summarized in the following figure.

Results: Monitor Sites and Proximate Emissions

Results: Cumulative Exposure

The resulting cumulative exposure measures indicate that no monitor risk measured levels that would result in greater than 1 ppm-years exposure.

* The maximum value equals 1 ppm-years, which epidemiological evidence indicates is not associated with leukemogenesis.

All sites measure exposures below 1 ppm-years.

Results: Comparative Analysis

All peer-reviewed research analyzing the relationship between cumulative lifetime benzene exposures and leukemia. No studies found evidence of an association between 1 ppm-years benzene exposure and leukemia. In-depth analysis indicates that a potential threshold for benzene exposure and leukemogenesis exists at 20 ppm-years.

Conclusions

1. It is unreasonable to expect additional cancer cases in Florida residents due to measured ambient airborne benzene levels, despite the fact that all regulatory risk calculations exceed acceptable cancer risk levels in the State of Florida.
2. The implications of this research are relevant to contemporary practices of risk assessment and risk communication in terms of economic consequences as well as the impact on public perception of risk from regulatory risk assessments.
3. Gasoline fuel stations are common targets for benzene soil remediation costing on average $97,000 for soil treatment; money spent under the assumption that by remediating the contaminated soil a significant reduction to public health will be achieved. The results of the current research indicate that when soil benzene concentrations result in a risk of 1 to 2 magnitudes of order over the allowable limit, remediation will not increase public health protection, but will waste economic resources, fossil fuel resources, and produce unnecessary comburent pollution.
4. By using the linearized multistage model to "quantify" risk, we are essentially communicating to the public that not only does every molecule of benzene in the air pose some calculable amount of risk to their health, but further, that the concentration of benzene currently present exceeds the amount of risk we, as researchers and regulators charged with protecting the public trust, deem acceptable. Clearly, this is not a responsible means of preventing risk and the current research illustrates the inherent futility in utilizing this method to assess the health risk of low level carcinogen exposures.