HEALTH AND COAL UTILIZATION IN THE RURAL SOUTH:

A CARTOGRAPHIC APPROACH*

Eugenia E. Calle
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Introduction

Coal is currently used to generate 44% of all electricity in the United States and 43% of electricity in the South. These percentages may grow if national policy continues to favor increased use of coal resources to meet energy needs. Energy production has long been an important sector of the Southern economy. The region produces 50% of the nation's coal, primarily in the Appalachian areas of Kentucky and West Virginia, it consumes 33% of the nation's coal, and it has 63% of the workers employed in the coal industry (1).

In view of this large regional commitment to coal, the health impacts of current and future coal production and utilization are of primary concern to those involved in public health in the South. These impacts are twofold. The effects of coal production are seen primarily in miners, an occupational group at high risk

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of disease and disability, while the effects of coal utilization are manifested in general population groups exposed to emissions from coal-fired power plants. Many of these communities are rural in nature and consequently are not exposed to significant amounts of pollution from sources other than the power plants. They thus provide unique groups in which to study the health effects of single-source, local air pollution. This paper addresses some of the implications of coal combustion for these general populations and highlights opportunities for research.

Population Exposure

The sulfur oxide and particulate complex produced during the combustion of sulfur-containing fossil fuels is the major component of air pollution released from coal-fired power plants. In 1975, 62% of all sulfur oxide emissions in the U.S. came from coal electric utilities (2). The sulfur oxide is actually released to the atmosphere in three forms: sulfur dioxide, sulfuric acid, and sulfate aerosols. Recent interest has focused on the sulfate aerosols for two reasons. First, there is some evidence to suggest that the transformation products of SO_2, such as sulfates, may be responsible for the health effects originally attributed to the sulfur oxide and particulate complex (3). Second, atmospheric sulfates may be transported by the wind for considerable distances to areas where SO_2 emissions and atmospheric levels are low. Sulfates might thus present a risk to populations that are quite distant from the coal-fired power plant source.

The first step in assessing the relationship between air pollution and health is to quantify the exposure received by the population at risk. Air quality measurements constitute one way of determining population exposures. However, many of the current sources of air quality information are subject to limitations regarding the pollution data collected and the methods and locations of data collection. Air quality measurements are routinely made by state and local air pollution control agencies. The number of data collection sites and extent of geographic coverage have increased greatly in recent years. Historical measurements are most often available for SO_2 and total suspended particulates while substances currently measured vary across sampling stations.

Modeling the transport of emissions from a single source or group of sources provides an additional approach to exposure assessment that may be used to compliment available air quality data. Results from transport and diffusion models can be validated using air quality measurements in areas where monitoring activities are conducted and sufficient data are available. Along with estimating current exposures, modeling techniques can be used to predict future air quality levels if assumptions regarding future emissions can be made.

The atmospheric transport model (ATM) (4) is employed at Oak Ridge National Laboratory (ORNL) for short-range studies (up to 100 km). The ATM is a straight line, Gaussian plume model, and can be applied to point, area, and line sources. Necessary input parameters include meteorologic conditions, emissions data, stack properties, and estimates of burning efficiency. In Figure 1, isopleths of annual average ground-level concentration of sulfur dioxide are shown for the area surrounding a coal-fired power plant in Person County, North Carolina. Superimposing the county outline facilitates stratification of the resident population by exposure level.

To investigate long-range transport of pollutants, the regional trajectory and diffusion-deposition model (RETADD)(5) available at ORNL is appropriate. Using upper-air wind data, this model estimates the transport of pollutants from multiple sources to distances of hundreds to thousands of kilometers. The model requires input parameters similar to those needed for the ATM as well as additional assumptions regarding depletion processes. The array of data points estimated by RETADD may be entered into a contouring program to generate a cartographic representation of regional pollutant concentrations. Figure 2 illustrates calculated regional concentrations of SO_2.

Health Effects

More studies of the human health effects of sulfur oxides and particulates have been conducted than for the other components of air pollution. Both short-

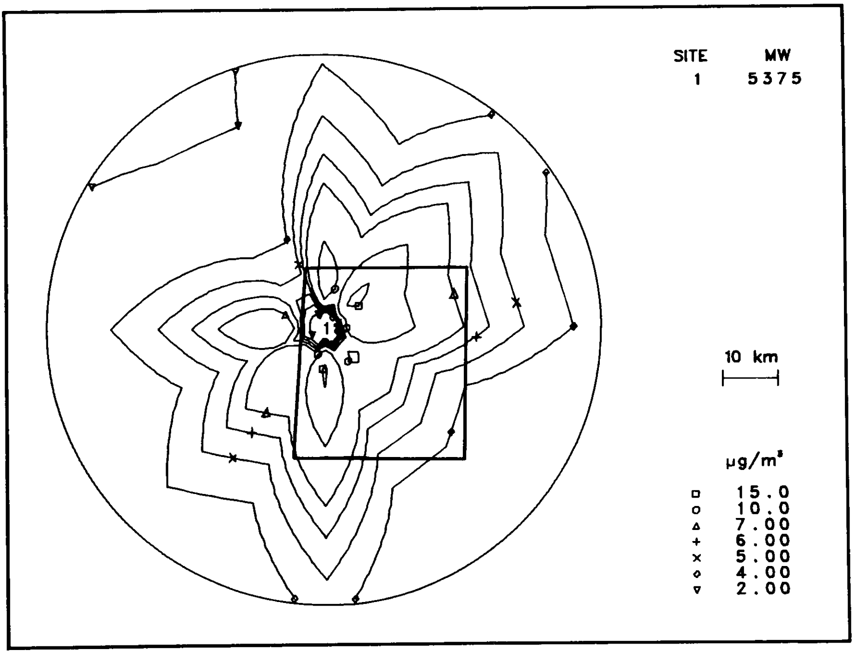

Figure 1. Annual average calculated ground-level concentration of sulfur dioxide from a coal-fired steam plant in Person County, North Carolina.

term acute air pollution episodes and long-term elevations in air pollution levels (such as those present in many major cities) have been shown to be associated with increased mortality. This increase is most probably attributable to elevated mortality in individuals already at high risk. Numerous studies of the health effects of long-term elevated exposures have revealed associations with chronic respiratory disease in adults (both prevalence and exacerbation of symptoms), and with changes in pulmonary function and acute lower respiratory tract illnesses in both adults and children (6).

While there is abundant evidence identifying the adverse health effects of air pollution, there is still considerable uncertainty in evaluating and quantifying

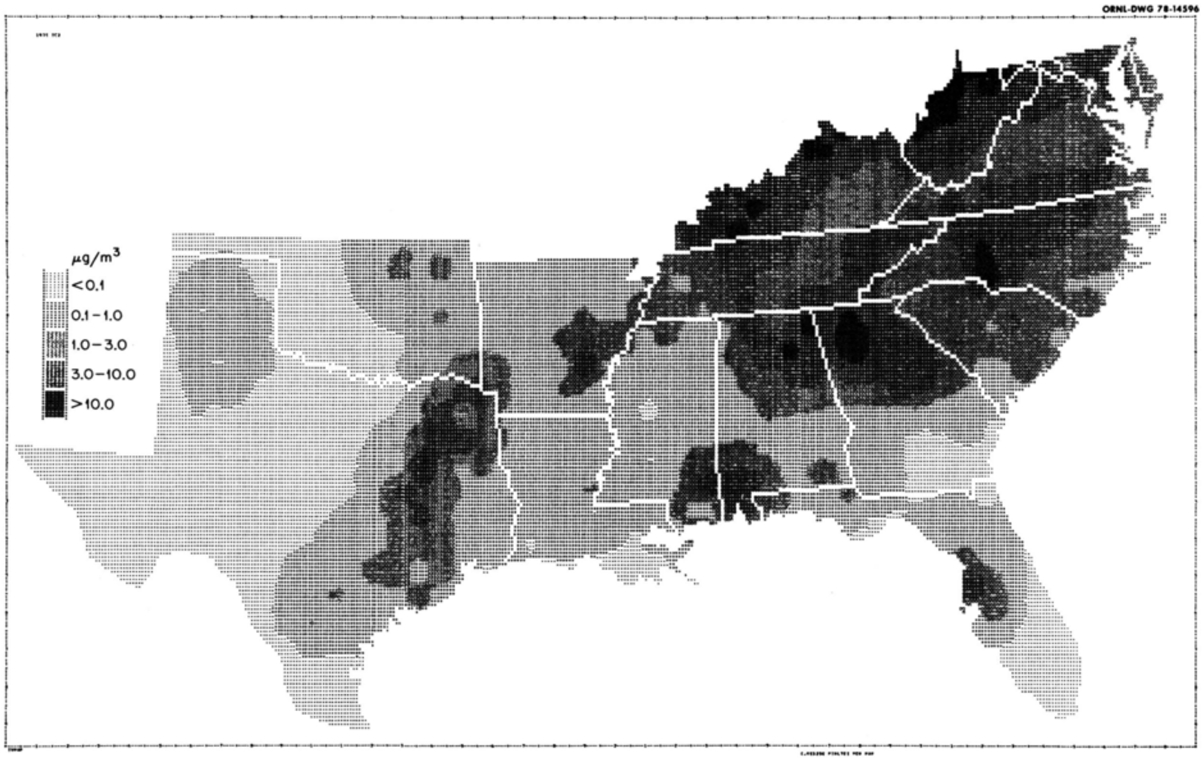

Figure 2. Calculated regional concentrations of sulfur dioxide.

public health risks of various pollutant concentrations. Problem areas include adequately assessing exposure, separating the health effects of individual pollutants and combinations of pollutants, quantifying the effects over a large range of pollutant concentrations, and isolating the effects of air pollution from the effects of other causal and contributing factors.

The great majority of research conducted thus far on the health effects of air pollution has focused on urban areas where the mix of atmospheric pollutants is a result of many and varied sources including industrial and automotive emissions. In contrast, many of the coal-fired power plants in the South are located in rural areas. Populations exposed to the effluents of coal combustion in these areas provide a unique opportunity to study the health effects of a single, primary source of local air pollution.

The association of health effects and pollutants may be studied at the aggregate (ecological) level or at the individual level of analysis. The former is the easier and less costly approach but it may also be the less informative. Ecological studies should attempt to correlate mortality and/or morbidity rates with levels of exposure (based on measurements and transport models) while controlling for confounding factors such as socioeconomic status and urbanicity. The analysis can compare populations at the sub-county, county, or county group level, depending on the diseases of interest and the availability of health data by different geographic units. Studies of this nature have several major limitations. First, exposure assessment is done at the group level and does not reveal the wide range of individual exposures resulting from differences in indoor air pollution, place of residence, place of work, travel and mobility patterns, etc. Also, data for many important confounding variables, including smoking and occupational exposures, are generally not available in the aggregate. Finally, when the unit of analysis is shifted from a person to groups of persons, inferences based on significant correlations between variables at the group level may not hold true for the individual.

An alternative approach is to use the exposure data available to reveal areas of high and low pollution levels and conduct detailed laboratory and epidemiologic studies in these areas, focusing on individual differences in both exposure and health endpoints and controlling for individual differences in confounding variables. In this regard, the surveillance of high risk groups through organized rural health clinics might serve research objectives as well as practical public health needs at the local level.

Rural communities in the vicinity of coal-fired power plants offer a unique opportunity for epidemiologic investigation of the health effects associated with quantifiable, single-source emissions. The research suggested here seems particularly appropriate in light of current energy needs. Quantifying the health risks of additional increments of coal-fired electricity would add to present knowledge and aid in future energy decisions.

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