A Study of Air Pollution in New York City*

SOL PINCUS, C.E., F.A.P.H.A., AND ARTHUR C. STERN, M.E.

Sanitary Engineer and Deputy Commissioner, Department of Health, New York, N. Y.; and Superintendent, WPA Air Pollution Survey, New York, N. Y.

IT has long been recognized that constant supervision of the supply of food and water to maintain high standards of purity is a responsibility of public health authorities. However, the same principle has not, in general, been applied to the maintenance of purity of the air in spite of the fact that our daily consumption of food and water is only 5½ lb. whereas we breathe as much as 25 lb. of air per day. To be sure, it has been shown that the public health may be rapidly undermined by polluted food and water, whereas epidemics traced to polluted air are rare. The public health significance of smoke, dust, gases, pollen, and microörganisms in the air has been studied from time to time with largely negative conclusions. Prevailing medical opinion seems to be that atmospheric dust, bacteria, moulds and yeasts have little or no pathogenic import and that the spread of disease by any of these media is a remote possibility. However, there has been a unanimity of expert opinion that the presence of smoke and fumes in the air will cause a diminution of the amount of ultra-violet light reaching the earth. This fact has been correlated with the treatment of diseases such as tuberculosis, rheumatic fever, and rickets, so that it is now common practice to remove patients from cities and transport them to sunnier areas. The diminution of ultra-violet light combined with the presence of acid gases in the air and of the polluting elements previously noted, may cause a general lowering of the "tone" of large masses of people and lessen their vitality. Herein lies our concept of the principal public health significance of air pollution. This view places smoke and fumes as the most significant factors in air pollution, acid gases next, and the remaining factors last.

If these same elements are evaluated from a strictly non-medical point of view, the same order of importance is arrived at. From an engineering standpoint, smoke means the incomplete combustion of fuel and consequently waste. In large cities it has been estimated as amounting to millions of dollars worth of fuel each year. Smoke, soot, cinders and fly ash are charged with the dirtying of vegetation, streets, buildings, homes, clothing, and humans, causing cleaning bills amounting to enormously high figures. If to this be added the destruction of vegetation, structures, and personal property by the corrosive effects of the acid gaseous constituents,

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it can readily be seen why prevention of air pollution was for many years known to the public as "Smoke Abatement." The exhaust fumes of internal combustion engines introduce gases, both malodorous and otherwise, capable of producing nausea, headache, and, in extreme concentrations, death. The fume and odor emission from non-fuel burning sources is also frequently of a noxious and offensive character.

Considering the principal source of air pollution to be the combustion of fuel, it was logical that, when in September, 1935, the Works Progress Administration organized the Air Pollution Survey of New York City, under the sponsorship of the Department of Health, the first studies were those of fuel consumption and smoke production.

Through the coöperation of the Port of New York Authority, the U. S. Army Engineers, and the traffic divisions of the railroads having terminals in New Jersey, a complete record of all fuel movement into New York City during the year 1934 was obtained. These data were analyzed as to fuel type, month of movement, and both borough and public utility distribution.

The annual consumption of solid fuel is 20,000,000 tons, of which 53 per cent is anthracite. The annual consumption of fuel oil is 600,000,000 gallons. This means that approximately 5 per cent of all the coal consumed in the United States is burned within the area of 309 square miles that constitute New York City; that 20 per cent of the nation's anthracite is consumed to make New York the largest anthracite consuming area in the country. These data are shown graphically in Figures I and II. Figure I indicates that the bulk of the soft coal is burned in the furnaces of public utilities. There is an increase of anthracite consumption during the winter months (Table I) but a uniform bituminous coal consumption throughout the year. This analysis shows that, during a typical year, there were discharged into the atmosphere of New York City, exclusive of the discharge

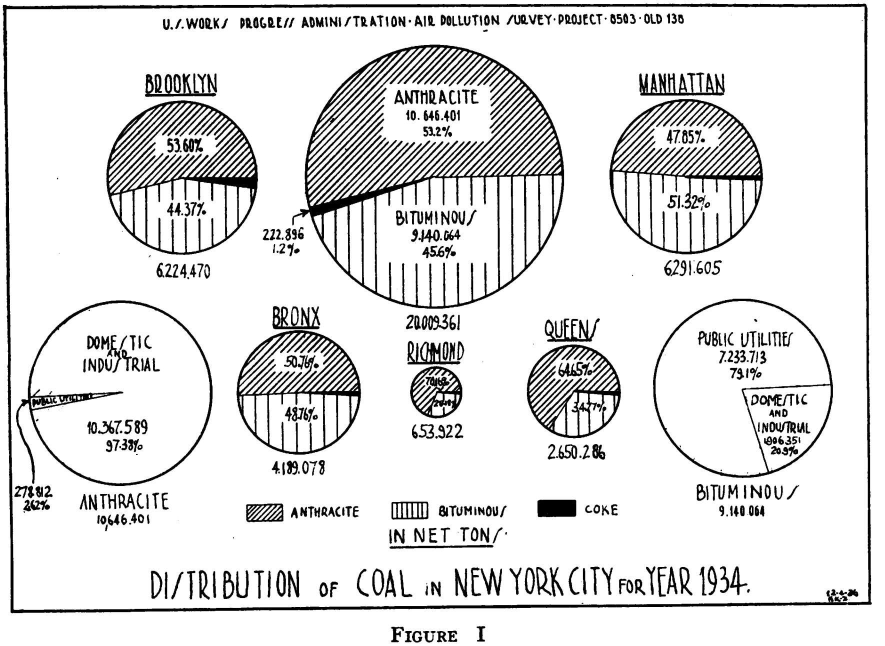

FIGURE I

TABLE I

Monthly Movement of Coal Into New York City for Year 1934—Net Tons

Month	*Anthracite*	*Bituminous*	*Coke*	*Total*
January	1,305,976	848,540	22,028	2,176,544
February	1,274,244	808,896	38,939	2,122,079
March	1,244,619	866,899	48,026	2,159,544
April	714,477	741,260	7,732	1,463,469
May	735,635	716,581	6,351	1,458,567
June	640,462	708,280	6,730	1,355,472
July	672,186	688,245	3,321	1,363,752
August	587,579	706,728	6,664	1,300,971
September	693,336	709,868	13,451	1,416,655
October	777,883	759,538	23,470	1,560,891
November	703,912	778,733	20,484	1,503,129
December	1,296,092	806,496	25,700	2,128,288
Total	10,646,401	9,140,064	222,896	20,009,361

from internal combustion engines, 300,000 tons of soot, tar, cinders, and fly ash, and 350,000 tons of sulphur in an oxidized form which probably forms about 1,000,000 tons of sulphuric acid. The largest consumption of both total solid fuel and bituminous coal occurs in the borough of Manhattan where 31 per cent of the total fuel is consumed. In this borough 35 per cent of the bituminous fuel is consumed, and for it much more detailed survey information was obtained concerning fuel distribution and use than for any of the other 4 boroughs. Simultaneously with the study of fuel movement into New York, the Air Pollution Survey conducted a house-to-house survey of Manhattan. The data obtained were summarized into block, census tract, health area, and

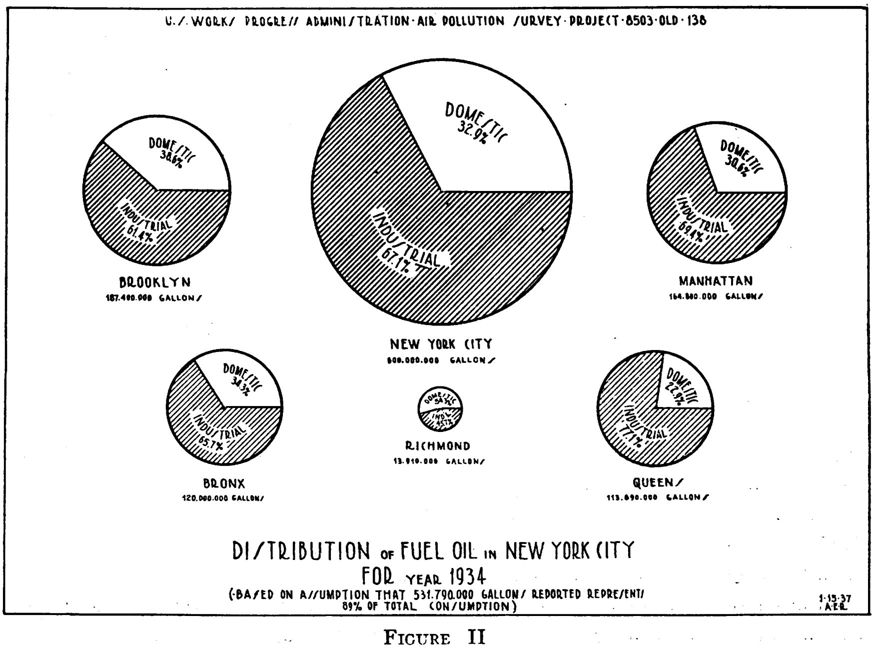

FIGURE II

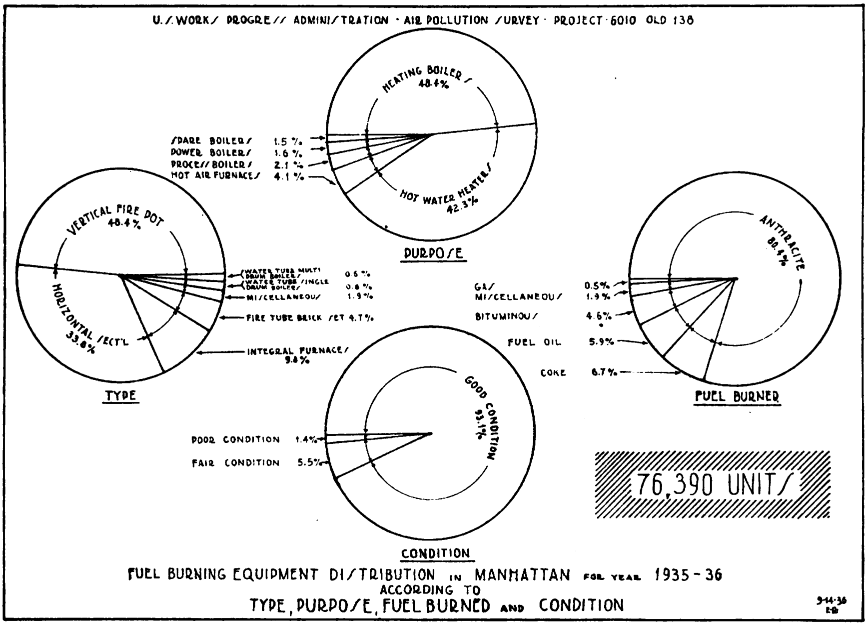

FIGURE III

health center district totals for each of the items surveyed. Access was obtained to over 95 per cent of the 72,784 Manhattan premises and it was ascertained that 66 per cent of these had installations of fuel burning equipment, hence, were potential producers of smoke. In these premises were found 76,390 units of fuel burning equipment. The consumption of fuel oil in the borough, obtained by summarizing the data from 3,238 oil burning premises is 141 million gallons, which checks quite well with the 146 million gallons obtained from the study of fuel movements. Similarly the 7,120,000 tons of coal obtained from the fuel burning equipment survey checks closely with the 6,290,000 tons from the fuel movement study.

The summarized results given in Figure III show the types of equipment installed in Manhattan for the burning of fuel. In order to secure data on potential sources of smoke among vessels in the harbor, one of the most active in the world, records were obtained of the fuel consumption of each of 1,200 steamships. The largest single class of steamships operating is tow boats. A summary based on 488 of the 548 such craft known to be operating, indicates that 64 per cent of the fuel consumption is bituminous and 16 per cent fuel oil, both capable of producing smoke. However, based on 97 of the 101 ferry boats, 69 per cent of their fuel is smokeless, indicating considerably less of a smoke problem than with tow boats.

In contrast with other large cities locomotive smoke in New York City is a relatively minor problem, as almost all the railroads within the city are electrified or use Diesel engines. The few coal burning locomotives operating, plus such sources as open dump fires, steam rollers, steam shovels, cranes, and tar kettles constitute the remaining possible sources of smoke as yet unsurveyed. These will be surveyed during the coming year, in order to complete the picture of smoke sources in Manhattan. Surveys are now being made of the other boroughs. Data such as these for the entire city form the ideal background of information upon which an intelligent campaign of smoke elimination can be based.

Maps are prepared showing the geographical distribution of fuels likely to cause smoke and may be used to form the basis for equivalent maps showing the geographical distribution of smoke production. However, a preferable procedure is to prepare these smoke production distribution maps based directly upon measurements of smoke in the various parts of the city. All smoke survey procedures are based upon the familiar Ringleman Chart. Surveys conducted in other cities such as Chicago, Salt Lake City, and St. Louis, have been based upon the average smoke density of a number of individual stacks each read at random for a period of at least 15 minutes This is at best an unsatisfactory method, particularly when applied to a large city. Therefore, for our work, a new method of smoke survey was devised and tried, using a group averaging 20 smoke observers located on 20 of the 64 tall buildings distributed throughout the 5 boroughs as observatories. The smoke survey form and details of the method have had several changes during the year, with a view of obtaining the fullest information about smoke production so that both a geographical and a seasonal variation of smoke production could be obtained from an analysis of the survey data. The size range of stacks are graded according to Table II. The most recent modification of smoke density measurement procedure allows a geographical and seasonal coverage of every section in New York with but 10 observers rather than a coverage of but one-fifth of the city with the original requirement of 20 observers. It will thus soon be possible to map smoke production for New York City, just as potential sources of smoke production have been mapped. Maps of this nature are also of value to show progress in the elimination of smoke.

Coupled with the burning of fuel and the production of smoke is the production of cinders, fly ash, soot, and tarry particles emitted from these chimneys. This material will eventually settle out of the air on to the earth's surface. The larger particles will settle directly due to their own weight; the smaller will

TABLE II

Classification of Stacks
Smoke Survey

Class	*Type of Stack*	*Diameter in Feet*	*Flue Gas Emission cu. ft. per Minute*
A	1–2 Family Dwellings Tenements 1–2 Story Commercial Buildings Rooming Houses	0–1	0–1,000
B	Apartment Houses 6–7 Story Office Buildings Small Factories—Garages—Theatres 6–7 Story Hotels—Schools—Churches Public or Semi-public Buildings	1–3	1,000–10,000
C	Large Commercial—Industrial Buildings Large Hotels—Lofts—Warehouses Breweries—Laundries—Bakeries—Hospitals Processing Plants—Incinerators	3–9	10,000–100,000
D	Public Utility Power Plants	9–up	over 100,000

float for a considerable distance but will eventually either settle out due to their own weight, be washed out by rain or snow, or flocculate to form larger particles that will then settle or be washed out of the air. It is thus obvious that prevailing wind direction and velocity will have a very large effect in determining when and where these particles will settle but that the principal factor in the distribution of particle settlement will be when and where these particles are produced. It is thus possible to ascertain the general direction of the sources of particulate matter by determining where it settles and what sort of wind carried it to the point of settlement. In addition to the value of tracing pollution to its source, it is of interest to know the actual distribution of settled matter in so far as it visibly represents the dirtiness caused by air pollution. This settled matter, the so-called "soot-fall," is the cinder that gets in one's eye, the dirt that settles on the roof and the street and on the floor in one's home. It includes the tarry matter that dirties windows, building walls, vegetation, and clothing, and the soluble particulate matter dissolved and precipitated by the rain. There obviously must be a close relationship of the quantity and character of this sort of emission to the smoke that originally accompanied a large part of it, and the fuel from which it was produced.

Soot-fall is collected in copper cans 5 inches in diameter and 8 inches deep exposed for a month on flat roofs of one and two story buildings, and is reported in terms of tons of settled matter per square mile per month. In this Air Pollution Survey an average of 130 such cans were exposed in all 5 boroughs each month. Their contents were analyzed in the Chemical Laboratory for 2 fractions, insoluble and sol-

TABLE III

Typical Soot-fall Data for the Month of April, 1936—Tons per Square Mile per Month

		Insoluble Matter				*Soluble Matter*						
Type Area	*Station*	*Solids*	*Ash*	*Carbon*	*Tar*	*Solids*	NH_3	*Cl as NaCl*	SO_3	*Ash*	*Total Solids*	*Total Ash*
Industrial												
21 King St.	130	139.06	76.69	62.37	1.37	18.68	0.37	2.27	7.49	15.87	157.74	92.56
80 Van Alst. Ave.	312	174.55	137.80	36.75	....	17.83	0.63	2.18	12.49	10.46	192.38	148.26
Commercial												
1 W. 125th St.	112	59.86	42.23	17.63	4.69	10.35	0.41	1.48	4.09	7.06	70.21	49.29
33rd St. & 8th Ave.	104	91.36	55.92	35.44	0.48	20.97	0.37	2.64	6.78	6.37	112.33	62.29
Slum												
Rivington & Chrystie	131	103.24	59.82	43.32	2.25	9.16	0.35	0.94	11.14	6.12	122.40	66.00
38 Catherine St.	133	226.96	91.63	135.33	3.18	16.87	0.52	1.40	14.56	10.38	243.83	102.01
Harbor												
Aquarium	103	51.49	30.82	20.67	0.24	9.94	0.26	0.63	4.62	4.33	61.43	35.15
131 Water St.	135	198.75	93.09	105.65	0.17	17.00	0.44	3.14	6.82	9.98	215.75	103.07
River												
692 11th Ave.	118	24.43	16.42	8.01	0.48	9.53	0.22	1.48	1.16	4.75	33.96	21.17
Franklin & Dupont	411	96.13	69.30	26.83	0.15	16.43	0.61	2.11	4.43	8.41	112.56	77.71
Residential (Multiple)												
1414 Inwood Ave.	204	33.05	20.03	13.02	....	11.45	0.26	1.13	3.90	2.42	44.50	22.45
156th & St. Nicholas	109	42.12	30.10	12.02	0.65	9.20	0.41	1.77	4.05	5.95	51.32	36.05
Residential (Private)												
212th & Hillside	322	10.25	7.50	2.75	....	1.96	....	0.15	1.66	1.96	12.21	9.46
1215 E. 15th St.	409	38.06	31.34	6.72	0.22	....	0.28	0.87	3.47	....	.....	....
Suburban (Control)												
Beth Page	705	3.90	1.72	2.18	....	13 18	....	1.11	1.83	0.57	17.08	2.29
Westbury	703	7.63	5.34	2.29	....	27.92	0.17	1.00	4.75	....	35.55	....

uble. The insoluble fraction is further divided into insoluble solid matter, ash, combustible matter, and tar (carbon disulphide soluble matter). The soluble fraction is broken down into soluble solids, SO_3, NH_3, Cl (as NaCl), and ash. Control stations were used in Westchester and Long Island. These cans collect, as well, settled matter of non-fuel burning origin, such as plant matter, salt from sea spray, and inorganic atmospheric dusts from numerous sources. However, the percentages of soluble matter, combustible matter, tar, SO_3, NH_3 and Cl serve as good indicators of the source of the greater part of the settled matter in each gauge. Typical data from this survey are reported in Table III. As can be seen from this chart, the slum areas are the worst, with the harbor, industrial, and commercial areas next in order. Residential sections are low; private residential sections are of the same order as the suburban areas, and are lower than multiple dwelling areas.

Each of the components for each month are also drawn up on a 5 borough map to show the geographic distribution. Figure IV shows the distribution of total solids for the month of April, 1936. It should be noted, that regardless of wind direction a map of this sort shows which health district has the heaviest deposit and this is primarily what the survey is interested in, as it visibly represents the dirtiness caused by air pollution.

Because SO_2 emitted from the stacks of fuel burning plants diffuses rapidly and is mixed into the atmosphere by wind and convection, it is not possible to trace this gas to its source with the same facility as particulate matter.

Because of the very small quantities of SO_2 in the air, it is necessary to absorb this polluting element from a relatively large volume of air in order that the absorbent contain a sufficient concentration for accurate laboratory analysis. By the method used, which is to pass 1 cubic foot of air per minute for 60 minutes through the Greenburg-Smith type impinger tubes, which are used as absorbing bottles, the concentration of SO_2 in the absorbent is still so low as to require very sensitive methods of determination. Most of these depend upon the oxidation of SO_2 to SO_3 and the corresponding reduction of an iodine compound, which releases free iodine as a colorimetric indicator.

The particular technic used in this survey consisted in absorbing in a 10 per cent NaOH solution, adding HCl and CCl_4, and titrating with KIO_3 until a pink color due to iodine appears and then disappears in the CCl_4 layer. It will be noted that this method does not measure SO_2, but rather measures total active reducing gases present in the air. This fact was checked by measurements of total sulphate gravimetrically and it was thus shown that other reducing agents than SO_2 were active in New York City air. In an attempt to explain this finding, a number of special studies were made. It was found that in clean glassware, SO_2 (absorbed in NaOH solutions) does not change much on standing; that there is no appreciable oxidation of SO_2 to SO_3 on passing air through the solution for an hour; that higher gas concentrations are absorbed with more efficiency than lower concentrations; and that the colorimetric phenomenon representing the end point of the titration differs in appearance between equivalent concentration of pure SO_2 and of reducing substances in city air. An interesting speculation, on which research is now being undertaken, is that some of these other reducing substances are from automobile exhaust gases.

Regardless of the exact nature of the polluting gases measured by this technic, a part is SO_2 and measurements by

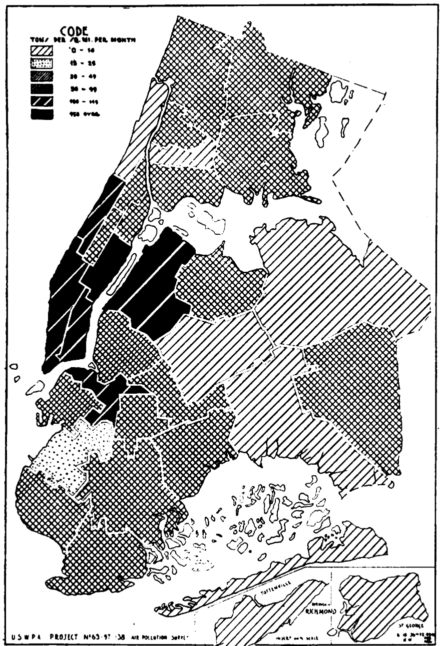

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FIGURE IV

this method give an index to the potential corrosive acidity of the air. In other words, this method does give a measurement of the extent that the air is polluted by the gases that damage vegetation, structures, and fabrics.

Just as SO_2 and the associated gases in the air have been measured by absorption in NaOH solutions in the Greenburg-Smith Impinger, so have NH_3 and other alkaline gases been absorbed in dilute H_2SO_4 and the ammonia measured in a Kjeldahl apparatus. Ammonia is a normal constituent of air, the small quantities usually present coming from the decomposition of organic matter. However, in the several months for which data are available, ammonia in New York City air has consistently been close to normal and therefore consistently below levels likely to cause physiological effects.

The procedure has been to sample simultaneously for SO_2, NH_3, and atmospheric dust using 3 impinger bottles actuated by a common pump. The bottles used for dust collection contain distilled water and are counted microscopically in the laboratory, using Sedgewick Rafter counting cells with Whipple disc and light field according to the standard U. S. Public Health Service technic, although at the present writing correlative studies are being made of the use of darkfield illumination. The range of the impinger dust counts by standard light field procedure has varied between a maximum of 148 million particles per cubic foot near sand-blasting operations on building faces to a minimum of 85,000 particles per cubic foot in the street air of a residential area, with an average of about 200,000 particles per cubic foot of air in the street. Dust counts were also made by the Owens Jet Dust Counter under light field and high power and show an average count in the street air of 16,500,000 particles per cubic foot.

Dust content in schools, theatres, and other places of congregation will be measured this year and correlated with bacteria count. A study of dust content in New York City subways has been made. The results in subways shows that the greatest concentration of dust is found on all lines between 34th Street and 96th Street, Manhattan; also that the concentration of dust in the tunnel was about 3 times as high as that obtained just as soon as the train left the tunnel and emerged into the open air. The concentrations on platforms in the subways were greater than those found in the train at the same station.

The original plans for the gas analysis procedure to be employed for the measurement of atmospheric CO called for the use of the blood-pyrotannic acid method. However, after a careful trial, this method proved unsatisfactory for the particular sampling conditions desired and was abandoned. It was replaced by a commercial CO indicating meter based upon temperature measurement of the heat of the catylitic combustion of CO to CO_2 in a hopcalite bed. This has proved more satisfactory and has allowed the measurement of CO in streets and in automotive vehicles. These latter studies in vehicles have indicated that the headache and nausea occasionally experienced in automotive vehicles frequently occur when the CO concentration is below that capable of producing those symptoms. Since these symptoms almost invariably occur only when odor is present, and since CO is known to be odorless, the conclusion is that the aldehydes, both saturated and unsaturated, cause the symptoms noted. Quantitative measurements of these gases by absorption are now being attempted, but we have as yet been unable to obtain a satisfactory absorbent.

This completes that part of the survey devoted to the measurement of air pollution caused mainly by the combustion of fuels. Two of the remaining parts are quite independent of this source: pollen and bacteriological (including moulds and yeasts), while the final study occupies an intermediate position: ultra-violet light study. This latter is an attempt by means of quartz spectrographs and Geiger-Mueller quantum counters sensitive to the ultraviolet region to determine the amount of the various wave lengths of ultraviolet light reaching the street level in the heart of New York after having traveled through the city's smoke and dust haze. In so far as this diminution of ultra-violet is one of the few definitely proven harmful effects of air pollution upon health, this type of measurement should by itself serve as an index of the extent to which the pollution is remedied by efforts at smoke and dust abatement.

During the pollen season—March to October—we have exposed daily microscope slides, coated with glycerine jelly dyed with basic fuchsin, for a period of 24 hours at each of 9 different locations in the 5 boroughs of New York. These are being counted for the presence of each of the common tree, grass, and weed pollens likely to be found in New York, particularly noting, of course, the ragweeds. Pollen counts of this sort such as shown in Figure V are arbitrary to the extent that they do not propose to determine the number of pollen per unit volume of air, but merely the relative number falling on one slide compared with that falling on a similarly exposed slide at some other location or some other time. These pollen counts were published daily in a New York newspaper during the latter part of ragweed season in the form of a bulletin listing the total number of pollen and the total number of ragweed. A number of physicians have subsequently stated that these were of value to them in determining the daily treatment of their patients.

The bacteriological survey was instituted because of the belief that the subject warranted extensive reinvestigation. A new method of study was made feasible by the perfection in 1933 of a machine, the Wells Air Centrifuge, which, it was believed, would yield reliable data.

While numerous studies of bacteria in air were made during the 19th century, the results were of negligible significance. However, during the first two decades of the present century, a number of workers in public health in the United States (Winslow, Baskerville, Rettger, Weinzirl, Soper, Browne, Ruehle, Whipple and others) using various modifications of the double sand filter originally designed by Petri and, in one instance (Rettger) using an improved water aeroscope, made studies

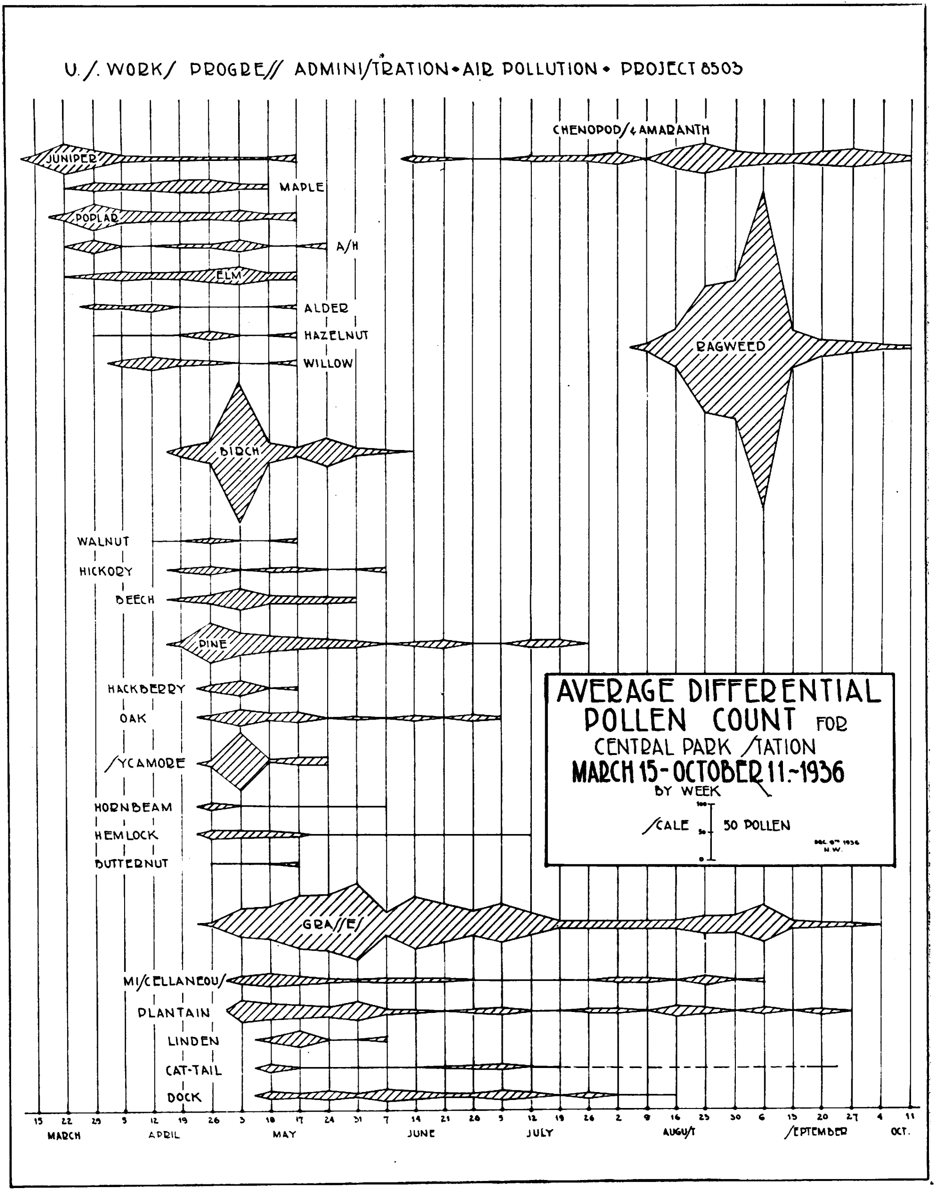

FIGURE V

of air in schools, streets, subways, dairies, and other places. Most of their efforts were concerned with the estimation of the number of bacteria per unit volume of air, and in some instances, the number of streptococci that appeared on litmus lactose plates. The wide variations in results leads one to suspect unavoidable errors in technic. Most of the methods demanded a separate piece of apparatus for each step in the process of isolating bacteria; that is, one apparatus to create air flow, another to measure it, still another to remove bacteria from the air, and a final one to grow them for counting.

No doubt the complications entailed, combined with cumbersomeness of apparatus, hampered routine collection of samples. This may account for the waning interest in air analysis and its lapse into disfavor. The study of air bacteriology was greatly stimulated, if not actually revived, by the development of the Wells Air Centrifuge, in 1933—referred to above. This centrifuge creates an air flow, measures the flow, precipitates the bacteria onto a thin layer of agar, and then permits of their being counted after incubation of these media on the same bottle.

The objectives of this study are to obtain a composite picture of the number and kind of bacteria in the air of places of assembly such as schools, theatres, and subways in which could be delineated the variations induced by population density, season, time of day, and meteorology, and to determine the degree of relationship, if any, of these findings to the public health.

The ease with which samples are obtained by the Wells centrifuge simplifies the planning of routine collection of samples and allows the maintenance of fixed schedules for sampling. For example, 6 public schools have each been sampled twice a week on the same days of the week, in the identical rooms, and at the same hours of the day, for a period of approximately 6 months (until the schools closed for the summer vacation). Similarly, air in subways has been studied at the same hours 5 days a week. The same routine was followed in theatres, both before and during performances, and at the remaining types of locations. As is seen from

TABLE IV

Bacteria per Cubic Foot of Air in New York City at Various Locations
Incubated 18 Hours at 37° C.
(2,734 Samples)
Week Ending Friday, January 10, to Week Ending Friday, June 26, 1936

	Sheep's Blood Beef Infusion Agar		*Beef Infusion Agar*	
Type of Location	*No. of Samples*	*Bacteria per cu. ft. of Air*	*No. of Samples*	*Bacteria per cu. ft. of Air*
Schools	707	29.6	678	21.1
Subway	290	19.2	294	12.4
Theatre—Non-ventilated (Auditorium)	104	13.2	110	8.4
Theatres—Ventilated (Ducts)	149	3.1	114	1.4
Streets	143	11.2	134	8.5
Park	13	3.0	18	1.8

Streptococci per Cubic Foot of Air in New York City at Various Locations
(Sheep's Blood Beef Infusion Agar)
16 Week Period—January 23 to May 15, 1936

Type of Location	*No. of Samples*	*All Streptococci*	*Beta Hemolytic Streptococci*	*Alpha Hemolytic Streptococci*
Schools	553	0.20	0.01	0.18
Subway	225	0.10	0.0003	0.085
Theatres—Non-ventilated (Auditorium)	78	0.04	0.001	0.038
Theatres—Ventilated (Ducts)	116	0.03	0.0005	0.026
Streets	123	0.05	0.0001	0.045

Table IV which presents data on the number of bacteria and the number of streptococci per cubic foot of air collected in several types of locations during the first 6 months of 1936, of 2,754 samples (approximately one-half on blood agar and one-half on plain agar), more than 57 per cent, or 1,585, were taken in schools, 21 per cent in subways, and 22 per cent in theatres, streets, and parks. The number of bacteria grown on blood agar samples exceeds that on plain agar samples in every type of location. There is no explanation for this except the obvious one that blood agar allows full growth of certain delicate organisms which are unable to propagate on plain agar. Each batch of media used for sampling, both plain and blood agar, is tested in the laboratory for its ability to grow streptococci and pneumococci. Plain media, therefore, would be expected to grow these organisms from the air. Another point of interest is the apparent distinct differences in the total counts at the several types of locations. A definitely greater number of bacteria were found in school air than in that of any other type of location. The air of subway cars, while showing fewer bacteria than schools had more than that of theatres, streets, and parks. The auditoriums of theatres (non-ventilated) had more bacteria than streets, the park, and the ventilating ducts of theatres. Streets had more bacteria than the park and the ventilating ducts of theatres. The latter two locations had approximately the same number.

Since these results cover only a part of the samples which it is hoped to have collected when this study is completed, they are being presented solely to indicate the trend of the data. Presumably, the difference between the several types of locations will remain in the same order of magnitude. It may be stated tentatively, therefore, that schools and subway cars have greater concentrations of bacteria per cubic foot of air than do theatres and outdoor locations.

Table IV also gives the estimated number of streptococci per cubic foot of air in the same types of locations for a 16 week period from January 23 to May 15. It is seen that, here again, the schools have more streptococci than do any other type of location, and the subway is again second. The streets, in contrast with the findings for all bacteria per cubic foot, have slightly more streptococci than do the auditoriums of non-ventilated theatres. The ducts of ventilated theatres again have the lowest number. The division of the streptococci into Alpha and Beta streptococci show that the Alpha streptococci are in great preponderance. It is of very great interest that approximately 90 per cent of the Alpha hemolytic streptococci from schools and subway air are organisms whose normal habitat presumably is the human naso-pharynx, as determined by the Holman system of classification of streptococci.

SUMMARY

Little attempt has been made in this paper to present complete or final data, this being reserved for a subsequent report of the survey now in the process of preparation. Some of the highlights and some typical results have been presented. The plan of the most comprehensive study of air pollution ever attempted in New York City has been outlined. These studies lack the air of authority given by years of repetitive results which have served to verify the studies of the Meteorological Office in Great Britain and of certain other American cities. However, they do more than make up for this deficiency by including in the short range program a more intensive geographical coverage

of a municipality, and a wider scope of correlated studies than it has ever been possible to obtain heretofore.

The results obtained from this investigation will be made the basis for an extensive revision of the sanitary regulations relating to smoke and air pollution to provide for such requirements as the approval of plans for new installation or extensive alterations of fuel burning equipment, and for standards for allowable emission of smoke, soot, fly ash, cinders, acid gases, fumes, and other polluting elements. With such detailed data on local conditions available and an adequate code on air pollution, it will be more readily possible to reduce to a minimum air pollution in this metropolitan city, and to be able to measure the results obtained.

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Without the men and money made available to the Health Department by the Works Progress Administration, this program which has long been in the minds of officials interested in the abatement of air pollution, would have still remained a hope rather than the present actuality employing over 150 men to provide the basic data upon which future abatement programs may be planned. Acknowledgment must be made of the valuable aid of Dr. John Oberwager, Director of the Sanitary Bureau, New York City Department of Health, in planning and directing this survey, and of Dr. Leon Buchbinder, Director of the Bacteriological Laboratory and of Jacob Siegel, Director of the Chemical Laboratory of the Air Pollution Survey, in developing methods, supervising the work, and preparing and compiling the data of this study.

Popular Interest in Science

. . . Nevertheless, he [Voltaire] did science one good turn: he impressed the general public with her importance. This is all that a literary man can do for science, and perhaps only a literary man can do it. The expert scientist is too conscious of the difficulties of his subject; he knows that he can only communicate his discoveries to us by simplifying and therefore falsifying them, and that even when he can state a fact correctly we receive it incorrectly, because we cannot relate it to the thousands of other facts relevant. The literary man has no such misgivings. His imagination is touched by the infinite variety of the natural world; he reads books about it, skipping the statistics, he forgets most of what he does read, and perhaps he performs a few experiments in order to grasp the meaning of research. Then, in the course of his other activities, he writes about science, with a spurious lucidity that makes the expert smile. Spurious, but stimulating; the public does realize, from the remarks of such men as Lucretius, Voltaire, Charles Kingsley, Samuel Butler, Aldous Huxley, Gerald Heard, that something is happening It does get a misty idea of the expanding empire of mankind. . . . The literary man loves images, and as soon as he has found a vivid one, his interest in the truth it is supposed to illustrate is apt to cease. But the scientist knows that Nature is Nature.

Voltaire himself was literary, yet he had enough sense of science to perceive his own limitations, and . . . if "popular interest in science" has any importance (for my part, I think it has immense importance), he must be honoured as an early popularizer." — E. M. Forster, *Abinger Harvest,* 1936, p. 213.