Daily and Weekly Changes in Total Suspended Particulate Matter Concentrations at Anderson, Indiana

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Abstract

Hourly total suspended particulate concentrations for the period August 10—September 14, 1973, at Anderson, Indiana, were analyzed to illustrate the hourly and daily variation in urban air pollution. Hourly and daily changes in air quality as measured by hourly particular concentrations are identified; comparisons are made between these measurements and the hourly and daily changes in industrial activity and meteorological conditions. These comparisons are the basis for the proposed reasons for the recorded changes in hourly and daily air quality.

Introduction

Urban air pollution concentrations vary from day to day and from hour to hour during the day. In general, high levels of atmospheric pollution are associated with stable, stagnant meteorological conditions, while low levels of pollution are related to more unstable conditions. However, normal local meteorological changes coupled with variations in human activity in a given urban area can lead to substantial periodic patterns in air pollution concentrations.

These patterns must be considered when setting up any air pollution monitoring system. For example, the least biased estimate of the annual mean of the suspended particulate concentrations at Indianapolis, Indiana, can be obtained by sampling on Fridays, as opposed to sampling on any other day of the week (3). Since the City of Anderson has recently begun an air pollution monitoring program, it was appropriate to examine the daily and hourly variations in suspended particulate matter in this urban setting as an assistance in setting up the proper sampling schedule at the outset of the program.

Data and Methods

The usual method of measuring suspended particulates is by drawing a high volume of air through a filter paper in a sampler. The difference in the mass of the filter before and after sampling is used to determine the particulate concentration in micrograms per cubic meter of air. A 24-hour sampling period is normally used.

In this study I looked at hour-by-hour variations in suspended particulate rather than just 24-hour variations; a paper tape sampler was used instead of the high volume sampler. In this instrument air is drawn down a 0.5-inch intake pipe and past a filter tape upon which the particulate matter is deposited. After a set sampling period (1 hour in this study) the tape is automatically advanced and sampling is begun at a clean position on the tape. The dirt spots thus produced are evaluated by measuring the difference in light transmission through

the tape between a clean and sample spot. This optical density (O.D.) is then changed into the standard unit coefficient of haze (COH) according to the formula:

$$\text{COH/1000 feet} = \frac{\text{O.D.} \times 10^5 \times A}{V}$$

where A = area of the dirt spot in square feet $= 0.00136$ ft^2
V = volume of air sampled in cubit feet $= 24$ ft^3

$$\text{O.D.} = \frac{1}{\text{per cent light transmission}}$$

A COH unit of 1 or below represents a clean outdoor condition, while a COH unit of 10 is an extremely dirty condition. Although the high volume sampling method is preferred for legal purposes, recent studies indicate that the paper tape sampler is a very reliable method for determining short time interval variations in studies such as this one (2).

The sampler was placed on the roof of Hartung Hall on the Anderson College campus, which is generally down wind from Anderson industry. Sampling began at noon on August 10, 1973. Except for the down time needed to change the tapes, the sampler ran continuously through noon on September 14, 1973, a period of 5 weeks. A total of 828 sample spots were collected and evaluated during the study. The overall mean COH unit was 0.59, with 1.53 being the highest COH unit measured. Mean values for each day of the week and each hour of the day were calculated, and these data were subjected to an analysis of variance.

Results and Discussion

The general weather pattern during this study was anticyclonic in nature, as expected for this time of year from climatic information (1). Such stable conditions should lead to some of the highest air pollution concentrations of the year. The 0.59 mean COH unit found in this study indicates that Anderson has relatively clean air, especially for an industrial urban community. This substantiates the preliminary findings of the Anderson Air Pollution Control Department (J. Hoenstine, pers. comm., 1973).

Table 1 shows that the average suspended particulate in Anderson is not constant from day to day during the week. An analysis of variance test gave an observed F ratio of 6.77 which is significant at both the 0.01 and the 0.05 levels. A subsequent Newman-Keuls test (Anderson, V. L., and R. A. McLean, unpubl. data) shows that, at the 0.05 level, Sunday and Monday are significantly lower than Thursday, Friday, and Saturday, while Friday is significantly higher than Sunday, Monday, Tuesday, and Wednesday. The data indicate a slight build-up in particulate pollution during the course of the work week with a subsequent decline during the week-end when less industrial activity occurs. The data also show that the least biased sampling days are Tuesday and Wednesday, since they have the mean daily values closest to the reported weekly mean value.

TABLE 1. *Mean daily values of total suspended particulates for each day of the week at Anderson, Indiana, August 10 — September 14, 1973.*

Day	Mean COH Value
Sunday	.50
Monday	.53
Tuesday	.58
Wednesday	.57
Thursday	.63
Friday	.69
Saturday	.63
Weekly $\overline{X}$	.59

Table 2 shows the diurnal variation in the particulate concentration in Anderson. An analysis of variance test on this test gave an observed F ratio of 9.54 which is also significant at both the 0.01 and the 0.05 levels. The Newman-Keuls test in this case confirms that, at the 0.05 level, the particulate concentration during the 6:00 PM to 10:00 AM period is significantly higher than the particulate concentration during remaining hours of the day. Meteorological factors are the prime reason for this pattern, since in Anderson nearly all industrial activity takes place on a round-the-clock basis. During the daylight period the sun's heat increases the convectional mixing in the atmosphere and the winds are relatively strong, leading to a reduction in pollution concentrations at the ground. As the sun goes down, however, the winds diminish and the convectional activity ceases or at least is reduced. The result is an increase in pollution concentrations at the ground during the night time period.

TABLE 2. *Mean hourly values of total suspended particulate for each hour of the day at Anderson, Indiana, August 10 — September 14, 1973.*

Time Interval, E.S.T.	Mean COH Value	Time Interval, E.S.T.	Mean COH Value
0000-0100	.71	1200-1300	.42
0100-0200	.71	1300-1400	.43
0200-0300	.79	1400-1500	.44
0300-0400	.67	1500-1600	.41
0400-0500	.64	1600-1700	.42
0500-0600	.71	1700-1800	.44
0600-0700	.74	1800-1900	.58
0700-0800	.62	1900-2000	.61
0800-0900	.66	2000-2100	.66
0900-1000	.55	2100-2200	.69
1000-1100	.45	2200-2300	.68
1100-1200	.43	2300-2400	.69
Daily $\overline{X}$			

Conclusions

From the measurement of total suspended particulate during the period August-September 14, 1973, I conclude that daily and diurnal variations are significant for Anderson, Indiana. I would expect similar results for other sampling periods during the year except that the exact days of significance might shift from season to season. Therefore, if periodic sampling of air pollutants on fixed days of the week is to be practiced in Anderson, proper procedures must be used or a seriously biased estimate of air quality may result.

Literature Cited

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