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STATISTICAL SUMMARY OF AIR-QUALITY DATA FOR METROPOLITAN CLEVELAND, OHIO, 1967-1972: TOTAL SUSPENDED PARTICULATES, NITROGEN DIOXIDE, AND SULFUR DIOXIDE

by Robert B. King, Harold E. Neustadter, J. Stuart Fordyce, John C. Burr, Jr., and C. Lawrence Cornett

Lewis Research Center
Cleveland, Ohio 44135

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16. Abstract

Air-quality data for metropolitan Cleveland, Ohio, from 1967 through 1972 have been collated and statistically analyzed. Total suspended particulates (TSP), in contrast with previous years, departed from lognormal distribution in 1972. Nitrogen dioxide and sulfur dioxide, although only somewhat lognormal in previous years, also departed significantly from lognormal distributions in 1972. Nowhere in Cleveland were the Ohio standards met. However, all Lewis-operated western suburban stations, except one, met the annual mean standard for TSP, but state-operated suburban stations did not. The data indicate a general improvement in air quality; unusually high precipitation (43 percent above normal in 1972) may have been the major factor in lowering these values from 1971 levels. The mean values of TSP, NO_2, and SO_2 were 104, 191, and 83 $\mu g/m^3$, respectively.

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by Robert B. King, Harold E. Neustadter, J. Stuart Fordyce, John C. Burr, Jr.,* and C. Lawrence Cornett†

Lewis Research Center

SUMMARY

Air-quality data (total suspended particulates (TSP), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)) for the metropolitan Cleveland, Ohio, area for the period 1967 through 1972 have been collated and subjected to statistical analysis. Comparison of 1972 data for the City of Cleveland indicates a departure from the lognormality reported previously for 1969-71 data. The State of Ohio standards were not met anywhere in Cleveland for TSP, NO_2, and SO_2. TSP standards were met at six of seven Lewis-operated western suburban stations but at none of the State of Ohio suburban stations. The data suggest a general improvement in air quality in metropolitan Cleveland: the mean for TSP decreasing from 129 to 104 $\mu g/m^3$; that for NO_2 decreasing from 209 to 191 $\mu g/m^3$; but that for SO_2 increasing from 70 to 83 $\mu g/m^3$. Abnormally high precipitation (43 percent above normal in 1972) may have been the major factor in the lowered numerical values. Polludex, the pollution index based on the two-point air-quality standards, has been calculated as before.

INTRODUCTION

This report is a continuation of the series of reports prepared by the Lewis Research Center (refs. 1 and 2) to present and analyze information regarding concentration

*Formerly with Air Pollution Control Division, Cleveland, Ohio; now with Ohio Environmental Protection Agency, Columbus, Ohio.

†Air Pollution Control Division, Cleveland, Ohio.

levels of total suspended particulates (TSP), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) for Cleveland, Ohio. In previous studies all the data were obtained from the air-quality-monitoring program conducted by the Air Pollution Control Division (APCD) of Cleveland, Ohio. This report also considers TSP data from two additional sources and covers most of Cuyahoga County.

PROCEDURE

Data Sources

The air-sampling program of APCD is currently in its seventh year. Twenty-four-hour samplings have been made of TSP since January 1967, and of NO_2 and SO_2 since January 1968. The sampling methods used are high-volume air sampling for TSP, Jacobs-Hocheiser for NO_2, and West-Gaeke for SO_2. Starting in June 1972 a modification (ref. 3) was made to the West-Gaeke procedure which was fully implemented by October 1972. The APCD sampling sites are denoted by capital letters in figure 1 and described in the accompanying key. The meandering heavy line in the center of the city is the Cuyahoga Rivér, about which is centered most of the region's heavy industry.

In 1972 there were 21 municipal air-monitoring stations. Eighteen of these stations monitor all three pollutants, while the remaining three (stations O, Q, and S in fig. 1) measure TSP only. Seventeen of these sites have been in operation for more than 5 years. Stations B, D, K, and N underwent relocation early in the program. However, because of the proximity of their present sites to their former sites, we have assumed that essentially the same environment has been measured throughout. Currently, the air is sampled nominally every third day, although the sampling frequency has varied over the 6 years and has been as low as once a week. Except for site L, all APCD monitoring sites are located within the City of Cleveland.

In early February of 1972 the suburban schools network, identified by lower-case letters a to g in figure 1, was established. The Environmental Research Office (ERO) of the Lewis Research Center, in cooperation with seven local school districts, initiated the monitoring program to establish the TSP concentration levels of the ambient air entering Cleveland from the west (the predominant wind direction). Six high schools and one elementary school operated the high-volume air samplers placed on their roofs. The samplers were run on the same schedule as APCD and alternated glass fiber and Whatman 41 (W-41) filters.

Filters were weighed by Lewis personnel using the same procedure as APCD (ref. 4), placed in filter-holder cassettes, and delivered to the school sites. After exposure, Lewis personnel collected the filter-holder cassettes, reweighed the filters, and calculated the TSP levels. Both glass and W-41 filter values are averaged together to obtain the reported TSP concentrations. The validity of this procedure has been established in a previous study (ref. 4).

The State of Ohio Environmental Protection Agency (OEPA) operated seven TSP-monitoring stations within Cuyahoga County but outside the city limits. These are identified in figure 1 by the numerals 1 through 7.

Ambient Pollution Levels

The pollution levels measured during 1972 were subjected to the same analysis as in previous years. The statistical analysis of the data included evaluation of the estimated mean and standard geometric deviation; estimation of the expected second-highest pollution level for the year; application of the Kolmogorov-Smirnov statistic for goodness of fit to the lognormal distribution; and evaluation of Polludex, an index of compliance with Ohio standards. A detailed discussion of the assumptions, methods, and limitations of the analysis appeared in an earlier report (ref. 2) and for completeness is repeated herein as an appendix.

Pertinent results are presented in tables I through III for TSP, NO_2, and SO_2, respectively. In each table, the first column gives the designation of the monitoring site corresponding to the code shown in figure 1. The second column lists parameters of interest for each of the pollutants. These parameters are (1) number of readings; (2) geometric (TSP) or arithmetic (SO_2 and NO_2) averages in $\mu g/m^3$; (3) standard geometric deviation; (4) estimated value of the second-highest pollution level for the year in $\mu g/m^3$; (5) an adjusted Kolmogorov-Smirnov goodness-of-fit statistic for lognormality, denoted as $\sqrt{N}\,D$ (see discussion in appendix); and (6) the Polludex value.

Air-quality standards are set nationally by the Environmental Protection Agency (EPA) of the Federal Government (ref. 3) and statewide by OEPA (originally by the Air Pollution Control Board of the Department of Health of the State of Ohio) (ref. 5). Whenever these two standards differ, we have chosen to work with the OEPA (more stringent) standard, which is listed in the third column. In the remaining five columns are the various statistics for each of the years 1967 through 1972.

DISCUSSION

The data for 1971 and 1972 can be compared from tables I through III. It should be noted that the sets of days for which values are available differ slightly from station to station. The geometric mean for TSP averaged over the entire APCD network decreased from 129 $\mu g/m^3$ for 1971 to 104 $\mu g/m^3$ for 1972; the arithmetic mean for NO_2 decreased from 209 $\mu g/m^3$ for 1971 to 191 $\mu g/m^3$ for 1972; but the arithmetic mean for SO_2 increased from 70 $\mu g/m^3$ for 1971 to 83 $\mu g/m^3$ for 1972. The decreases in the annual geometric mean for TSP from the 1971 level to the 1972 level at the various stations range from 46.7 percent to 4 1 percent, with an average decrease of 18.6 percent. In a similar manner the decrease of NO_2 mean concentrations ranged from 26 percent to 0.5 percent, with an average decrease of 20 percent. Because of the change in the analytical procedure for SO_2 during 1972, and noted in the section Data Sources, the average increase of 10 percent for mean SO_2 concentrations over the 1971 values probably is open to question, particularly since the downward trend in previous years seemed well established.

The decrease in NO_2, a pollutant for which control efforts have been minimal to date, might be attributed to the difference in the amount of precipitation encountered in these two years. While precipitation in 1971 was 6.5 percent below normal, in 1972 it was 42 percent above normal (ref. 6). If source conditions had remained the same in 1972 as in 1971, decreases due to precipitation, roughly paralleling the NO_2 decrease, should have been noted in TSP and SO_2. The TSP data show this influence. Since confidence in the SO_2 data is questionable, it is unsafe to draw any conclusions from the increases noted, although increased economic activity in 1972 may be responsible. In the presence of such drastic changes in meteorlogical conditions, trend comparisons from year to year are hazardous unless some method of meteorological normalization is introduced.

Nowhere in the City of Cleveland have the air-quality standards been attained. However, all stations in the Lewis-operated western suburban network, except one, had annual arithmetic means for TSP that were less than the state requirements, but none of the state-operated suburban stations had satisfactory means. It is, perhaps, not unexpected that the Lewis-operated western suburban stations should find lower TSP values since they are not downwind of any major pollution sources and are located in predominantly residential or rural areas. The state-operated suburban stations appear to be on busy thoroughfares and/or downwind of moderate pollution sources such as greenhouses and large expanses of residential housing. (In this regard, note the higher TSP value at APCD station K than at suburban school station c. Station e is about $1\frac{1}{2}$ miles west of station K but most importantly is predominantly upwind of a major highway, while K is predominant downwind of the same highway.)

Table IV compares the goodness-of-fit statistic data from tables I through III displayed as the percentage of stations with distributions consistent with a lognormal description. Contrary to general expectations (ref. 7), the gases (NO_2 and SO_2) show only slightly less lognormality than does TSP. The strong contrast between the Lewis- and state-operated suburban stations is notable. However, two monitoring sites, one from each network (c and 1), located about 1/2 mile apart, measured different TSP values (50 compared with 81) but had similar standard geometric deviations (1.7 compared with 1.6) and goodness-of-fit statistics (0.63 compared with 0.62). Site c is in a residential environment, which may act as a single broad area source. On the other hand, site 1 is affected by its proximity to a high-traffic-density state highway.

The adequacy of a lognormal description for the distribution of the 1972 data for the APCD network decreases quite significantly from that of 1971 and previous years (table IV). The Lewis-operated suburban network data appear similar. The drastic reduction in the percentage of stations fitting a lognormal distribution from 90 percent in 1971 to only 29 percent in 1972 for TSP and from 60 percent in 1971 to only 28 percent in 1972 for NO_2 may possibly be attributed to the extensive rainfall throughout much of 1972. The reduction in the percentage of stations fitting a lognormal distribution for SO_2 from 47 percent in 1971 tc 33 percent in 1972 may be caused by either the unusual amount of precipitation, the continued trend away from lognormality started in 1969, or the change in the analytical method.

The question of the adequacy of a lognormal representation is a difficult one to assess. Lognormal distributions arise from incremental changes that are proportional to the previous value (e.g., a +10 percent or a -20 percent change). At first sight, precipitation could be expected to remove a fraction of the particles or gases from the air. Gases would be removed relative to their affinity for water; but TSP most likely would be removed as a function of particle size, impaction being the more probable mode of removal for the larger particles. It would be expected that for TSP sufficiently far downwind of its source for the steady-state establishment of a "self-preserving aerosol distribution" (ref. 8), precipitation would remove a proportional amount. Thus, lognormality of the limited set of which the measured values are a subset would be generated or maintained. The fact that tnis is not true in the 1972 APCD data set leads to the conclusion (1) that the self-preserving aerosol size distribution is not operative; (2) that the precipitation did not remove proportionate amounts because of different removal mechanisms or varying affinities for water; or (3) that other factors were involved that are not precisely known (e.g., the aerosol may be the combination of two or more aerosols with lognormal distributions whose resultant integrated distribution is not necessarily lognormal).

Polludex values for the years 1967 through 1972 are shown in figures 2 to 4. Comparison of these values for 1971 and 1972 shows that for TSP the average for 19 stations was 38 points lower in 1972 than in 1971. The values ranged from one increase (dirtier) of 19 points at station I (the dirtiest station in the city) to a maximum decrease of 170 at station N. In a similar manner, NO_2 Polludex values averaged a decrease of 27 points; the lowest value occurred at station A (which also had a low value for TSP) and four stations had considerably greater decreases than the average. However, SO_2 showed increased values except at two stations. These increases, though questionable because of the change in analytical methodology mentioned previously, may be due to increased economic activity and increased SO_2 production in winter when little precipitation is available for removal. Three stations (C, J, and L) show fair agreement between decreases in NO_2 and TSP. These stations are in somewhat similar environments (mixed residential-industrial). No agreement between SO_2 and either TSP or NO_2 is apparent.

As shown in the appendix, the Polludex value depends upon the determination of the second-highest value x_{2nd}. Larsen (ref. 9) indicates a graphical and analytical technique for determination of x_{2nd} based upon the assumption of lognormality; Neustadter and Sidik (ref. 2) have used a similar analytical method. They have also considered (ref. 10) the errors inherent in this formulation and found that, for a data set of 90 samples, the 95 percent confidence interval for x_{2nd} is ±44 percent, provided the assumption of lognormality is valid.

Larsen (ref. 9) emphasizes that caution must be used with nonlognormally distributed data such as those shown in this report for Cleveland for 1972. In view of this further potential for error arising from nonlognormality, an attempt was made to graphically extrapolate to x_{2nd} for some 90 data points from the plot of the logarithms of the concentrations against the frequency of occurrence. The method failed in some cases because of the arbitrariness involved in projecting the plot beyond the actual data. In other cases, where the plot was reasonably linear for values larger than the median (50 percent), the graphically determined x_{2nd} values were about 11 percent lower than those calculated for TSP and about 25 percent lower than those calculated for SO_2. These deviations are well within the expected error limits for lognormally distributed data. (NO_2 was not compared since x_{2nd} values are not used for NO_2 Polludex determinations as the standards refer only to the mean.)

CONCLUSIONS

Air-quality data for the year 1972 for metropolitan Cleveland have been presented and reviewed in terms of previous data and environmental conditions. Averaged over the entire city, the mean values for total suspended particulates (TSP), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) were 104, 191, and 83 $\mu g/m^3$, respectively. Mean values of TSP and NO_2 were lower in 1972 than in 1971, probably because of the unusually high levels of precipitation in 1972. Higher levels of SO_2 were measured in 1972 than in 1971, probably because of the change in analytical methods made during 1972 coupled with increased economic activity. Only TSP levels were measured in the suburbs. The high TSP values found in the state-operated suburban network are probably due to local commercial or traffic sources. The Lewis-operated suburban network, in a predominantly residential environment, exhibited the only TSP levels that met the

State of Ohio mean standard. Finally, it was noted that the 1972 data could be less adequately described by a lognormal distribution than those of previous years. Polludex values for TSP, NO_2, and SO_2 generally decreased.

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APPENDIX - ASSUMPTIONS, METHODS, AND LIMITATIONS OF AIR-QUALITY ANALYSIS

Number of Readings

For each pollutant, both the Federal (EPA) and State of Ohio (OEPA) environmental protection agencies require a minimum of one sampling every sixth day, or an equivalent set of at least 61 random samples per year. Thus, we designate this standard as >60 in the tables Even though early in the program some stations did not take 60 samples per year for each pollutant, we include the analyses of these data sets. The nominal schedule of the Cleveland Air Pollution Control Division (APCD) calls for monitoring the environmental air every third day. This procedure generally allows sufficient margin for unanticipated disruptions (e.g., equipment failure) while still exceeding 60 readings per year.

Geometric and Arithmetic Averages

The geometric average is used in table I and the arithmetic average is used in tables II and III. This corresponds to the particular averaging method stipulated by EPA and OEPA standards. Calculations were performed whenever the number of readings exceeded 10. The values listed as standards are the OEPA primary standards, which correspond to the EPA secondary standards.

Standard Geometric Deviation

It has been noted that, irrespective of sampling duration or location, air-sampling data are generally distributed lognormally (ref. 7). When such is actually the case, the entire data set is sufficiently described by its geometric average and its standard geometric deviation (SGD). The higher the SGD, the greater is the spread between the lower and higher values. As with the averages, SGD was calculated for data sets of more than 10 readings.

Second-Highest Value

Both EPA and OEPA standards for TSP and SO_2 specify that a certain level of pollution is ". . . not to be exceeded more than one time per year." This implies that for the 365 daily pollution levels per year (366 for leap years), there is no upper bound on the highest single value. However, the next largest value (i.e., the second-most-polluted day of the year) is required to be at or below the standard. Thus, tables I through III include estimates of the second-highest pollution level for each year. As with the averages, the standards listed there are the OEPA primary standards, which correspond to EPA secondary standards. While there is a standard for only the annual average of NO_2, we believe the estimated second-highest value for a year is useful information, and we have included it in table I.

An approximation to the second-highest pollution level estimate, for a year of n days and a sample of N observations is obtained by the following procedure: The logarithms of the data values are computed because we need to use the expected values of normal order statistics; these are well developed in the literature. Comparable development for lognormal distributions exists only for very small sample sizes (ref. 11). The logarithms $y_i = \ln (x_i)$ of the pollution levels x_i are computed. According to the assumption of lognormality, these y_i values follow a normal distribution. The sample mean $\bar{y}$ and the sample standard deviation s_y of the set of logarithms are computed. From reference 8, the expected value of the second-highest observation in a sample of 365 (366 in a leap year) independent values from a normal distribution is 2.63 (to three significant digits) standard deviations from the mean. This value, along with the average $\bar{y}$ and the standard deviation s_y of the set of logarithms, is used in the following equation to obtain the estimate of the second-highest pollution level of the year:

$$y_{2nd} = \bar{y} + 2.63\, s_y \tag{1}$$

The values of x_{2nd} listed in tables I through III are obtained by exponentiation, as

$$x_{2nd} = \exp (y_{2nd}) \tag{2}$$

Because of the decreased precision which occurs when extrapolating to the tail of a distribution and because the sample mean and standard deviation are used, the minimum number of readings for this calculation was increased to 30, as opposed to 10 readings used for the averages. Implicit in using equation (1) is the assumption of lognormality of the data: the Kolmogorov-Smirnov statistic discussed in the next section leads us to the final entry in these tables. A more comprehensive discussion of the limitations and variability of this approach has been presented elsewhere (ref. 10).

Kolmogorov-Smirnov Statistic

The Kolmogorov-Smirnov statistic is a goodness-of-fit statistic which can be applied to any distribution (ref. 12). In testing for a lognormal distribution, it is easier for calculation purposes to take the logarithms of the values and test for goodness of fit to a normal distribution. This statistic was originally intended for use when the distribution which the data are suspected of following is completely specified. For the normal distribution, this is equivalent to knowing the mean μ and the standard deviation σ. In this case, the Kolmogorov-Smirnov statistic is denoted as D and is calculated as

$$D = \max_{i=1,N} \left| \Phi\left(\frac{y_i - \mu}{\sigma}\right) - \left(\frac{i}{N}\right) \right| \tag{3}$$

where the function $\Phi(z)$ denotes the cumulative standard normal distribution function.

The statistic D measures the maximum deviation of the observed cumulative distribution function from the theoretical cumulative distribution function. Thus, D is always a value between 0 and 1. A value of 0 would indicate a perfect fit of the sampled data to a lognormal distribution; larger values indicate an increasing deviation from lognormality.

When the mean and the standard deviation are unknown, it is common to use the estimates $\bar{y}$ and $s_y = \left[\sum_i (y_i - \bar{y})^2 / (N - 1)\right]^{1/2}$ in place of μ and σ, respectively. Lilliefors has studied the use of the Kolmogorov-Smirnov statistic in this situation (ref. 13). Table V presents the significance levels of $\sqrt{N}D$ from reference 13 for samples of $N > 30$. Thus, the goodness-of-fit statistics in tables I through [illegible] are presented as $\sqrt{N}D$.

It should be recognized that the observed pollution levels are but a sample of levels from some distribution. Thus, even if the distribution of the complete set of pollution levels is indeed lognormal, some of the samples will lead to large values of $\sqrt{N}D$. The interpretation of the tabulated significance levels α is that if the distribution is indeed lognormal, about 100α percent of the samples tested will lead to a value of $\sqrt{N}D$ which exceeds $(\sqrt{N}D)_\alpha$, whereas about $100(1 - \alpha)$ percent will lead to a value of $\sqrt{N}D$ lower than $(\sqrt{N}D)_\alpha$. Because calculations in this report depend heavily on the assumption of lognormality, the value of $\alpha = 0.20$ was chosen. Choosing this large value for α has the drawback of rejecting the assumption of lognormality a substantial proportion of the times (20 percent) that the distribution is lognormal. However, it has the compensating advantage of being more discriminating against distributions which are not lognormal.

Polludex, An Air-Pollution Index

Many indices have been proposed, and a number are in use by various agencies (ref. 14). Polludex is a variation of an index proposed by Pikul (ref. 15). The rationale for constructing this modified index is as follows: The standards for TSP and SO_2 specify values for the annual mean which may not be exceeded and also values which may not be exceeded more than once per year. In relation to a lognormal plot of the underlying population, these standard values specify the coordinates of two points on a straight line. If the data obtained during a 1-year period conform to lognormality and conform to the required standards, the plot of the data will closely approximate a straight line falling entirely below (or on) the line segment joining the standard points.

For each of the three pollutants, define

$$r = \frac{\text{Sample average}}{\text{Standard for average}}$$

$$s = \frac{\text{Estimate of second-highest value}}{\text{Standard not to be exceeded more than once yearly}}$$

Then the Polludex value, P (pollutant), is defined for TSP and SO_2 by

$$P(TSP, SO_2) = 50 \times \left[\max(0, r - 1) + \max(0, s - 1)\right]$$

and for NO_2 by

$$P(NO_2) = 100 \times \left[\max(0, r - 1)\right]$$

where max(a, b) means that the larger of the two values, a or b, is to be used. The geometric average is to be used in calculating r for TSP, and the arithmetic average is to be used in calculating r for SO_2 and NO_2. For the estimate of the second-highest value to be used for s, we used the approximate value listed in table I for TSP and in table III for SO_2.

With this definition, the same weight is given to the long-term (chronic) effects of pollution as is given to the severe short-term (acute) incident. The standards for these pollutants have presumably been set with regard to maximum acceptable levels for reasons of public health and/or welfare. Thus, we assume that normalization of the estimated mean and second-highest values by the standards will, in a sense, put each P on an equal basis with respect to the potential harm caused by excesses. If the air quality is equal to or better than the standards, P = 0. A Polludex value of 100 (P = 100) can be understood to mean that the air is, in a sense, 100 percent polluted, in that a value of 100 is obtained when the average and the second-highest values are each 100 percent higher than their respective permissible levels. Of course, a Polludex value of 100 would also result from a continuum of other combinations, as, for example, when the second-highest value is three times its standard, provided the average is at or below its standard. Figure 5 graphically illustrates several of these possibilities. Figure 5(a) shows three possible examples which have $P = 0$. Figure 5(b) shows a line having $P = 100$ where both the mean and second-highest standards are exceeded. Figure 5(c) shows a line where again $P = 100$ but where the standard for the mean has been met. Finally, figure 5(d) shows a line with $P = 50$ where the standard for the mean is not met but the second-highest-value standard is.

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TABLE I. - DATA SUMMARY FOR TOTAL SUSPENDED PARTICULATES, 1967-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1967	1968	1969	1970	1971	1972
A	Number of readings	≥ 60	19	70	73	76	69	75
	Geometric average	60	190	242	199	188	183	170
	Standard geometric deviation	----	1.4	1.7	1.6	1.6	1.7	1.7
	Estimated second-highest level	150	----	919	[a]711	[a]682	730	[a]726
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	0.53	0.84	0.81	0.73	0.96
	Polludex value	0	----	408	303	284	296	284
B	Number of readings	≥ 60	36	64	66	[b]72	63	87
	Geometric average	60	112	104	94	113	92	86
	Standard geometric deviation	----	1.5	1.6	1.4	1.6	1.6	1.6
	Estimated second-highest level	150	351	349	226	370	319	[a]286
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.76	0.72	0.63	0.48	0.53	0.77
	Polludex value	0	111	103	54	117	82	67
C	Number of readings	60	64	79	72	97	89	93
	Geometric average	60	124	121	107	124	121	95
	Standard geometric deviation	----	1.5	1.6	1.6	1.6	1.7	1.6
	Estimated second-highest level	150	343	[a]429	346	420	502	[a]350
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.55	0.76	0.50	0.39	0.65	0.98
	Polludex value	0	117	144	105	144	167	96
D	Number of readings	≥ 60	44	72	74	[b]62	[c]30	82
	Geometric average	60	134	126	123	154	163	87
	Standard geometric deviation	----	1.5	1.5	1.5	1.6	1.8	1.6
	Estimated second-highest level	150	371	390	378	487	----	[a]305
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.37	0.42	0.50	0.40	----	1.13
	Polludex value	0	135	135	129	191	(c)	74
E	Number of readings	≥ 60	61	75	75	93	80	90
	Geometric average	60	139	147	119	136	120	94
	Standard geometric deviation	----	1.4	1.5	1.4	1.5	1.5	1.6
	Estimated second-highest level	150	352	[a]410	276	[a]395	[a]328	[a]319
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.59	0.83	0.61	0.80	0.80	1.05
	Polludex value	0	133	159	91	145	109	85

[a]Calculation used to obtain the estimate assumed lognormality despite $\sqrt{N}D > 0.736$.

[b]Sampling site was relocated within same general neighborhood in midyear. It is assumed that for sampling purposes the environmental air was the same at both locations.

[c]Temporarily discontinued because of construction at sampling site.

TABLE I. - Continued. DATA SUMMARY FOR TOTAL SUSPENDED PARTICULATES, 1967-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1967	1968	1969	1970	1971	1972
F	Number of readings	≥ 60	64	75	75	82	74	78
	Geometric average	60	101	103	88	109	105	85
	Standard geometric deviation	----	1.5	1.6	1.6	1.5	1.5	1.6
	Estimated second-highest level	150	[a]303	357	297	[a]307	304	[a]291
	Goodness-of-fit statistic, $\sqrt{N}D$	----	1.0	0.67	0.64	0.87	0.72	1.07
	Polludex value	0	85	104	72	93	89	68
G	Number of readings	≥ 60	8	75	73	103	83	83
	Geometric average	60	----	99	82	94	91	80
	Standard geometric deviation	----	----	1.6	1.6	1.7	1.6	1.6
	Estimated second-highest level	150	----	317	[a]292	358	337	[a]264
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	0.56	0.79	0.59	0.57	0.99
	Polludex value	0	----	89	66	98	89	55
H	Number of readings	≥ 60	----	65	68	96	70	88
	Geometric average	60	----	83	84	94	89	75
	Standard geometric deviation	----	----	1.6	1.6	1.7	1.7	1.7
	Estimated second-highest level	150	----	280	299	384	352	294
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	0.53	0.59	0.48	0.68	0.46
	Polludex value	0	----	62	70	106	91	61
I	Number of readings	≥ 60	55	75	75	101	93	83
	Geometric average	60	210	232	223	225	196	188
	Standard geometric deviation	----	1.4	1.5	1.5	1.5	1.6	1.7
	Estimated second-highest level	150	[a]543	694	[a]639	701	[a]658	[a]735
	Goodness-of-fit statistic, $\sqrt{N}D$	----	1.08	0.60	0.97	0.51	0.83	1.19
	Polludex value	0	256	324	299	321	283	302
J	Number of readings	≥ 60	63	76	74	103	90	77
	Geometric average	60	174	161	151	156	163	131
	Standard geometric deviation	----	1.5	1.6	1.7	1.6	1.7	1.6
	Estimated second-highest level	150	474	[a]538	[a]613	[a]530	645	[a]450
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.62	0.78	0.76	0.98	0.73	0.91
	Polludex value	0	203	213	230	207	250	159

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D > 0.736$.

TABLE I. - Continued. DATA SUMMARY FOR TOTAL SUSPENDED PARTICULATES, 1967-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1967	1968	1969	1970	1971	1972
K	Number of readings	> 60	75	80	75	[b]87	78	73
	Geometric average	60	85	81	73	88	92	67
	Standard geometric deviation	----	1.5	1.6	1.6	1.5	1.6	1.6
	Estimated second-highest level	150	[a]254	[a]273	246	257	312	[a]246
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.96	0.92	0.68	0.68	0.52	0.93
	Polludex value	0	55	59	43	59	81	38
L	Number of readings	> 60	----	----	----	37	73	82
	Geometric average	60	----	----	----	170	212	153
	Standard geometric deviation	----	----	----	----	1.5	1.6	1.7
	Estimated second-highest level	150	----	----	----	525	637	[a]245
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	0.49	0.64	1.22
	Polludex value	0	----	----	----	222	280	245
M	Number of readings	> 60	60	72	74	89	72	76
	Geometric average	60	86	82	75	86	82	69
	Standard geometric deviation	----	1.5	1.6	1.5	1.6	1.6	1.6
	Estimated second-highest level	150	266	281	222	294	284	228
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.48	0.64	0.60	0.62	0.59	0.57
	Polludex value	0	61	62	37	70	63	34
N	Number of readings	> 60	48	75	73	[b]75	86	62
	Geometric average	60	129	158	142	134	138	109
	Standard geometric deviation	----	1.8	1.8	1.9	2.4	2.0	1.7
	Estimated second-highest level	150	592	784	747	[a]1273	905	465
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.60	0.57	0.67	0.99	0.71	0.55
	Polludex value	0	205	293	268	463	316	146
O	Number of readings	> 60	69	75	72	90	76	56
	Geometric average	60	92	86	79	89	90	75
	Standard geometric deviation	----	1.5	1.6	1.6	1.7	1.8	1.8
	Estimated second-highest level	150	265	298	[a]270	333	422	332
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.62	0.39	0.83	0.71	0.55	0.74
	Polludex value	0	65	71	56	85	116	73
P	Number of readings	> 60	62	74	72	93	74	84
	Geometric average	60	135	130	127	137	140	114
	Standard geometric deviation	----	1.4	1.5	1.6	1.5	1.4	1.7
	Estimated second-highest level	150	343	390	407	412	371	[a]426
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.71	0.40	0.64	0.55	0.60	1.17
	Polludex value	0	127	146	142	151	145	137

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D \geq 0.736$.

[b]Sampling site was relocated within same general neighborhood in midyear. It is assumed that for sampling purposes the environmental air was the same at both locations.

TABLE I. - Continued. DATA SUMMARY FOR TOTAL SUSPENDED PARTICULATES, 1967-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1967	1968	1969	1970	1971	1972
Q	Number of readings	60	63	69	70	88	79	76
	Geometric average	60	105	95	96	100	101	87
	Standard geometric deviation	----	1.5	1.5	1.4	1.8	1.4	1.5
	Estimated second-highest level	150	310	277	241	[a]495	256	[a]272
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.62	0.42	0.67	0.97	0.65	1.01
	Polludex value	0	91	71	60	153	69	63
R	Number of readings	60	57	72	65	90	66	72
	Geometric average	60	81	80	81	89	89	77
	Standard geometric deviation	----	1.6	1.7	1.6	1.6	1.7	1.7
	Estimated second-highest level	150	265	304	285	309	384	294
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.44	0.69	0.52	0.49	0.60	0.59
	Polludex value	0	56	68	62	77	102	62
S	Number of readings	60	----	----	----	----	51	61
	Geometric average	60	----	----	----	----	92	67
	Standard geometric deviation	----	----	----	----	----	1.5	1.8
	Estimated second-highest level	150	----	----	----	----	290	[a]304
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	0.71	1.10
	Polludex value	0	----	----	----	----	73	57
T	Number of readings	60	----	----	----	----	41	75
	Geometric average	60	----	----	----	----	170	134
	Standard geometric deviation	----	----	----	----	----	2.0	1.9
	Estimated second-highest level	150	----	----	----	----	1014	692
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	0.48	0.69
	Polludex value	0	----	----	----	----	380	242
U	Number of readings	60	----	----	----	----	[d]26	64
	Geometric average	60	----	----	----	----	162	141
	Standard geometric deviation	----	----	----	----	----	1.5	1.9
	Estimated second-highest level	150	----	----	----	----	----	[a]735
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	1.28
	Polludex value	0	----	----	----	----	----	262
a	Number of readings	60	----	----	----	----	----	45
	Geometric average	60	----	----	----	----	----	63
	Standard geometric deviation	----	----	----	----	----	----	1.7
	Estimated second-highest level	150	----	----	----	----	----	260
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.74
	Polludex value	0	----	----	----	----	----	39

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D \geq 0.736$.
[d]Sampling was initiated in the latter part of the year.

TABLE I. - Continued. DATA SUMMARY FOR TOTAL SUSPENDED PARTICULATES, 1967-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1967	1968	1969	1970	1971	1972
b	Number of readings	60	----	----	----	----	----	48
	Geometric average	60	----	----	----	----	----	54
	Standard geometric deviation	----	----	----	----	----	----	1.6
	Estimated second-highest level	150	----	----	----	----	----	[a]193
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.84
	Polludex value	0	----	----	----	----	----	14
c	Number of readings	60	----	----	----	----	----	32
	Geometric average	60	----	----	----	----	----	50
	Standard geometric deviation	----	----	----	----	----	----	1.7
	Estimated second-highest level	150	----	----	----	----	----	192
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.63
	Polludex value	0	----	----	----	----	----	2
d	Number of readings	60	----	----	----	----	----	54
	Geometric average	60	----	----	----	----	----	56
	Standard geometric deviation	----	----	----	----	----	----	16
	Estimated second-highest level	150	----	----	----	----	----	185
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.53
	Polludex value	0	----	----	----	----	----	12
e	Number of readings	60	----	----	----	----	----	61
	Geometric average	60	----	----	----	----	----	55
	Standard geometric deviation	----	----	----	----	----	----	1.7
	Estimated second-highest level	150	----	----	----	----	----	235
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.80
	Polludex value	0	----	----	----	----	----	28
f	Number of readings	60	----	----	----	----	----	37
	Geometric average	60	----	----	----	----	----	48
	Standard geometric deviation	----	----	----	----	----	----	1.8
	Estimated second-highest level	150	----	----	----	----	----	239
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.99
	Polludex value	0	----	----	----	----	----	30
g	Number of readings	60	----	----	----	----	----	56
	Geometric average	60	----	----	----	----	----	54
	Standard geometric deviation	----	----	----	----	----	----	1.8
	Estimated second-highest level	150	----	----	----	----	----	238
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.99
	Polludex value	0	----	----	----	----	----	29

[a]Calculation used to obtain the estimate assumed lognormality despite $\sqrt{N}D \geq 0.736$.

TABLE I. - Concluded. DATA SUMMARY FOR TOTAL SUSPENDED PARTICULATES, 1967-72

All concentrations are in micrograms per cubic meter.

Monitoring station (see fig. 1)	Statistic	Standard	1967	1968	1969	1970	1971	1972
1	Number of readings	$\geq$ 60	----	----	----	----	----	61
	Geometric average	60	----	----	----	----	----	81
	Standard geometric deviation	----	----	----	----	----	----	1.6
	Estimated second-highest level	150	----	----	----	----	----	277
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.62
	Polludex value	0	----	----	----	----	----	60
2	Number of readings	$\geq$ 30	----	----	----	----	----	48
	Geometric average	60	----	----	----	----	----	98
	Standard geometric deviation	----	----	----	----	----	----	1.7
	Estimated second-highest level	150	----	----	----	----	----	393
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.43
	Polludex value	0	----	----	----	----	----	113
3	Number of readings	$\geq$ 60	----	----	----	----	----	59
	Geometric average	60	----	----	----	----	----	96
	Standard geometric deviation	----	----	----	----	----	----	1.5
	Estimated second-highest level	150	----	----	----	----	----	298
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.64
	Polludex value	0	----	----	----	----	----	79
4	Number of readings	$\geq$ 60	----	----	----	----	----	58
	Geometric average	60	----	----	----	----	----	79
	Standard geometric deviation	----	----	----	----	----	----	1.9
	Estimated second-highest level	150	----	----	----	----	----	441
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.74
	Polludex value	0	----	----	----	----	----	113
5	Number of readings	$\geq$ 60	----	----	----	----	----	56
	Geometric average	60	----	----	----	----	----	159
	Standard geometric deviation	----	----	----	----	----	----	1.6
	Estimated second-highest level	150	----	----	----	----	----	533
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.68
	Polludex value	0	----	----	----	----	----	210
6	Number of readings	$\geq$ 60	----	----	----	----	----	60
	Geometric average	60	----	----	----	----	----	86
	Standard geometric deviation	----	----	----	----	----	----	1.4
	Estimated second-highest level	150	----	----	----	----	----	206
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.62
	Polludex value	0	----	----	----	----	----	40
7	Number of readings	$\geq$ 60	----	----	----	----	----	61
	Geometric average	60	----	----	----	----	----	80
	Standard geometric deviation	----	----	----	----	----	----	1.5
	Estimated second-highest level	150	----	----	----	----	----	239
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	----	0.58
	Polludex value	0	----	----	----	----	----	51

TABLE II. - DATA SUMMARY FOR NITROGEN DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
A	Number of readings	60	71	73	84	86	82
	Arithmetic average	100	211	220	214	202	203
	Standard geometric deviation	----	1.4	1.4	1.4	1.5	1.6
	Estimated second-highest level	----	517	470	464	538	600
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.60	0.57	0.61	0.59	1.04
	Polludex value	0	111	120	114	102	103
B	Number of readings	60	----	----	9	81	87
	Arithmetic average	100	----	----	----	190	170
	Standard geometric deviation	----	----	----	----	1.5	1.4
	Estimated second-highest level	----	----	----	----	[a]539	418
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	0.77	0.97
	Polludex value	0	----	----	----	90	70
C	Number of readings	60	76	75	115	96	93
	Arithmetic average	100	177	248	234	255	192
	Standard geometric deviation	----	1.5	1.3	1.4	1.6	1.4
	Estimated second-highest level	----	[a]495	[a]454	[a]576	835	469
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.87	0.88	0.88	0.64	0.38
	Polludex value	0	77	148	134	155	92
D	Number of readings	60	55	70	[b]83	[c]47	78
	Arithmetic average	100	207	219	217	199	163
	Standard geometric deviation	----	2.0	1.3	1.5	1.4	1.8
	Estimated second-highest level	----	[a]1056	424	[a]576	465	654
	Goodness-of-fit statistic, $\sqrt{N}D$	----	1.65	0.70	1.03	0.62	0.99
	Polludex value	0	107	119	117	99	63
E	Number of readings	60	69	74	108	96	89
	Arithmetic average	100	203	237	217	205	188
	Standard geometric deviation	----	1.4	1.3	1.4	1.6	1.6
	Estimated second-highest level	----	497	[a]437	[a]504	[a]686	552
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.70	0.90	1.39	1.69	0.74
	Polludex value	0	103	137	117	105	88

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D > 0.736$.

[b]Sampling site was relocated within same general neighborhood in midyear. It is assumed that for sampling purposes the environmental air was the same at both locations.

[c]Temporarily discontinued because of construction at sampling site.

TABLE II - Continued. DATA SUMMARY FOR NITROGEN DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
F	Number of readings	60	47	74	96	86	87
	Arithmetic average	100	212	197	215	203	197
	Standard geometric deviation	----	1.4	1.3	1.3	1.5	1.6
	Estimated second-highest level	----	[a]511	[a]370	444	[a]518	577
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.78	0.76	0.70	0.93	1.18
	Polludex value	0	112	97	115	103	97
G	Number of readings	60	72	72	104	89	88
	Arithmetic average	100	201	221	224	203	196
	Standard geometric deviation	----	1.5	1.3	1.3	1.5	1.9
	Estimated second-highest level	----	571	[a]432	453	516	884
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.56	0.91	0.43	0.65	1.26
	Polludex value	0	101	121	125	103	96
H	Number of readings	60	66	71	114	78	84
	Arithmetic average	100	166	225	213	202	191
	Standard geometric deviation	----	1.5	1.3	1.4	1.6	1.5
	Estimated second-highest level	----	[a]471	[a]443	464	[a]633	536
	Goodness-of-fit statistic, $\sqrt{N}D$	----	1.03	0.75	0.70	1.1	0.97
	Polludex value	0	66	125	113	102	91
I	Number of readings	60	67	76	111	88	88
	Arithmetic average	100	247	253	238	217	214
	Standard geometric deviation	----	1.4	1.3	1.3	1.5	1.4
	Estimated second-highest level	----	535	495	[a]495	[a]615	513
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.45	0.71	1.1	0.93	0.76
	Polludex value	0	147	153	137	117	114
J	Number of readings	60	----	52	113	93	82
	Arithmetic average	100	----	225	255	240	214
	Standard geometric deviation	----	----	1.4	1.4	1.5	1.5
	Estimated second-highest level	----	----	488	[a]548	600	538
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	0.65	0.82	0.58	0.71
	Polludex value	0	----	125	155	140	114

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D > 0.736$.

TABLE II. - Continued. DATA SUMMARY FOR NITROGEN DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
K	Number of readings	60	74	74	[b]104	88	86
	Arithmetic average	100	162	192	209	183	178
	Standard geometric deviation	----	1.5	1.4	1.4	1.6	1.5
	Estimated second-highest level	----	433	417	[a]486	565	475
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.53	0.67	0.76	0.67	0.81
	Polludex value	0	62	92	109	83	78
L	Number of readings	60	----	----	41	80	59
	Arithmetic average	100	----	----	220	219	173
	Standard geometric deviation	----	----	----	1.4	1.5	2.1
	Estimated second-highest level	----	----	----	513	572	964
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	0.68	0.71	1.47
	Polludex value	0	----	----	120	119	73
M	Number of readings	60	55	74	96	73	86
	Arithmetic average	100	157	168	176	159	151
	Standard geometric deviation	----	1.4	1.3	1.3	1.6	1.4
	Estimated second-highest level	----	[a]342	335	341	507	374
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.80	0.60	0.65	0.54	0.79
	Polludex value	0	57	68	76	59	51
N	Number of readings	60	----	----	39	88	87
	Arithmetic average	100	----	----	208	223	201
	Standard geometric deviation	----	----	----	1.6	1.6	1.6
	Estimated second-highest level	----	----	----	647	[a]712	645
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	0.65	0.95	0.84
	Polludex value	0	----	----	108	122	101
P	Number of readings	60	----	----	----	----	73
	Arithmetic average	100	----	----	----	----	226
	Standard geometric deviation	----	----	----	----	----	1.5
	Estimated second-highest level	----	----	----	----	----	630
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	0.72
	Polludex value	0	----	----	----	----	126

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D > 0.736$.

[b]Sampling site was relocated within same general neighborhood in midyear. It is assumed that for sampling purposes the environmental air was the same at both locations.

TABLE II. - Concluded. DATA SUMMARY FOR NITROGEN DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
R	Number of readings	60	----	----	----	-----	84
	Arithmetic average	100	---	-	----	-----	178
	Standard geometric deviation	----	---		----	-----	1.6
	Estimated second-highest level	----	----		----	-----	547
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----		----	-----	0.96
	Polludex value	0	----	----	----	-----	78
T	Number of readings	60	----	----	----	-----	70
	Arithmetic average	100	----	----	----	-----	183
	Standard geometric deviation	----	----	----	----	-----	1.9
	Estimated second-highest level	----	----	----	----	-----	849
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	-----	1.38
	Polludex value	0	----	----	----	-----	83
U	Number of readings	60	----	----	----	[d]36	83
	Arithmetic average	100	----	----	----	230	223
	Standard geometric deviation	----	----	----	----	1.9	704
	Estimated second-highest level	----	----	----	----	[a]1030	704
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	-- -	1.34	0.47
	Polludex value	0	----	----	----	129	123

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D$ · 0.736.
[d]Sampling was initiated in the latter part of the year.

TABLE III. - DATA SUMMARY FOR SULFUR DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
A	Number of readings	60	71	74	2	88	80
	Arithmetic average	60	137	135	116	84	89
	Standard geometric deviation	----	2.4	2.0	1.9	2.2	2.6
	Estimated second-highest level	260	[a]972	[a]674	[a]518	523	753
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.75	0.96	0.88	0.66	1.13
	Polludex value	0	201	142	97	70	119
B	Number of readings	60	----	----	9	86	87
	Arithmetic average	60	----	----	----	50	71
	Standard geometric deviation	----	----	----	----	2.1	2.4
	Estimated second-highest level	260	--	----	----	284	509
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	0.70	0.64
	Polludex value	0	----	----	----	5	57
C	Number of readings	60	72	76	105	93	85
	Arithmetic average	60	95	85	74	67	71
	Standard geometric deviation	----	2.4	2.3	2.3	2.4	2.8
	Estimated second-highest level	260	644	546	476	485	706
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.61	0.48	0.54	0.73	1.13
	Polludex value	0	103	75	53	49	95
D	Number of readings	60	53	72	[b]79	[c]45	77
	Arithmetic average	60	106	103	109	89	83
	Standard geometric deviation	----	1.8	1.7	2.0	2.0	2.2
	Estimated second-highest level	260	413	278	[a]538	[a]469	502
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.52	0.47	0.91	0.76	0.73
	Polludex value	0	68	58	94	64	66
E	Number of readings	60	71	75	107	94	85
	Arithmetic average	60	112	107	96	65	58
	Standard geometric deviation	----	1.9	1.6	1.8	2.1	2.8
	Estimated second-highest level	260	476	314	[a]397	375	602
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.68	0.42	0.88	0.71	1.09
	Polludex value	0	35	50	56	26	66

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D$ 0.736.

[b]Sampling site was relocated within same general neighborhood in midyear. It is assumed that for sampling purposes the environmental air was the same at both locations.

[c]Temporarily discontinued because of construction at sampling site.

TABLE III. - Continued. DATA SUMMARY FOR SULFUR DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
F	Number of readings	≥ 60	47	75	97	86	87
	Arithmetic average	60	84	76	90	59	63
	Standard geometric deviation	----	1.9	2.1	1.8	2.3	2.3
	Estimated second-highest level	260	[a]364	[a]409	373	[a]401	411
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.80	1.04	0.68	0.83	0.61
	Polludex value	0	40	42	47	27	31
G	Number of readings	≥ 60	69	71	105	86	81
	Arithmetic average	60	77	58	63	50	59
	Standard geometric deviation	----	2.1	2.0	1.9	2.4	2.7
	Estimated second-highest level	260	414	294	295	[a]363	532
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.57	0.70	0.70	0.75	0.97
	Polludex value	0	44	7	10	20	52
H	Number of readings	≥ 60	62	71	113	72	79
	Arithmetic average	60	64	63	66	48	57
	Standard geometric deviation	----	2.3	2.3	2.2	2.4	2.5
	Estimated second-highest level	260	[a]416	390	408	336	462
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.85	0.69	0.47	0.72	0.96
	Polludex value	0	34	27	34	15	39
I	Number of readings	≥ 60	64	77	108	83	88
	Arithmetic average	60	129	110	101	67	82
	Standard geometric deviation	----	1.8	1.8	1.9	2.1	2.9
	Estimated second-highest level	260	[a]522	467	[a]449	[a]358	879
	Goodness-of-fit statistic, $\sqrt{N}D$	----	1.04	0.64	0.87	0.90	1.37
	Polludex value	0	108	82	70	25	138
J	Number of readings	≥ 60	----	52	113	93	80
	Arithmetic average	60	----	113	124	79	79
	Standard geometric deviation	----	----	1.9	1.8	2.0	2.5
	Estimated second-highest level	260	----	543	504	[a]410	618
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	0.53	0.70	1.23	1.02
	Polludex value	0	----	99	100	45	85

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D \geq 0.736$.

TABLE III. - Continued. DATA SUMMARY FOR SULFUR DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
K	Number of readings	60	74	75	[b]105	81	81
	Arithmetic average	60	53	58	59	49	56
	Standard geometric deviation	----	2.5	2.1	1.9	2.4	2.4
	Estimated second-highest level	260	399	320	258	[a]359	388
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.55	0.57	0.64	0.83	0.76
	Polludex value	0	27	11	0	19	25
L	Number of readings	60	----	----	42	79	70
	Arithmetic average	60	----	----	157	116	109
	Standard geometric deviation	----	----	----	1.7	2.6	2.2
	Estimated second-highest level	260	----	----	569	[a]1013	691
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	0.62	0.98	1.09
	Polludex value	0	----	----	141	192	124
M	Number of readings	60	53	73	98	58	79
	Arithmetic average	60	50	55	58	41	61
	Standard geometric deviation	----	1.9	1.9	2.3	2.6	2.5
	Estimated second-highest level	260	220	235	309	[a]372	494
	Goodness-of-fit statistic, $\sqrt{N}D$	----	0.72	0.67	0.67	0.74	0.90
	Polludex value	0	0	0	9	22	46
N	Number of readings	60	----	----	35	81	85
	Arithmetic average	60	----	----	68	72	67
	Standard geometric deviation	----	----	----	2.6	2.9	2.7
	Estimated second-highest level	260	----	----	[a]548	[a]755	606
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	0.76	0.90	0.90
	Polludex value	0	----	----	62	105	72
P	Number of readings	60	----	----	----	----	66
	Arithmetic average	60	----	----	----	----	75
	Standard geometric deviation	----	----	----	----	----	2.4
	Estimated second-highest level	260	----	----	----	----	561
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	1.06
	Polludex value	0	----	----	----	----	70

[a]Calculation used to obtain this estimate assumed lognormality despite $\sqrt{N}D > 0.736$.
[b]Sampling site was relocated within same general neighborhood in midyear. It is assumed that for sampling purposes the environmental air was the same at both locations.

TABLE III. - Concluded. DATA SUMMARY FOR SULFUR DIOXIDE, 1968-72

[All concentrations are in micrograms per cubic meter.]

Monitoring station (see fig. 1)	Statistic	Standard	1968	1969	1970	1971	1972
R	Number of readings	60	----	----	----	----	79
	Arithmetic average	60	----	----	----	----	64
	Standard geometric deviation	----	----	----	----	----	7.4
	Estimated second-highest level	260	----	----	----	----	474
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	0.74
	Polludex value	0	----	----	----	----	44
T	Number of readings	60	----	----	----	----	73
	Arithmetic average	60	----	----	----	----	85
	Standard geometric deviation	----	----	----	----	----	2.5
	Estimated second-highest level	260	----	----	----	----	629
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	----	0.67
	Polludex value	0	----	----	----	----	91
U	Number of readings	60	----	----	----	[d]34	82
	Arithmetic average	60	----	----	----	114	93
	Standard geometric deviation	----	----	----	----	2.3	3.0
	Estimated second-highest level	260	----	----	----	137	1026
	Goodness-of-fit statistic, $\sqrt{N}D$	----	----	----	----	0.55	1.29
	Polludex value	0	----	----	----	138	175

[d]Sampling was initiated in the latter part of the year.

TABLE IV. - PERCENTAGE OF STATIONS HAVING READINGS CONSISTENT WITH LOGNORMALITY[a]

Year	Total suspended particulates			Nitrogen dioxide	Sulfur dioxide
	Cleveland Air Pollution Control Division stations	Lewis-operated suburban stations	State of Ohio operated suburban stations	Cleveland Air Pollution Control Division stations	
	Percentage of stations having distributions consistent with lognormality				
1967	73	--	---	--	--
1968	77	--	---	60	60
1969	71	--	---	55	82
1970	67	--	---	54	62
1971	90	--	---	60	47
1972	29	42	100	28	28

[a]The expected result is 80 percent.

TABLE V. - SIGNIFICANCE LEVELS FOR KOLMOGOROV-SMIRNOV

GOODNESS-OF-FIT STATISTIC

[From ref. 13.]

Significance level, α	0.20	0.15	0.10	0.05	0.01
Statistic, $(\sqrt{N}D)_\alpha$	0.736	0.768	0.805	0.886	1.031

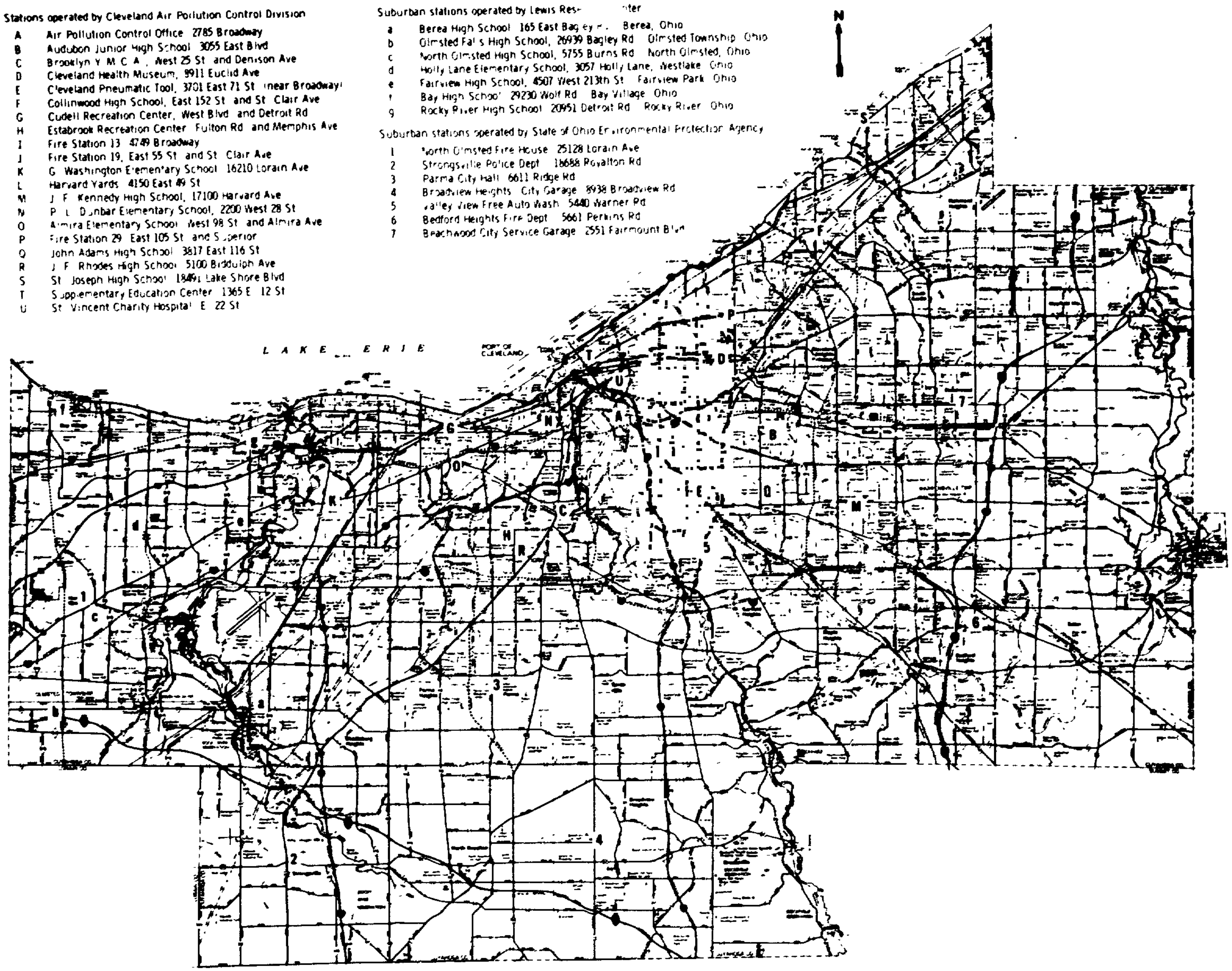


Figure L. - Air-pollution-monitoring stations in metropolitan Cleveland.

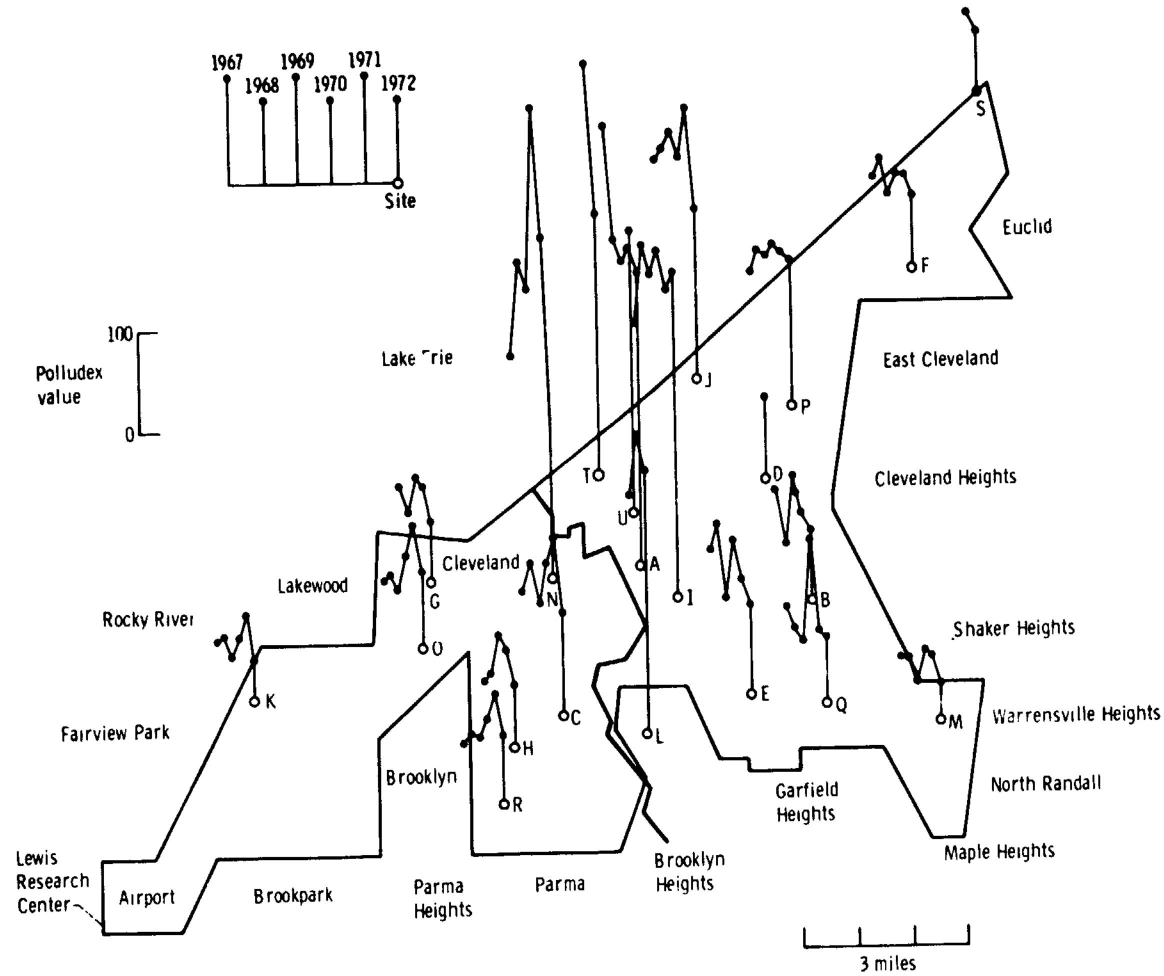


Figure 2. - Polludex readings of total suspended particulates in metropolitan Cleveland

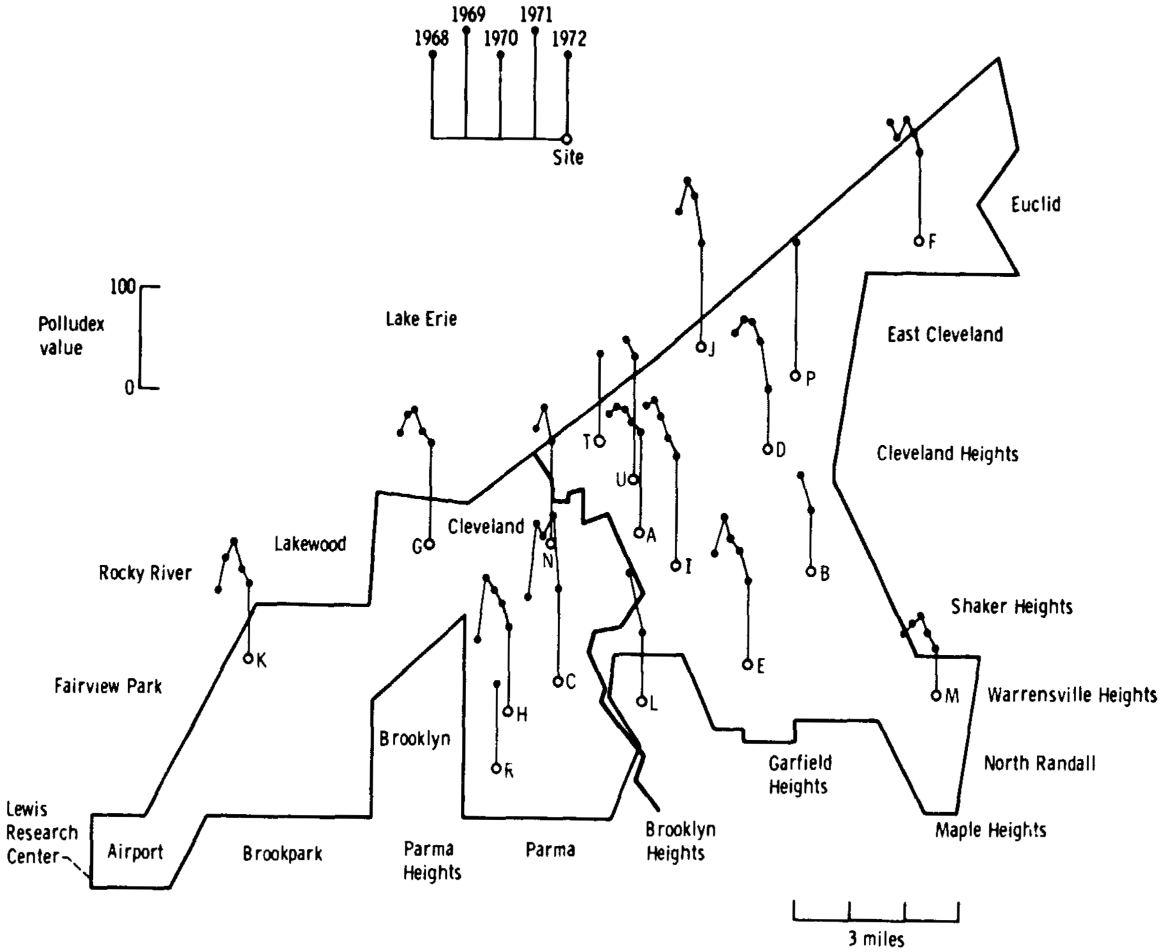


Figure 3. - Polludex readings of nitrogen dioxide in metropolitan Cleveland.

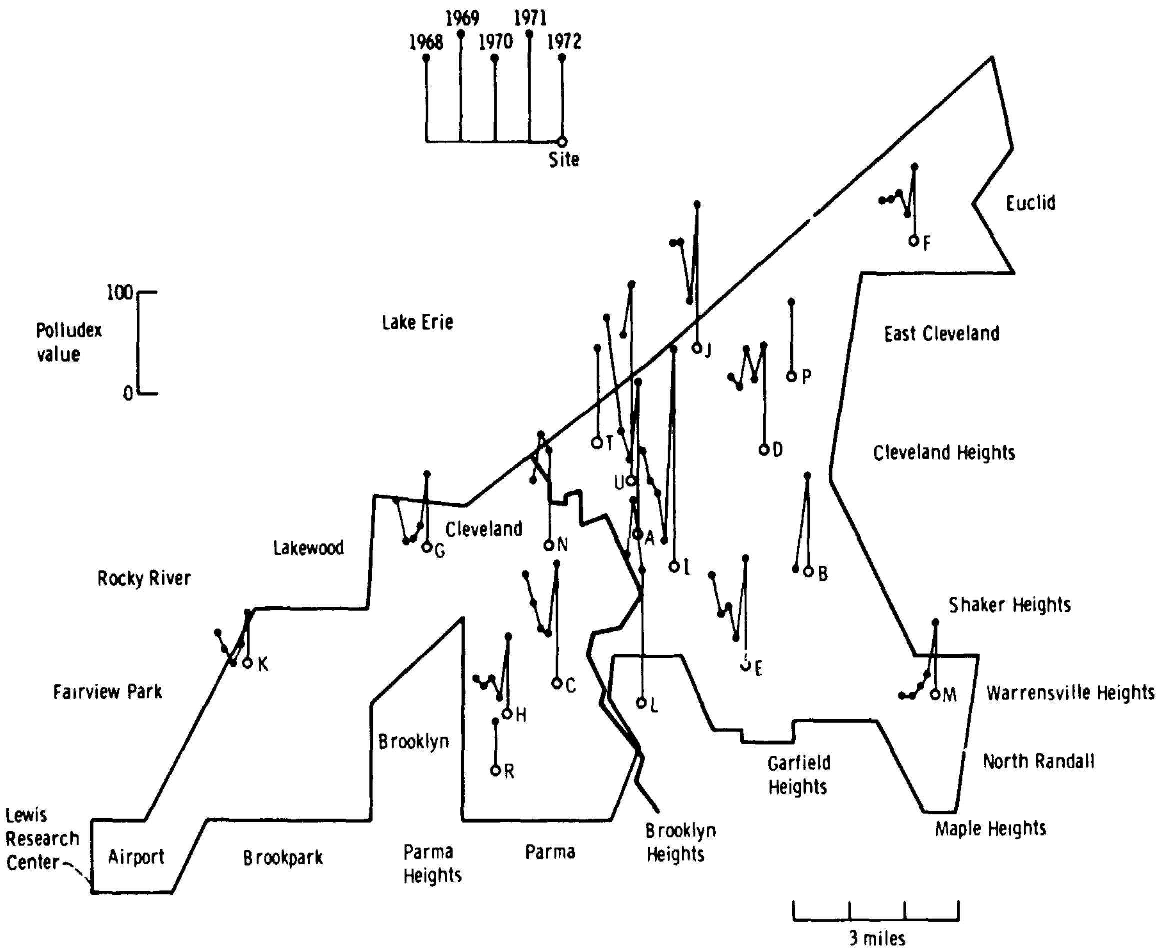
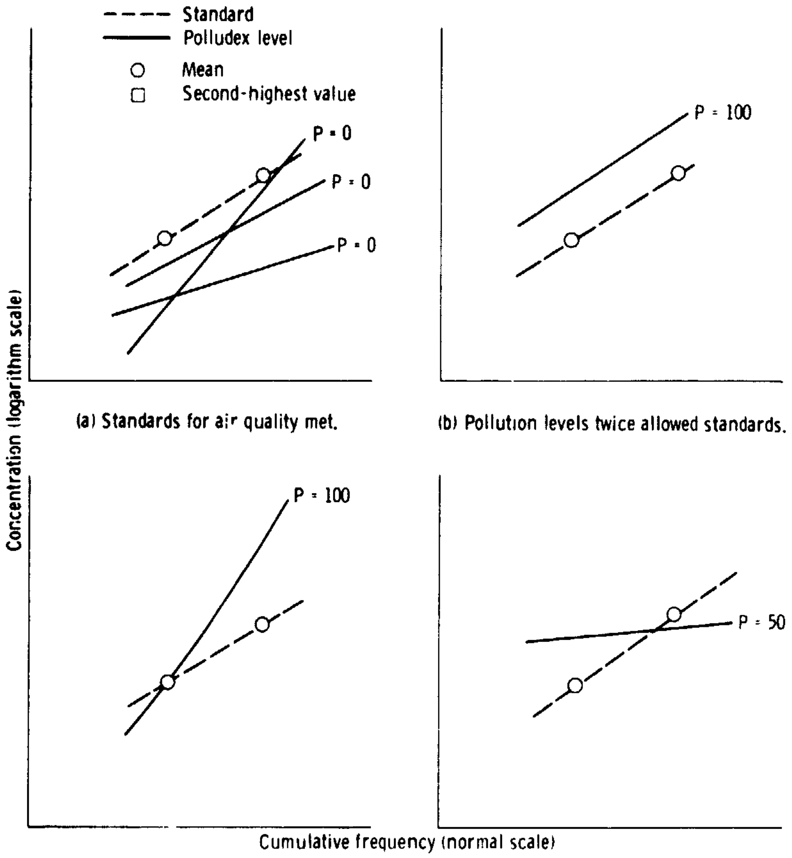


Figure 4. - Polludex readings of sulfur dioxide in metropolitan Cleveland.



(a) Standards for air quality met.

(b) Pollution levels twice allowed standards.

(c) One standard met and other exceeded by factor of 3.

(d) One standard met and other exceeded by factor of 2.

Figure 5. - Examples of Polludex levels.

NASA-Langley, 1974 E-7850