Update of Area Source Solvent Emissions and Methods

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ABSTRACT

Many of the current published emission factors for selected area source solvent categories are derived by, in effect, allocating National solvent consumption data to State and county locations. The emission factors, then, are a composite or National average of solvent consumption at the local or regional level. Due to process changes and introduction of new technology, the National solvent consumption patterns have changed over time. Therefore, improved methods must be considered for allocating National solvent consumption to represent the area source solvent VOC and HAP emission activities occurring in the States and counties. With the support of the Emission Inventory Improvement Program (EIIP), an area source solvent emissions estimation technique was developed in this study that utilized current National solvent consumption data and improved spatial allocation techniques, and included procedures to reflect local control programs. This methodology was used to calculate source category-specific area source solvent emissions estimates for 1999 by State and county, which may be included in the EPA's National Emission Inventory (NEI) as an initial estimate for State/local agencies to review and consider for further improvement. This paper describes the method and emission results to date.

INTRODUCTION

The U.S. Environmental Protection Agency's (EPA's) Emission Factors and Inventory Group (EFIG) compiles the National Air Pollutant Emissions Inventory (NEI) for criteria and toxic pollutants. Area source categories are those processes whose emission releases are estimated in the aggregate, and usually summed at the county level. The significant area source categories in the NEI include the solvent usage categories (e.g., architectural coatings, dry cleaning, graphic arts, pesticide use, etc.) which emit volatile organic compounds (VOCs), one of the National criteria pollutants that contributes to ozone formation. These source categories make up approximately 23 percent of the total VOC emissions in the current 1999 NEI.

The methods used to estimate area source solvent emissions for the NEI started with the National Emissions Data System (NEDS) area source methodology for estimating emissions from solvent categories. The NEDS methodology, developed in the 1970s, included the top 20 solvents by sales volume and used a 'material balance' approach. In the mid-1980's, the National Acid Precipitation Assessment Program (NAPAP) produced emissions for year 1985, which served for several years as the basis for future year estimates. In the early 1990's, the EPA commissioned a long range program in its Office of Research and Development to improve inventory methodologies for area source solvent emission categories. That effort resulted in a 1993 draft report, entitled "Inventory Data Base Analysis for Area Source Solvent Emissions,"[1] which described improvements in the way National solvent consumption may be quantified and allocated to the State and county levels. This 1993 draft report was updated by EPA in 1998, and reflected changes in data sources, among other items. More recently, the EPA reviewed both the1993 and 1998 reports and proposed improved methodologies and data sources for compiling area source solvent emission estimates for the NEI inventory that were based in large part on these previous EPA (draft) documents.

The Emission Inventory Improvement Program (EIIP) program was developed in 1995 by the EPA and STAPPA/ALAPCO to bring together the EPA, State and local agencies, and industry in a joint effort to improve emission inventory data sources and the methodologies used in the inventory process. The current project, which this paper describes, is sponsored by the EIIP. The focus of the current EIIP data development effort is to improve the procedures for estimating solvent area source emissions as well as the emissions estimates for these sources in the 1999 NEI. It is expected that, with State/local input, the EPA will use these emission results to improve the area solvents data during the next update cycle for the 1999 NEI.

The purpose of the project was to document emissions estimating methodologies and algorithms, data sources, geographic allocation procedures, and emission estimates for each of the following eleven solvent area source categories: architectural surface coatings; automobile refinishing; traffic paints; industrial coating operations; surface cleaning (degreasing); consumer and commercial products; graphic arts; pesticide application; dry cleaning; industrial adhesives and sealants; and process solvents and other operations.

PROJECT APPROACH

The methodology developed to estimate National solvent consumption and area source emissions in this study attempts to include all solvents used within a source category in a material balance or 'top down' approach. The approach begins with total National solvent production or sales for a solvent process category and then apportions the solvent demand to the county level using spatial surrogates that are readily available but specific to each source category. The emission contribution of individual point sources and emissions controls are then accounted for on the source and county level. A procedure for estimating solvent use for future years is also provided for the situations where National consumption data are not available, as yet, for the inventory year in question. This ‘top down’ solvent emission estimating methodology is described in detail in the EPA project report for this study,[2] with the major steps in the procedure summarized here.

Obtain and Categorize National Solvent Consumption Data

The initial steps in the ‘top down’ area source solvent emissions estimation procedure divide the area source categories into two groups because of the availability and specificity of solvent consumption data that could be matched to the EPA area source classification codes (SCCs). One group consists of four ‘paint and coating (P&C)’ source categories and the other group consists of seven ‘non-paint and coating (NPC)’ source categories. The solvent consumption data for the seven NPC source categories were taken from the Freedonia Solvents report.[3] For the four P&C source categories, the solvent consumption data were taken from the Census Bureau report called “Paint and Allied Products (2000).”[4] The Freedonia data were not used for the P&C source categories because these data did not provide enough detail to assign the P&C solvent use to specific solvent SCCs.

The area SCCs were used to further subdivide solvent consumption on the National level and also utilized in a later step in the procedure so that point source solvent consumption could be subtracted from total National solvent consumption.

To facilitate the spatial allocation of National-level consumption data to the county, National solvent consumption was allocated among SIC (Standard Industrial Classification) codes considered applicable to the solvent process description in the Freedonia and Census reports. The SIC code assignments were made for those source categories that use employment by SIC code for spatial allocation. In some cases, several SIC codes applied to one solvent process category. The solvent consumption was then divided equally among all the SIC codes for the source category.

Converting Solvent Demand to Solvent Emissions

The P&C solvent data obtained from the Census were in units of 1,000 gallons of coating consumed. These data were converted to “tons of VOC consumed” by multiplying the gallons of coating by “pounds of VOC per gallon” coating factors derived from the literature, that are shown in Table 1. The NP&C solvent data obtained from Freedonia were in units of “1,000 pounds of coating consumed.” These data were converted to “tons of VOC consumed” by multiplying by a unit conversion factor of 500 (e.g., $2{,}000^{-1}$ lbs x 10^6 tons).

All VOC consumed as solvent in coatings were assumed equal to the amount of VOC emitted from application of the coating, i.e., no VOC was assumed to be retained in the coated products. Since solvent in coatings is used as a vehicle to enhance the ability to spread the coating onto the product, this assumption was considered reasonable.

Table 1. Estimated VOC content of paint and coatings.

Paint and Coating Source Category/Subcategory	Source	VOC (pounds per gallon)
Architectural surface coating	National VOC Rule (40 CFR, part 59, subpart D)[5]	4.2
Autobody refinishing	National VOC Rule (40 CFR, part 59, subpart B)[6]	5.5
Industrial coatings	National Paint and Coating Association report (NPCA '90)[5]	3.6
Special purpose total (including marine)	NPCA '90[5]	4.0
Misc. allied (special purpose - other)	NPCA '90[5]	3.9
Traffic markings	NPCA '90[7]	3.1

Applying Growth

The most recent available data on detailed solvent consumption were for 1998. However, the target year for the emissions inventory (the NEI) was 1999. Therefore, it was necessary to project the 1998 solvent consumption figures from 1998 to 1999. Most of the solvent consumption information for 1998 was derived from National estimates given in the Freedonia Solvents report,[1] which also included projected growth estimates. These growth estimates were used to project the data from 1998 to 1999. For most of the solvent source categories, growth data were on the industry-level. In a few cases for the purpose of estimating growth, the solvent source categories were matched to broad industry or solvent categories. Growth for the entire P&C solvent category in the Freedonia report was used to project growth for each of the P&C subcategories, even though the category-specific P&C data were taken from the Census Bureau. Table 2 summarizes the factors applied to grow 1998 data to 1999.

Table 2. Estimated growth for solvent source categories based on available Freedonia data.

Freedonia[1] Solvent Source Category	NEI/EIIP Solvent Source Category	Estimated Growth[a] from 1998 to 1999 in Freedonia[1] (percent)
Printing inks	Graphic arts	1.40
Manufacturing	Process solvents and other operations	1.15
Consumer products	Consumer and commercial products	0.33
Paints and coating solvents[b]	Architectural surface coating, automobile refinishing, industrial coating operations, traffic paints	0.20
Other solvents	Pesticide application	0.18
Industrial cleaning	Surface cleaning (degreasing)	-1.4
Adhesives	Industrial adhesive and sealants	-1.5
Hydrocarbon solvents	Dry cleaning	-12.5

[a] As calculated from the total solvent consumption in the Freedonia report for 1999, divided by the corresponding solvent consumption for 1998 and multiplied by 100.

[b] A Freedonia-based growth factor was used for these source categories even though the solvent consumption data were estimated using the U.S. Census' Paint and Coating[2] shipment data.

Spatial Allocation of National Data to State/Counties

Spatial allocation of the National solvent consumption to the county level in the 'top down' methodology was performed using either employment or population as a spatial surrogate. In the current analysis, population was used as a surrogate with two of the 11 solvent source categories and employment was used with nine of the solvent source categories. State and county FIPS (Federal Implementation Placement System) codes were used to identify each State/county. With this State/county apportionment step, the National solvent consumption for the source category was allocated to one unique combination of area source SCC, SIC code, and county (FIPS code).

For those solvent source categories where population was used for spatial allocation (graphic arts and traffic paints), solvent consumption data were allocated using the proportion that the county's population was out of the total National population for the target year (1999). This proportion is called the spatial allocation factor (SAF). County solvent consumption for these source categories was obtained by multiplying the total National solvent consumption for the source category by the SAF.

For those solvent source categories where employment was used for spatial allocation, employment by SIC code information was obtained from County Business Patterns (U.S. DOC/Census, 1997), to derive a SAF equal to the proportion that the total (mid-March) employees in each SIC code in the county were out of the total National (mid-March) employees for the SIC code. Solvent consumption was allocated to the county level by multiplying the National total solvent consumption for that SIC code in the source category by the SAF.

Applying Control Information

Since the 'top down' area source solvent emissions estimation procedure estimates the amount of solvent purchased, the amount of solvent destroyed by air pollution controls at the source should be accounted for to obtain an estimate of controlled emissions from solvent use. Investigation of National regulations with controls potentially applicable to area sources in the solvent source categories in 1998/1999 revealed the following regulations: NESHAP rules for "Degreasing" (surface cleaning), "Dry Cleaning," "Magnetic Tape" (industrial surface coating), and "Printing and Publishing" (graphic arts) source categories; and National VOC rules for "Architectural Coatings," "Automobile Refinishing," and "Consumer Products."

A review of the National regulations listed above showed that the applicable area source controls in both the NESHAP and VOC rules serve only to reduce solvent demand in the solvent source categories. This reduced demand should be reflected in the 1998 Freedonia data used in the 'top down' approach for the 1999 projections and would not need to be otherwise incorporated into the emission estimating procedures. The point source controls included in the above regulations were not considered, since for the 1999 estimates the point source controls were expected to be reflected in the NEI data.

Since State and local area source regulations may also be important to emissions estimates for the solvent source categories, the 'top down' methodology also includes algorithms to incorporate these controls as well. The potential emissions reductions due to State/local area source regulations were split into two parts: the reductions resulting from higher add-on/destructive control efficiencies (over the National) and the reductions due to reduced solvent usage in some counties as compared to others within the State. In the 'top down' approach, if solvent use in a specific county is reduced as compared with other counties, then the solvent allocation to other counties should increase so as to maintain the National solvent usage total. Specific State and local control information was not obtained for this project so the data results may not account for any additional State / local controls in place.

Point Source Subtraction

The assumption that all solvent/VOC consumed is emitted in the process requires that to obtain an estimate of area source solvent/VOC consumption, the point source contribution to the National solvent/VOC consumption needs to be subtracted out as uncontrolled emissions. Point source emission and control information from the EPA's 1999 NEI was used to guide this step. While the NEI is a ready source of detailed emissions data, it is not confirmed to be a complete nor accurate source of control information, and undergoes continuous improvement with input by State/local agencies.

In the NEI, point source VOC emissions with no applicable control devices and/or control efficiencies were assumed to equal uncontrolled VOC/solvent emissions. Uncontrolled solvent emissions were then assumed equal to consumption, as described above. Solvent point source emissions with nondestructive controls were treated similarly, and assumed equal to uncontrolled VOC emissions and solvent consumption. For solvent point sources with destructive control devices, the uncontrolled emissions were 'backed out' from the controlled emissions, utilizing the mathematical relationship between controlled and uncontrolled emissions, and control efficiency.

The resulting point source uncontrolled VOC emissions/consumption were subtracted from the total uncontrolled National solvent consumption (which included solvent/VOC consumption by point and area sources) to provide county-level area source solvent consumption by area SCC, which was later summed up to the National level.

PROJECT RESULTS

The project results to date are provided here in terms of the status of the documentation of the methodology developed and the 1999 emission estimates. Also included is a description of the various methods that will be used to validate the emissions estimates, to determine that the data are reasonable for inclusion and use in the 1999 NEI.

Emission Results

The project results that represent the total uncontrolled area and point source solvent consumption/emissions in 1999 are estimated at 7,795,318 tons per year. Table 3 summarizes the emission results based on the EPA 'Tier' solvent utilization categories.

Table 3. Total estimated National 1999 VOC solvent process emissions (tons) using the 'top down' approach.

Solvent Utilization Tier Source Categories	'Top Down' 1999 VOC Emission Estimates [a] (short tons)
Degreasing	271,761
Graphic Arts	438,511
Dry Cleaning	71,241
Surface Coating	3,028,728
Other Industrial	538,468
Non-Industrial	3,097,219
NEC [b]	349,391

[a] Equal to the uncontrolled VOC emissions for area sources plus point sources.
[b] Not elsewhere classified.

Data Validation

In an attempt to 'ground-truth' this EIIP project area source solvent emission results, several data validation steps are planned, none of which were completed by the time of this writing. The 1999 emissions estimates generated from the current project will be compared to the EPA's 1999 NEI area source solvent data. The data comparison will be based on uncontrolled emissions and the EPA's 'Tier' summary category report. Portions of the current project data that represent architectural coating, and consumer and commercial products may also be compared to VOC emissions data that formed the basis for the National VOC control rules for Architectural Coatings and Consumer Products. In addition, a State-level comparison may be performed with a State data set that is considered to have been developed in a robust manner and has been incorporated directly into the NEI.

Documentation

This 'top down' solvent emission estimating methodology is described in detail in the EPA project report for this study.[2] The project report also includes reference to a database that documents the VOC emission results and the background data used to calculate the emissions.

Publication of the emission estimation procedure for area source solvents developed in this project will appear in the document: “Emission Inventory Improvement Program, Volume III: Area Sources.” See also the website at http://www.epa.gov/ttn/chief/eiip for this document.

Summary of Current Project Status

The methodology and emission results described here are currently under review by the Area Source Committee of the EIIP. Data validation procedures, as described above, are occurring concurrently with this review. Pending the outcome of the EIIP review and results of the data validation steps, it is expected that the project report and emission results will be finalized and published during early Summer 2001. In addition, a more widespread external review of the methodology has begun with presentation of this paper.

CONCLUSIONS

The solvent area source categories are significant sources in the EPA’s NEI. This study provides an improvement and refinement of solvent emission estimates on a consistent methodological basis. Use of consistent and reasonable methodology to update these significant contributing sources of VOC is expected to greatly benefit the use of the data in air quality modeling. Pending outcome of further data validation steps and agreement through external review that the estimation approach and results are reasonable, the area source solvent emissions data are expected to be used in the EPA’s National Emission Inventory for 1999. Because the 1999 area source solvent data will be updated with the results of the current study, it is expected that these data may appear significantly different as compared to previous years.

Several questions were raised during application of the ‘top-down’ method. The following questions/observations suggest possible follow-on work for future refinement of the project results:

- Assumptions made during development of VOC content (lb/gal) of coatings in the P&C solvent source categories may benefit from development of weighted average.

- Some of the background data obtained may be used to update the toxic chemical species profiles for many solvent processes.

- Since the assumption to distribute solvent process demand uniformly across several SIC codes influences the geographic distribution (spatial allocation) of the emissions, this allocation may not be representative of the true emissions profile.

- Application of State/local area source controls may not be well represented.

- The EPA’s NEI point source data, used in the point source subtraction step, may not be the best source of surrogate information.

- Assumptions for identifying which point source processes (SCC) involve the use of solvents may need validation.

- National/State/county area solvent emission estimates are probably best, e.g., most representative, when updated periodically and based on consistent methodological approach, such as this study. How can the estimates be consistently updated over time to ensure the best possible data?

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KEYWORDS

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Data Validation
EIIP (Emissions Inventory Improvement Program)
NEI (National Emissions Inventory)
Air Quality Modeling
VOC (Volatile Organic Compounds)
Toxic Pollutants
Chemical Species Profiles
National Solvent Consumption
Top Down Method