United States
Environmental Protection
Agency

Environmental Sciences Research
Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S3-84-023 Mar. 1984

EPA

Project Summary

Source Receptor Methodology for Some Chlorinated Hydrocarbons

F.L. Ludwig, E.M. Liston, and L.J. Salas

This study investigates the feasibility of a source-receptor methodology that is used to estimate halogenated hydrocarbon emission rates from a manufacturing plant when access to the plant is not possible. The method estimates fugitive emissions from sources within 10 or 15 m of ground level. If an area is tested at night or under overcast conditions, the method is generally insensitive to meteorological conditions, although it must be applied with discretion if interfering sources are present.

An inert tracer is released at a known rate near the plant area. Samples are collected downwind of the plant and analyzed for the tracer and halogenated hydrocarbons. The relationship between measured concentrations and the emission rates of the tracer and the halogenated hydrocarbons has been derived. Therefore, emission rates can be determined, and conventional Gaussian methods may be used to estimate maximum ground-level concentrations of halogenated hydrocarbons downwind of the plant.

A suitable manufacturing plant was selected, and the method was applied to estimate emission rates for four different halogenated hydrocarbons. The feasibility of the methodology was demonstrated and suggestions for improvements were made.

This Project Summary was developed by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The U.S. Environmental Protection Agency (EPA) is concerned that some hydrocarbon compounds, especially halogenated hydrocarbons that may be hazardous at low concentrations, might have an immediate local impact downwind of some manufacturing plants. Once a source strength is known, maximum ground-level concentrations can be estimated as a function of downwind distance and meteorological conditions. However, lack of source-strength data has prevented the prediction of the amounts of these materials that are released to the atmosphere and the concentrations that might exist downwind of the plants under various meteorological conditions.

Several factors have contributed to this lack of data. Hydrocarbon compounds are likely to be emitted from widely distributed sources such as valve leaks, plumbing, incompletely sealed containers, and filling and emptying operations or during transport. The magnitude of such fugitive emission sources is difficult to measure or estimate. Furthermore, at many plants the processes and equipment used to produce the materials are proprietary and for competitive reasons, manufacturers are unwilling to reveal their production and sales rates. In such an environment, manufacturers are reluctant to allow outsiders into their manufacturing plants to make measurements that would be necessary to characterize source strengths directly. EPA recognized a need for a source-receptor methodology that could be used to estimate the source strength of such fugitive emissions and predict maximum ground-level concentrations

and would not rely upon measurements made within the manufacturing complex.

Procedure

Theoretical research and field testing were combined to create and test a method for measuring halogenated hydrocarbon concentrations. The methodology relies upon the release of an inert, non-toxic tracer gas at a known rate outside the manufacturing site. Tracer and chlorinated hydrocarbon concentrations are measured downwind of the site, and the magnitude of hydrocarbon sources within the plant is estimated. Once these source strengths are established, conventional dispersion modeling techniques are used to estimate downwind concentrations for various meteorological situations.

The actual tests were conducted at the Vulcan Materials Company plant near Wichita, Kansas, on the nights of August 8-9, 10-11, 11-12, and 12-13, 1981. An inert, non-toxic tracer gas was released at a known rate from a vehicle traveling outside and upwind of the manufacturing site. Samples were collected at 1 to 5 km downwind of the plant. These samples were analyzed for tracer and chlorinated hydrocarbon concentrations. Tracer concentrations were measured to establish the magnitude of the atmospheric transport and dilution processes. This value was used with simultaneous downwind measurements of the chlorinated hydrocarbon concentrations to estimate the magnitude of their sources within the plant.

Results and Conclusions

Hourly samples were collected throughout the nighttime test periods. This measurement approach presents an inherent difficulty because of the potential for wind shifts which could affect the significance of the tracer release as well as the downwind collection of the pollutants by the ground-level receptors. Difficulties with analytical procedures, proper receptor location, high background and low receptor concentrations were also encountered. As a result, the data analyses involved the five best data sets from the entire sampling schedule.

Two equations were used to estimate the emission rates of the measured compounds:

$$Q_A = \frac{0.35\, C_A\, Q_l}{C_l (X_u^{0.35} - X_d^{0.35})\, x^{0.65}}$$

where Q_A=area source emission rate ($g/m^2 \cdot s$)
C_A=concentration of area source component (g/m^3)
C_l=concentration of line source component (g/m^3)
Q_l=line-source tracer emission rate ($g/m \cdot s$)
X_u=distance from receptor site to upwind edge of area source (m)
X_d=distance from receptor site to downwind edge of area source (m)
x=distance from integrated line sources to receptor site (m)

(which relates the dilution of a tracer released from a ground-level line source to the dilution of compounds from a nearby ground-level area source), and

$$Q_p = \frac{K\, C_p\, Q_l}{C_l} \quad \frac{X_p^{0.9}}{\text{Sin } \emptyset}$$

where Q_p=source strength of a point source (g/s)
C_p=point source ground-level concentration at plume center (g/m^3)
Q_l=line source emission rate ($g/m \cdot s$)
C_l=line source ground level concentration (g/m^3)
X_p=downwind distance from point source (m)
$\emptyset$=angle between wind and line source
K=constant reflecting meteorological conditions

(which assumes the source is a point or very small area source and that the point source and line source are close together compared to the downwind receptor distance).

By using the ratios of chlorinated hydrocarbons to the tracer concentrations all measured at the receptor sites, estimates were made for the hydrocarbon emission rates. Using the area source formulation, estimates of from 1.5×10^{-7} to 3.1×10^{-4} $g/m^2 \cdot s$ were obtained. Using the point source formulation, estimates of from 0.01 to 6 g/s of hydrocarbon emissions were estimated.

It was concluded that receptor placement strategy was critical for such a measurement approach as well as the consistency of the wind direction. The highly variable results of hydrocarbon concentrations from one receptor to another suggested that release of the compounds was a result of localized incidents, such as drum filling, leaking flanges, and materials handling.

Suggested improvements include greater spatial and temporal resolution of receptor sites. A further improvement would be establishing a screening procedure of the tracer analyses results to maximize quantitative results with a minimum number of analyses. A final suggested improvement in the method was adapting its use to daytime operations but this would be limited to neutral conditions sampling.

F. L. Ludwig, E. M. Liston, and L. J. Salas are with the SRI International, Menlo Park, CA 94025.
***James L. Cheney** is the EPA Project Officer (see below).*
The complete report, entitled "Source Receptor Methodology for Some Chlorinated Hydrocarbons," (Order No. PB 84-149 160; Cost: $10.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

☆ U.S. GOVERNMENT PRINTING OFFICE: 1984 — 759-015/7627