

Office of Science

Research Project Summary

May 2013

Air Toxics Analysis in New Jersey: Ambient Data Review and Model Validation

Authors

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Abstract

The Northeast States for Coordinated Air Use Management (NESCAUM) and the New Jersey Department of Environmental Protection (NJDEP) completed a project to better characterize air toxics levels in the atmosphere and evaluate air quality models for use in assessing policies to reduce levels of air toxics. The goal of the project was to provide a comprehensive assessment of air toxics in New Jersey based on three primary tasks: (1) statistical analyses of ambient air toxics data in New Jersey; (2) comparisons between existing ambient data, air quality modeling results, and emission inventories; and (3) evaluation of an updated model for use with air toxics. Ambient monitoring air toxics data in New Jersey and surrounding states were analyzed to determine the levels for air toxics in and around New Jersey. For species that are degraded but not produced by photochemistry (e.g., benzene, 1,3-butadiene, xylenes, toluene, ethylbenzene), there was an overall downward trend in annual average concentrations at most sites. For species with long atmospheric lifetimes and few known local sources, such as carbon tetrachloride (CCl₄), there was a bumpy positive trend from year to year. Further NJDEP analysis of the CCl₄ data showed that, given the high variability of the data, no firm conclusions about CCl₄ concentration trends appear warranted at this time. For compounds that are involved in and produced by photochemistry, in addition to anthropogenic emissions, concentrations rose steadily in some cases or were more variable from year to year. Summer concentrations for air toxics involved in photochemistry were often higher than winter concentrations. Air quality modeling was used to supplement the monitoring data and evaluate updated model chemistry for use with air toxics. Chemistry mechanisms used with the Community Multiscale Air Quality Modeling System (CMAQ) failed to adequately reproduce levels of pollutants observed in New Jersey. The accuracy of the emissions inventory may be a primary cause of the poor performance, while incomplete model chemistry may also be a contributing factor. It is concluded that these models are not adequate for assessing absolute levels of air toxics in New Jersey at this time. However, they could be useful for evaluations of relative changes in air toxics concentrations expected to result from policy or emission source changes.

Introduction

Regulated under the Clean Air Act, hazardous air pollutants (HAPs), or air toxics, are known or suspected to cause cancer or other serious diseases. Air toxics are emitted by a number of sources — from large and small facilities, to on- and off-road vehicles, to natural sources like wildfires and plant transpiration. Levels of air toxics in the atmosphere and the risks posed by them vary by species, location, and exposure. Despite their ubiquity and role in increasing the risks of adverse health impacts, relatively little is known about the ambient levels of air toxics that contribute to health risks. Characterizing air toxics levels remains one of the key challenges to effectively controlling their risks.

Ambient measurements of air toxics can provide useful information on their levels in the atmosphere and potential

community impacts. However, monitoring requires a significant investment of resources, can have limited precision for individual species, and is often limited in spatial and temporal coverage. As a result, air quality models have the potential to play a valuable role in community scale air toxics assessments. These models must be validated and their limitations addressed before they can be used with confidence in such applications.

The Northeast States for Coordinated Air Use Management (NESCAUM) and the New Jersey Department of Environmental Protection (NJDEP) conducted a study to better characterize air toxics and evaluate air quality models. The purpose of this study is to provide a comprehensive assessment of air toxics in New Jersey based on analyses of ambient data in New Jersey, comparison between existing ambient data, air quality modeling, and

emission inventories, as well as evaluation of an updated model for use with air toxics. This summary describes the activities performed to complete these tasks and presents the results.

Methods and Results

The US EPA's National-Scale Air Toxics Assessment (NATA) model predicts cancer and non-cancer risk levels from air toxics in the atmosphere at the census tract level using predicted annual average air toxics levels. NESCAUM examined results from NATA 2002 (EPA, 2009) and NATA 2005 (EPA, 2011) to determine which air toxics posed the greatest risks to public health in New Jersey. Toxics that are in large part directly emitted by mobile sources play a major role in the cancer risk and respiratory health quotients.

NESCAUM analyzed ambient monitoring data for individual air toxics species in New Jersey and surrounding states to determine the average concentrations of air toxics. The data from four NJDEP Air Toxics Monitoring Network sites in Camden, Elizabeth, New Brunswick, and Chester were analyzed.

Monitoring results show that for species that are degraded but not produced by photochemistry (e.g., benzene, 1,3-butadiene, xylenes, toluene, ethylbenzene), there was an overall downward trend in annual average concentrations at most sites. However, for some species at some sites, the data did not clearly point toward a trend.

For species with long atmospheric lifetimes and few known local sources, such as carbon tetrachloride, a bumpy upwards trend from year to year is observed. Further NJDEP analysis of the CCl₄ data for NJ and New England was performed. The lack of a downward trend in the CCl₄ concentration, given the distinct downward CCl₄ trend in global background concentrations, is puzzling. There is no evidence that the expected declines in CCl₄ are occurring in New Jersey or in New England. Based in additional NJDEP analysis, it appears likely that the steady or perhaps even increasing concentration pattern is an artifact of inaccurate analytical procedures. However, if concentrations over the next few years do not show a decrease consistent with global declines, further investigation seems warranted. It is recommended that the first step in such an investigation be a comparison of atmospheric concentrations as determined by one or more additional laboratories. Consulting with NOAA should also be useful, since it has measured this compound for many years and does not seem to have a problem of high variability.

Finally, for compounds that are involved in and produced by photochemistry in addition to anthropogenic emissions, concentrations rose steadily in some cases or were more variable from year to year. Concentrations between sites were also variable, and sites with the highest concentrations often changed from year to year. Summer concentrations for air toxics involved in photochemistry often surpassed winter concentrations.

While ambient measurements of air toxics provide useful information on air toxics levels in the atmosphere and potential community impacts, air quality models can be used to supplement monitoring data for community-scale air toxics assessments. However, before they can be used with confidence in such applications, air quality models must be evaluated, and their limitations addressed to estimate their ability to reproduce existing conditions and to determine their efficacy for testing potential policies and scenarios.

The Community Multiscale Air Quality Modeling System (CMAQ) (CMAQ, 2010) is a state-of-the-science model that treats major atmospheric and land processes and a range of species in a comprehensive framework. For the present analysis, NESCAUM built upon the previous modeling platform used in the Regional Haze evaluation, and launched a 2002 simulation of a 4.7.1 version of CMAQ, which includes a new chemical mechanism capturing the chemistry of key air toxics species. Results of the model performance evaluations for air toxics show similar performance for both the older Regional Haze model and the present model. Both models were broadly capable of reproducing temporal trends seen statewide, and both had common deficiencies.

However, both Regional Haze and updated chemistry model platforms failed to adequately reproduce absolute concentrations of air toxics observed in New Jersey. These problems in model performance may be primarily a result of the accuracy of the inventory, because the models were largely able to reproduce other processes. Limitations of model chemistry to reproduce complex processes, however, may also be a contributing factor. Additional analysis is required to better elucidate these error sources. Given the relative strengths and weaknesses identified by the study, it is concluded that these models are not adequate for assessing absolute levels of air toxics in New Jersey at present time. However, they may be useful in providing insight about relative changes expected to result from policy or emission source changes.

Summary and Conclusions

- Prior to this study, analysis of the NJ air toxics data had mostly been limited to basic summary statistics. This study presents results of additional analyses on temporal and spatial variability of air toxics concentrations that provides characterization of sources and a better understanding of air toxics in NJ. It also allows better comparison to modeling data, thus aiding the development of control strategies. The study also addressed some important technical issues, such as comparability of data, data quality, and different data set comparisons.
- Monitoring results show that for species that are degraded but not produced by photochemistry (e.g., benzene, 1,3-butadiene, xylenes, toluene, ethylbenzene), there was an overall downward trend at most sites. Concentrations were typically higher at Elizabeth, followed by Camden, New Brunswick, and Chester.

- For species with long atmospheric lifetimes and few known local sources, such as carbon tetrachloride, there is a rough positive trend from year to year. Because there are few large emission sources of carbon tetrachloride in and around New Jersey, monitors in the region are influenced by regional, national, and international sources, and therefore all sites had similar concentration levels. Further analysis of the CCl₄ data performed by NJDEP showed that, given the high variability of the data, no firm conclusions about CCl₄ concentration trends appear warranted at this time.
- For species such as formaldehyde, acetaldehyde, and acrolein that are involved in and produced by photochemistry in addition to anthropogenic emissions, concentrations rose steadily in some cases or were more variable from year to year. Data quality issues raise significant concern over how to interpret the monitoring data.
- Data from neighboring states generally exhibit the same temporal trends seen in New Jersey.
- Monitoring data from the Photochemical Assessment Monitoring Stations (PAMS) and NJ Air Toxics networks showed reasonable agreement.
- Both Regional Haze and updated chemistry air quality model simulations failed to adequately reproduce levels of air toxics observed in New Jersey. Problems in model performance point to the accuracy of the emissions inventory and possibly the need for further improvements in model chemistry specific to air toxics.
- While the models are not currently adequate for estimating absolute levels of air toxics, they may be useful in assessing relative changes resulting from policy or emission source changes.

References

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Funding

This project was funded by the US EPA grant # XA97247401 and NJDEP Office of Science contract # SR09-009.

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