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Project Summary

Determination of Materials Distribution in Suburban and Rural Areas

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The program was undertaken to assist in the quantification of material exposed in suburban and rural areas that is susceptible to the effects of gaseous and particulate air pollutants and acidic deposition. The study is based on a limited visual survey and photogrammetric measurement program to provide sufficient information on the amount and distribution of materials in suburban and rural areas. The study areas were selected to accommodate a variety of demographic and related variables such as structure sizes, structure ages, and household incomes as indicators of material in use in Tucson, AZ, Charlotte, NC, and Lincoln, NE.

Confidence limits and stepwise multiple linear regression were used to derive the area and amount of materials for single family housing. The exposed materials most prevalent in all cities were painted wood and brick. Stucco was also predominant in Tucson. Results are presented for rural farms and for public facilities, utilities, and bulk storage facilities.

This Project Summary was developed by EPA's Atmospheric 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

A critical element in determining the economic losses due to damage to structural materials from gaseous and particulate air pollutants and acidic deposition is the estimation of the amount of material-at-risk. A recent study that developed an economic materials damage model showed that uncertainty in lifetime maintenance costs for different pollution control scenarios is strongly influenced by existing uncertainty in material distribution estimates. Previous studies have generally concentrated on urban areas. This report presents information on material in place within the suburban and rural environments and thus provides a wider basis for calculating materials damage and the related economic impact due to the effects of gaseous and particulate pollutants and acidic deposition.

The objective of this project was to develop mathematical models which are relatively accurate and easy to apply for estimating the distribution of exposed materials susceptible to air pollution damage in suburban and rural areas. To accomplish this objective, representative suburban and rural areas were selected for study. Readily available census data served as estimators of the distribution of materials. The selected areas were examined photographically to determine the amounts of specific susceptible materials. A statistical relationship between the estimators and the amounts of susceptible materials was developed.

The materials of concern in this study are those used in suburban and rural stationary structures having surfaces exposed to the atmosphere and therefore susceptible to damage by gaseous air pollutants and acidic deposition. Commercial, industrial, and multifamily houses were excluded from the study. Materials of interest and their coatings are

stucco, wood (bare, painted, and stained), brick (bare and painted), steel (galvanized and painted), aluminum, concrete, cloth, wrought iron, stone, window, limestone, and marble.

Estimates of the amounts of materials in each of the three cities using regression analysis are shown in Table 1.

Table 1. Estimates of the Amounts of Materials in Each of the Three Cities (10^6 ft^2) Using Regression Analysis

Charlotte	
Painted Wood	*302.9*
Brick	*340.9*
Aluminum	*29.8*
Lincoln	
Painted Wood	*70.5*
Stained Wood	*6.3*
Brick	*70.3*
Aluminum	*9.1*
Tucson	
Stucco	*112.8*
Painted Wood	*104.0*
Stained Wood	*20.8*
Brick	*54.4*
Aluminum	*91.0*

Procedure

Two overall tasks were designed to meet the goals of the work: data gathering and model development and testing. Data on the materials-in-place at six sites consisting of the suburban and rural areas near Charlotte, NC, Tucson, AZ, and Lincoln, NE, were obtained from an analysis of Sanborn maps, a review of public and commercial sector maintenance records, and the field measurement of a statistical sample of buildings, fences, and outdoor fixtures. Data on climate, demographics, industrial and commercial activities, land use, and housing characteristics were obtained from sources such as the U.S. Census Bureau and local planning commissions and were analyzed to find appropriate factors for predicting the amounts of materials-in-place.

The materials-in-place analysis was divided into three sections: suburban residential, rural farms, and non-population-dependent materials. For the suburban residential and rural areas, photographic analysis and visual field surveys were used to gather the distribution (type and amount) of materials-in-place. For the non-population-dependent materials, defined as highways, bridges, guardrails, radio and TV towers, and telephone and electrical communication lines, a telephone survey was used to gather the data.

The census tract was chosen as the basic geographic study unit to obtain a sample of homes of various ages and sizes with residents of various income levels. This selection includes data which could be used as possible predictors in the regression analysis and which might be related to the type and amount of materials. Further, data from census tracts were available to form a data base for an analysis on a regional basis.

The census tract data were reviewed, and a total of ten residential suburban tracts were selected for study in each geographic area. These tracts were selected to ensure a variety of housing ages, of household incomes, and of structural sizes. A photographic survey was conducted of each selected census tract. The survey consisted of pictures of twelve typical houses and detailed photographs for one typical structure in each tract. The first set of photographs established the distribution of materials and size of houses within each tract. The detailed photographs of the one typical house in each tract showed the surface area components for different parts of the structure, including walls, windows, foundation, doors, door trim, wall trim, window trim, and gutters. The photographic survey also yielded information on materials associated with basketball backboards, light posts, birdbaths, clothesline poles, railings, and air conditioners. Standard measurements were developed for each of these structures.

These data were summarized to yield total amounts of each material type expressed in square feet of exposed surface area. Confidence limits of area were developed for each city. Additionally, stepwise multiple linear regression was used to derive mathematical equations using the material-in-place as the independent variable and the census data as the dependent variable for the suburban residential study areas.

A similar approach was taken for the rural areas surrounding the three cities. Detailed visual surveys were conducted on five farms in each city. Detailed photographs were taken of the main house, all outbuildings and sheds, including barns, pigstyes, coops, storage silos, and farm implements. The material types were determined from field survey notes and the detailed site photographs.

For the non-population-dependent material-in-place calculations, telephone surveys were conducted in each geographic area. Information was gathered from state and county road and public works departments, petroleum storage facilities, and electric and other public utility firms on the type of material and the distribution of structures within the geographic area.

Summary and Conclusions

Photographs were taken of houses in Charlotte, NC, Lincoln, NE, and Tucson, AZ. The areas measured include the fronts of 80 houses and all surfaces for 10 houses in each of the three cities. Methods were developed to estimate the amount of mterials-in-place using (1) confidence limits and (2) regression analysis. The census data on housing and population were combined with the area data computed from the photographs. The amount of materials-in-place on five farms in each of the regions was computed from photographs. Additional non-population-dependent materials in the suburban and rural areas were estimated by means of telephone surveys with public agencies and large corporations in the regions.

A comparison of the regression equations and the confidence limit method showed variations in the estimates of materials-in-place of 20 to 30 percent. Either method appears capable of estimating the materials-in-place. However, additional data should be collected or the procedure should be varied to improve the reliability of the estimates.

The confidence limits method needs additional data on the ratio of the front to the total exposed area. In the present case, the ratio was estimated from the detailed analysis of 10 houses. A number of nonphotographic sources of data are available, such as multiple listing services, that provide actual floor plans.

The regression analysis will need additional data points. In the present analysis, demographic or housing data of individual houses were not available. Thus, the demography and housing were represented by census tract data.

The methods of the present study can be used to estimate the amount of materials in a given region. The basic data, the census data, are available nationwide. However, additional sites will need to be sampled to provide the basic area of the structures. Additional data are needed to quantify the surface areas for industrial and commercial structures and for multifamily housing units.

Recommendations

A continuing criticism of economic assessments of air pollution effects on susceptible materials exposed outdoors is the uncertainty of the amount of exposed materials-in-place on a nationwide scale. The study was undertaken to provide an initial basis for estimating the amount of exposed materials in suburban residential and rural farm areas. To expand our knowledge of materials-in-place and provide accurate estimates of material-at-risk for assessment of material damage as part of the National Acid Deposition Assessment Program (NADAP), the following recommendations are made:

- Apply these mathematical techniques to calculate material-at-risk due to the effects of gaseous and particulate air pollutants and acidic deposition within given regions. Integrate air quality data and damage functions to calculate total material damage costs and that proportion attributable to air pollution.
- Conduct a random sampling of residential census tracts in other geographic regions using similar photogrammetric techniques to expand the accuracy of the methods.
- Expand the study to multiunit residential housing. The types of materials in use and any substitution practices will be different from those noted in single family residential structures.
- Select tracts which have representative numbers of industrial/commercial structures so these applications could be included in the aggregate estimate of material-in-place.
- Treat urban and suburban areas as a unit.
- Use existing census data for the basic building data.

Information gathered in these areas will result in improvements to the estimating techniques for the potential benefits and costs due to changes in ambient concentrations of atmospheric pollutants.

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The complete report, entitled "Determination of Materials Distribution in Suburban and Rural Areas," (Order No. PB 86-128 600/AS; Cost: $16.95, subject to change) will be available only from:
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