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METEOROLOGICAL OFFICE, AIR MINISTRY.

ADVISORY COMMITTEE ON

ATMOSPHERIC POLLUTION.

REPORT ON OBSERVATIONS IN THE YEAR ENDING MARCH 31st, 1921.

FORMING THE SEVENTH REPORT OF THE COMMITTEE FOR THE INVESTIGATION OF ATMOSPHERIC POLLUTION.

Published by the Authority of the Meteorological Committee.

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METEOROLOGICAL OFFICE, AIR MINISTRY.

Advisory Committee on Atmospheric Pollution.

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Forming the Seventh Report of the Committee for the Investigation of Atmospheric Pollution.

INTRODUCTION.

During this year the list of stations measuring deposit from the air was as follows:—

Municipalities.	*Gauges.*
London County Council	6
Corporation of London	1
Meteorological Office, London ...	1
Malvern	1
St. Helens	1
Southport	2
Rochdale	2
Rothamsted	1
Birmingham	3
Kingston-upon-Hull	1
Liverpool	1
Newcastle-on-Tyne	1
Glasgow	9
Stirling	1

The following report deals with the results obtained from the above stations.

During the year an automatic apparatus has been set up for measuring suspended impurity at the following places:—

Meteorological Office, South Kensington.
Kew Observatory.
47, Victoria Street, Westminster, S.W.1.
London County Council Laboratories.
Rochdale.
Glasgow.

As most of these instruments have been in operation for only a few months, comparative data for the year are not yet available, but this matter is dealt with further on in the present report.

Following the lines of previous annual reports the full figures for deposit from all stations are not included as these are available for reference in THE LANCET on the 14th and 21st May 1921.

List of Tables.—The tables embodied in the present report are similar to those in the 5th and 6th reports; a list of these is given below:—

1. Monthly deposit for two selected stations, representative of high and low deposits respectively, *i.e.*—Birmingham (Central) and Rothamsted.
2. Total solids deposited monthly at all stations.
3. Mean monthly deposits at all stations for the summer half years, *i.e.*, April to September 1919 and 1920.
4. Mean monthly deposit at all stations for the winter half years, *i.e.*, October to March 1919–20 and 1920–21.

5 and 6. Classification of the stations under Groups A, B, C and D, according to the amounts of the various elements of pollution for the same periods as in Nos. 3 and 4.

7 and 8. Totals of stations classed A, B, C and D for each element of pollution for summer and winter months, prepared from Tables 5 and 6, and for the same periods.

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9. Comparison of mean monthly deposit during summer and winter.
10. Average deposit of each element of pollution for each month for the following group of stations :—
   (X) 24 Stations.
   (Y) 8 London Stations.
   (Z) 4 Stations in Manufacturing Towns.

(A) Total solids deposited in the summer months of 1920 expressed as percentages of the deposits in the summer months 1919.
(B) Total solids deposited in the winter months of 1920–21 expressed as percentages of the deposits in the same months 1919–20.
(C) Summary of the classification of Tables 7 and 8, showing comparison of deposits for 1919–20 and 1920–21.
(D) Highest and lowest mean monthly deposits in 1920–21 in tons per square kilometre.
(E) Summary of Table 9. Comparison of summer and winter deposits for the year April 1920 to March 1921.
(F) Analysis of Table 10 showing the months of highest and lowest deposit for each element of pollution.

In Table 10 the figures for deposit for each month have been adjusted to a standard month of 30 days, as referred to in the Fifth Report, in order to eliminate apparent discrepancies arising from the different number of days in the months.

Deposit Gauges.

The present form of deposit gauge was described in the First Annual Report. It consists of a cast-iron vessel enamelled inside with a vitreous enamel. In the Fifth and Sixth Reports the Committee drew attention to the weathering of the enamelled surface when exposed to city air, and to the fact that a varnish had been found which appeared satisfactorily to resist weathering. Further experience with this varnish has, however, shown that it is not capable of withstanding exposure of the gauges without deterioration, and several of the gauges have had to be re-varnished.

After due consideration of this result, the Committee decided that the method of protecting the enamel being unsatisfactory it would be best to experiment with a gauge vessel made of resistance glass, the diameter of the gauge being reduced to 30 cms. This diameter was fixed as being small enough for construction in glass and at the same time large enough to enable a complete analysis to be made of the deposit in all cases, except for country stations.

Samples of resistance glass were accordingly obtained and after submission to suitable tests to determine if any vitiation of the results was likely to occur owing to a solution of the glass in the rain water, six vessels were ordered. It was found, however, that the vessels made from the selected glass were entirely unsuitable as several of the vessels broke spontaneously, presumably owing to difficulties in annealing. The attempt to get a suitable glass gauge was, therefore, abandoned and attention was turned towards enamelled stoneware. A sample of this was obtained and submitted to the following tests: The enamelled stoneware was first cleaned with benzine to remove grease and six small rings of paraffin wax fixed on the surface. Inside one of the cells thus formed concentrated sulphuric acid was placed, in the second concentrated nitric acid, in the third solid caustic soda and water, in the fourth chromic acid mixture, in the fifth distilled water, and the sixth was left dry. A week later these were emptied and examined and no effect whatever was observed on the enamel. A small piece was heated to redness twice and water thrown on, the result being that a few small cracks only developed.

The glaze was thick and hard like glass and evidently contained zinc, since it became yellow when heated. The thickness of the stoneware was 7 mm.

It was decided after this to obtain six enamelled stoneware gauges for experimental use and these were accordingly ordered, but have not yet been received.

The use of a small gauge presents certain advantages owing to the small quantity of liquid to be transported, hence it should be of value for outlying stations.

In the Sixth Report mention was made of the effect of wind upon the deposit gauge in modifying the quantity of rain caught in the gauge. This matter received the attention of the Committee, and at Mr. Baxendell's suggestion it was decided to experiment with the gauge at Woodvale Moss, Southport, which, being in an exposed position, usually recorded less rain than a rain gauge in the immediate neighbourhood.

The effect of an obstruction, such as a deposit gauge when struck by the wind, is to introduce certain irregularities or eddies into the movement of the air. Should the air be moving uniformly in "stream line motion" the nature of the disturbance caused by an obstruction depends to a great extent upon the shape of the obstruction. When the wind strikes a vertical surface, such as the face of a cliff, there is a deflection upwards and an eddy formed at the top; it is most unlikely under such conditions, if rain is falling, that it will be equally distributed over the area affected by the eddy motion and areas not so affected. An attempt to avoid the effect of such disturbances upon rain gauges was made by the introduction of what is known as the "Nipher shield" or "funnel." This consists of an inverted conical-shaped shield fixed around the gauge with its base upwards and surrounding the mouth of the gauge at some distance away. The effect of such a shield upon the wind is to cause the deflection to take place downwards, so that we may conceive a wind passing over a gauge so protected to have a part sliced off by the sharp edge round the base of the cone and deflected downwards, while the air above the base of the cone flows on undisturbed and, therefore, the effect of the necessary obstruction due to the gauge upon deposit is eliminated, or at least minimised.

A Nipher shield was therefore constructed under Mr. Baxendell's supervision and fitted to the Woodvale Moss gauge in January 1921, and the only results available so far for comparison are February and March. In the following table a list is given showing the rainfall in millimetres at Woodvale Moss for each month as obtained from the deposit gauge and from the rain gauge, and in a parallel column the rainfall in the deposit gauge as a percentage of that in the rain gauge. It will be observed that in February and March the two gauges practically record similar rainfalls. Of course a period of two months is insufficient to base any conclusion upon, but the results should be available for the next annual report.

Date	Deposit Gauge.	Rain Gauge.	Deposit Gauge as Percentage of Rain Gauge.
April 1920 ...	93	111	84
May 1920	39	88	44
June 1920	78	87	90
July 1920	115	146	79
August 1920 ...	39	55	71
September 1920 ...	86	89	95
October 1920 ...	28	31	90
November 1920 ...	28	32	87
December 1920 ...	39	53	74
January 1921 ...	82	99	83
*February 1921 ...	18	18	100
*March 1921 ...	59	63	94

* With Nipher Shield.

The deposit gauges at the different stations were inspected by Dr. Owens, who reported on them to the Committee. Practically all were found to be in good condition and well attended to.

Experiments are being made by Dr. Ashworth of Rochdale with a twin gauge; the object being to ascertain, if possible, the direction from which the impurities deposited in the gauge come. These experiments are not yet completed, but the results are so far promising, and are described in the following note.

A TWIN ATMOSPHERIC POLLUTION GAUGE.

By J. R. Ashworth, D.Sc.

1. In certain cases it is of importance to know how much atmospheric impurity is carried into a town from neighbouring towns and how much is carried out into the surrounding districts. The town of Rochdale from its situation affords an example of the need of an instrument which will give this information, for it is necessary to know how much of the high deposit which falls in this town is due to outside causes before an attempt can be made within the borough to mitigate the evil.

Rochdale is protected on the north and east by the high moorlands of the Pennine Chain of hills which rise in places to an altitude of 1,500 feet above sea level, but is exposed on the south and west to winds passing over large smoke laden manufacturing areas. On the south are Royton and Oldham, on the south-west Castleton and Middleton, and on the west Heywood and Bury, all within a radius of six miles from Rochdale, and as the prevailing winds are westerly and south-westerly it was thought that a considerable amount of atmospheric impurity might be carried from these towns into Rochdale, and that that would account for its exceptionally high deposit.

At first some experiments were made with screens to determine the amount of impurity carried along with the wind, but as these were not successful a dual gauge was devised, of which a brief description is here given, and this has yielded the information required for the solving of the problem.

2. The gauge consists of two receivers which in the first design were metal cylindrical cans 5 inches in diameter and 18 inches high, painted on the outside, and coated on the inside with two layers of "Duroprene" varnish. They were placed vertically in sockets on a base board with their centres 19 inches apart and midway between them was fixed an upright rod of iron about 36 inches high upon which a sleeve closed at the upper end and about 15 inches in length fitted easily. To the lower part of this sleeve was soldered in a horizontal plane a semicircular sheet of zinc, 12 inches in radius, which could rotate with the sleeve round the upright iron rod, and so cover either one or the other of the receivers, but not both, at the same time. A slight inclination was given to the cover so as to allow the rain falling upon it to drain off in a direction away from the receivers. An oblong piece of zinc was attached vertically along one edge to the sleeve and along an adjacent edge to the middle of the semicircular cover and this served as a wind vane by which the cover was orientated according to the direction of the wind. Between the closed end of the sleeve and the upper end of the iron rod a steel bicycle ball was inserted, plentifully smeared with vaseline, a device which made the cover turn so easily that a very slight movement of the air was sufficient to control its direction.

This twin gauge could be set with the line joining the receivers in any direction, but the one chosen was the line running due East and West, so that the gauge would automatically sort out the amount deposited with easterly winds from that deposited from westerly winds.

3. The site selected for the gauge was at Roch Mills on land used as a sewage farm belonging to the Rochdale Corporation, one mile west of the centre of the town and close to the borough boundary. On this site there is an 8-inch rain gauge, read daily; and a wind vane at the top of a lofty pole by which observations of the wind are taken three times a day; the site has the further advantage that it is under constant supervision by men engaged on the farm and therefore no suspicion need be entertained of unauthorised interference with the working of the gauge. A control gauge was placed in the vicinity which, like the twin receivers, was made of metal well varnished and 5 inches in diameter, but it was replaced after two months trial by a large earthenware gauge coated with acid resisting glaze, 9·8 inches in diameter and 10 inches deep.

Observations were begun on 1st May 1920, and were carried on through the summer, but as traces of rust sometimes appeared in the water collected from the receivers in spite of the protecting varnish, they were replaced by glass receivers of the same diameter and about 10 inches in depth. The first complete results to which no objection could be raised were taken in November 1920, and since then a monthly record has been kept.

Another twin gauge has been constructed twice the size of the one described above, but observation with it cover too brief a period to be included in this report.

Month.	East.				West.				East + West.			Control.		
	Days of E. Wind.	Insoluble Matter.	Soluble Matter.	Total.	Days of W. Wind.	Insoluble Matter.	Soluble Matter	Total.	Insoluble Matter.	Soluble Matter.	Total.	Insoluble Matter.	Soluble Matter.	Total.
1920.														
November ...	12	2·06	1·27	3·33	18	3·20	3·05	6·25	5·26	4·32	9·58	4·50	1·99	6·49
December ...	16	3·25	1·42	4·67	12	2·62	2·02	4·64	5·87	3·44	9·31	3·04	2·71	5·75
1921.														
January ...	2	1·43	1·61	3·04	28	2·09	3·25	5·34	3·52	4·86	8·38	2·64	6·57	9·21
February ...	12	2·16	1·77	3·93	12	0·55	0·03	0·58	2·71	1·80	4·51	1·31	0·84	2·15
March ...	3	1·09	0·39	1·48	27	1·79	1·95	3·74	2·88	2·34	5·22	1·63	1·41	3·04
	45	9·99	6·46	16·45	97	10·25	10·30	20·55	20·24	16·76	37·00	13·12	13·52	26·64
× 0·72 ...	—	7·20	4·64	11·84	—	7·38	7·42	14·80	14·57	12·07	26·64	—	—	—
Per Day ...	—	0·160	0·103	0·263	—	0·076	0·076	0·152	0·097	0·080	0·177	—	—	—

4. The results obtained by the twin gauge are set out in a table given below and embrace the five months, November 1920 to March 1921; the insoluble, soluble, and total deposits are given separately for the east and west receivers, with the number of days of east and west winds, and, in subsequent columns, the sums of the east and west deposits, and, for the sake of comparison, the amounts caught in the control gauge, all expressed in metric tons per square kilometre.

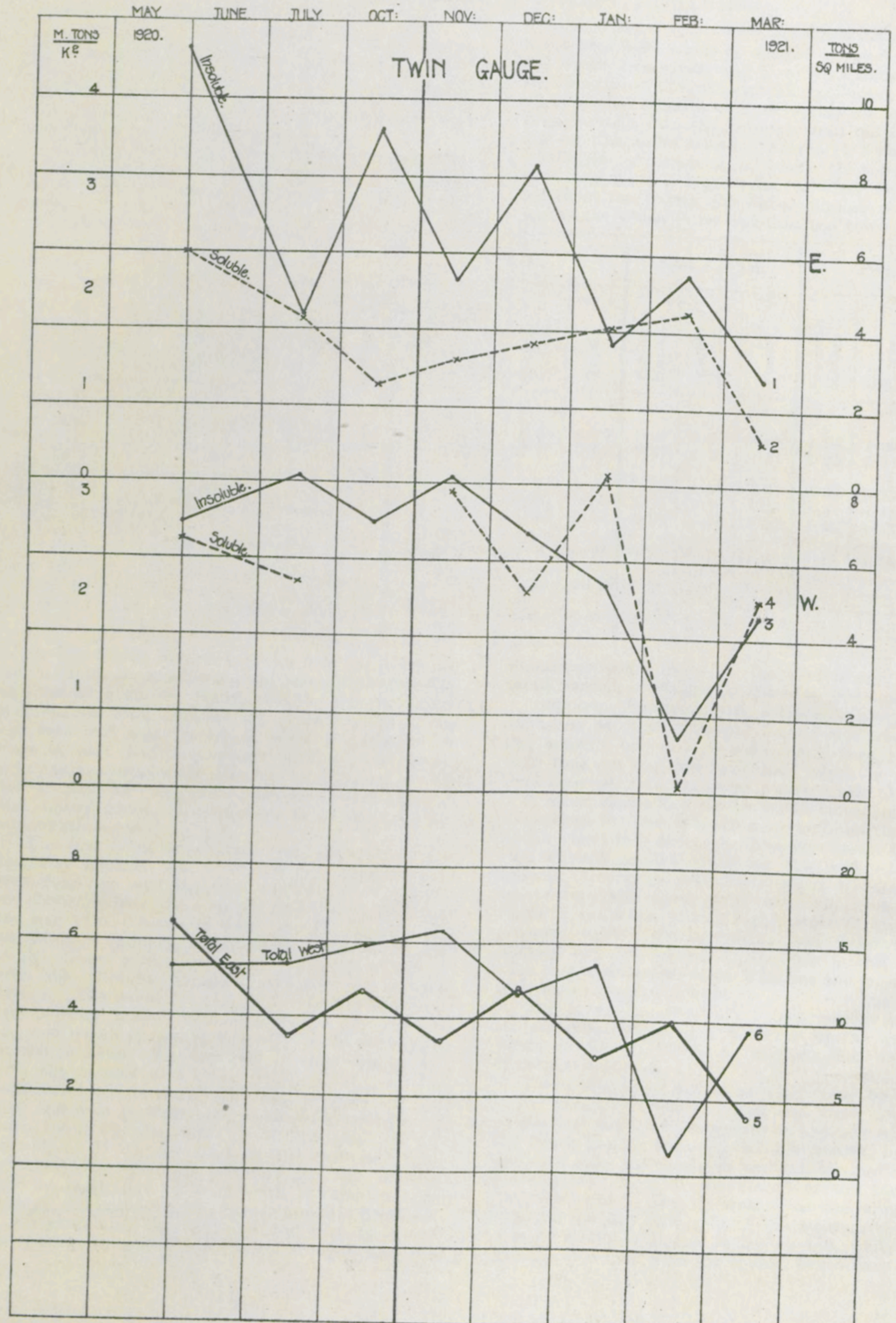
The first point which calls for notice is the discrepancy between the total sum of the east and west receivers and the total of the control gauge; we should expect these totals to be the same, but the sum of the east and west deposits is, with the exception of January, always larger than the deposit in the control gauge, and the discrepancy is greater with the insoluble matter than with the soluble matter. The cause for this difference has not been satisfactorily traced but experiments are now in progress which it is expected will throw some light on the problem. For the sake of easy comparison with the control and other similar gauges in the neighbourhood the total amounts recorded for the east and west receivers are reduced by multiplying them by 0·72, the ratio 26·64, the total of the control, to 37·00, the total of the east and west deposits. The quantity received per day of east wind and per day of west wind is calculated all through and entered under the appropriate headings.

On examining this table we find that 14·8 tons per square kilometre have been brought into the town with west winds as against 11·84 tons carried out by the east winds, and if we treat these numbers as measuring the atmospheric pollution, the net result is that about 3 tons per square kilometre have been brought into the borough from outside in the five months under review. This is 11·3 per cent. of what falls at Roch Mills, where the observations were taken, or 3·8 per cent. of what falls at the centre of the town; the latter number shows that the excess which is carried into the town from the smoke-producing areas on the west is only a very small fraction of what is produced in the town itself.

Suppose, however, we compare the amount deposited at Roch Mills per day of east wind with the amount per day of west wind, then we find 0·26 tons per day falls with east winds as against 0·15 tons per day with west winds, a raio of 1·7 to 1·0, which shows that the air which blows out of the town from the east is much more polluted than that which blows into the town from the west. Even if the amount carried away by the east winds be ignored, the gross amount brought by the west winds into the town from external smoke-laden areas is no more than 19 per cent. of the total received in the central gauge, and when this is allowed for, the deposit in Rochdale is still higher than that of any other town of its size and population for which there are records.

The conclusion from these observations is that the amount brought into Rochdale by the westerly winds is not sufficient to account for its high atmospheric pollution.

There is another deduction which may be made. If we analyse further the east and west deposits, we see that the insoluble matter on the east is about 1·5 times greater than the soluble matter, but on the west side the insoluble and soluble matter are nearly alike. Now at the centre of the town of Rochdale, which may be treated as the source of pollution on the east side of the twin gauge, the ratio of insoluble matter is 2·5 to 1·0, while at a distance of a mile from the source, as we have seen



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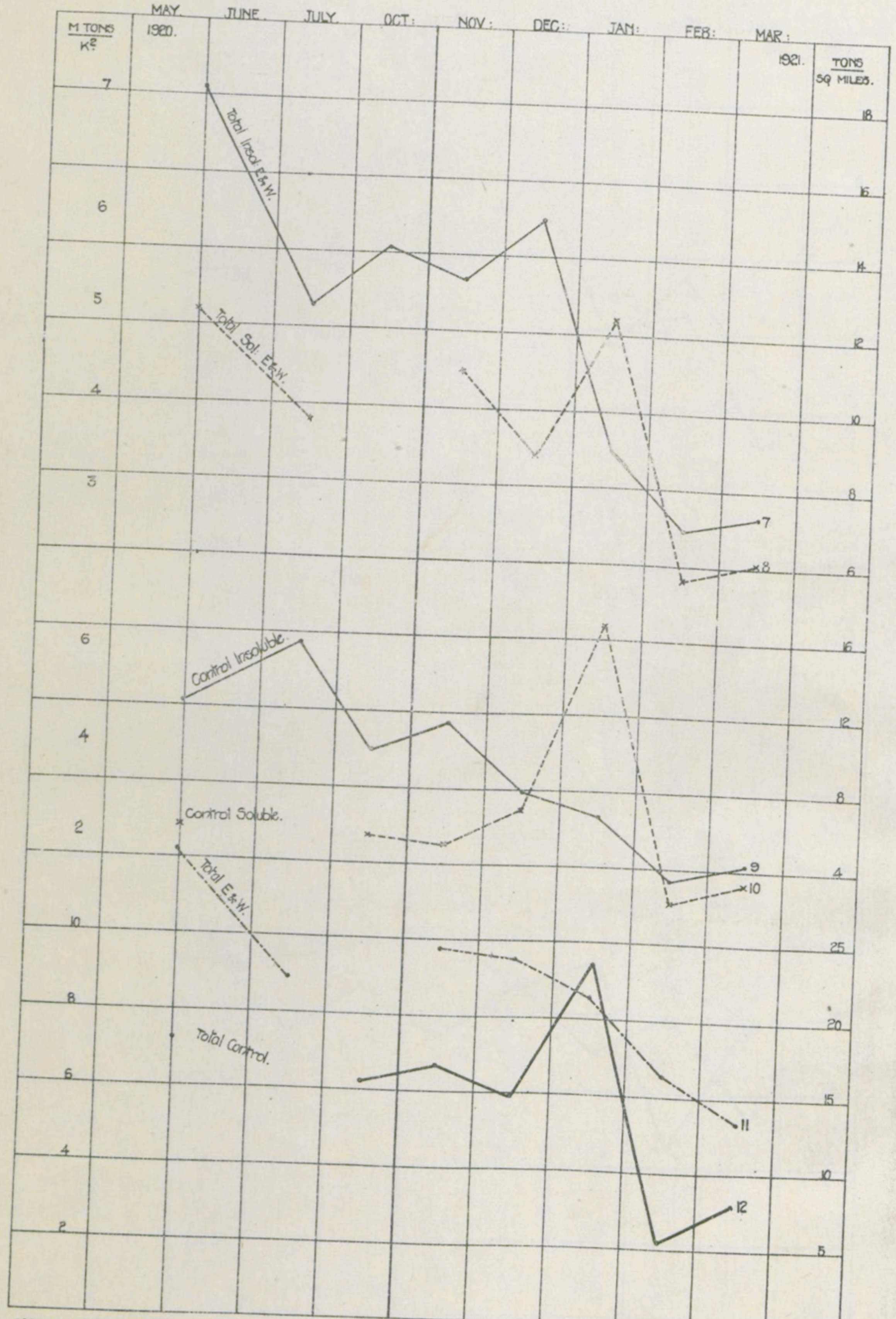
-FIG I.-



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-FIG 2.-

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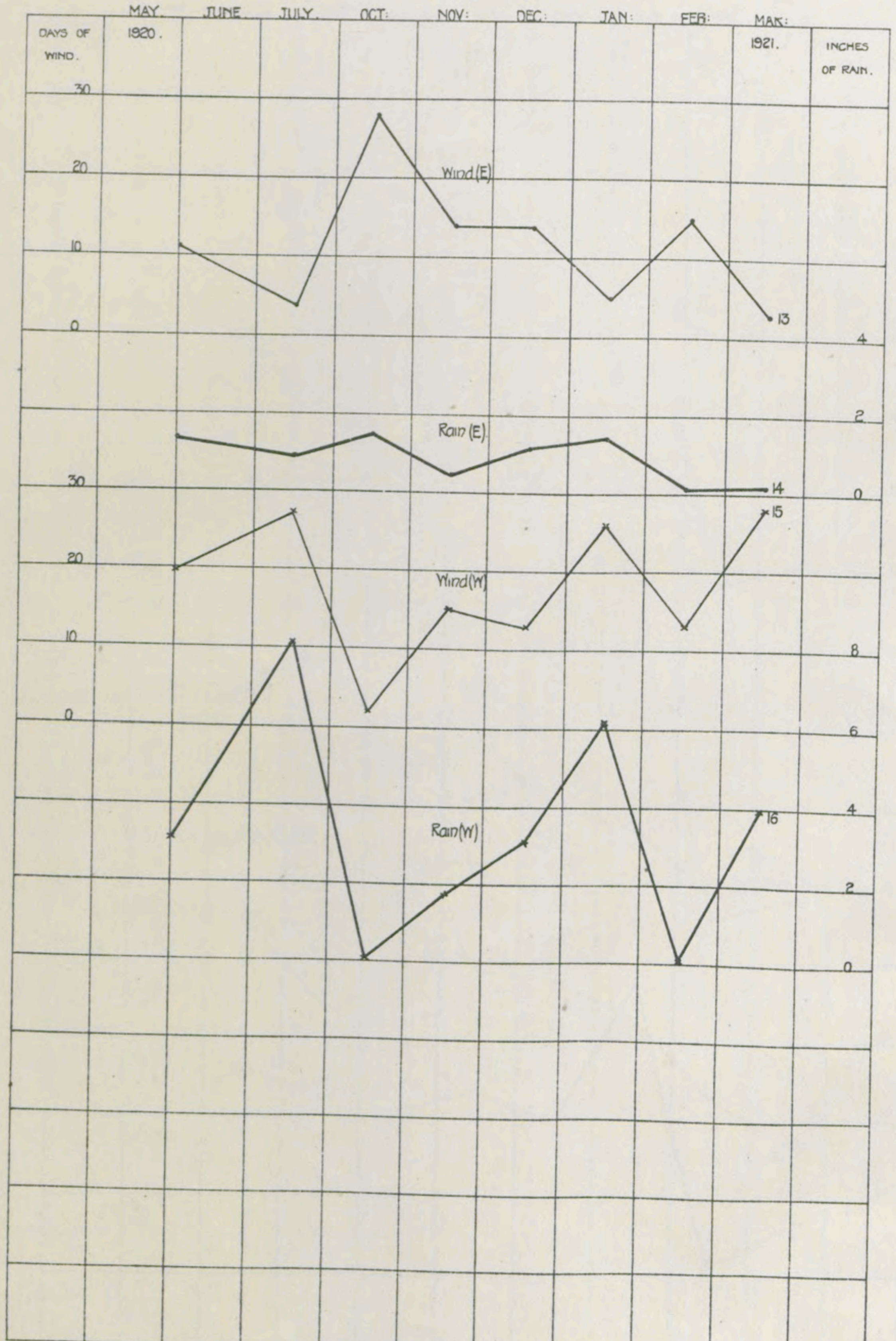

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- FIG 3.-

it is reduced to 1·5 to 1·0. On the west side of the twin gauge, the sources of pollution are further away than on the east side, and the ratio of insoluble to soluble becomes reduced still more, namely, to nearly 1·0 to 1·0. The inference is that the insoluble matter is deposited sooner and nearer to its source than the soluble matter, which, remaining longer in the air, travels with less loss to a distance. In all probability the insoluble matter is the heavier, and so settles down more quickly than the lighter soluble matter.

5. The amount of rain which has been received on the east and west side of the twin gauge cannot be told exactly because the receivers are only emptied once a month, and the water collected in them is constantly undergoing evaporation.

The record of rainfall which is available extends from May 1920 to March 1921, and in that time the rain gauge registered 44·10 inches of rain; if we dissect out from the daily record what falls with east winds and what falls with west winds, we find 8·76 inches precipitated with east winds and 35·34 with west winds, a ratio of almost exactly 1·0 to 4·0. Now the twin gauge registers 27·12 inches as the sum of both sides, of which 5·45 is on the east side and 21·67 on the west, again, a ratio of almost 1·0 to 4·0. This agreement, however, must be in part accidental, as the evaporation which has taken place would be in proportion, not to the volume precipitated, but to the area exposed and the time of exposure. From the fact that the control gauge registers 34·15 inches, instead of the true rainfall of 44·10 inches, the evaporation from its single surface must have been 10 inches; and since the two receivers of the twin gauge together register only 2712 inches, the joint evaporation from them must have been 17 inches; hence nearly double the evaporation goes on from the twin gauge, although only one receiver at a time is exposed.

It appears from this that the revolving cover is an insufficient protection against evaporation, no doubt because it does not fit closely to the top of the receiver over which it happens to be.

The twin gauge with which these observations have been taken has now been converted into a twin rain gauge with 5-inch funnel receivers, and a month's record with it gives 0·43 inch on the east side and 1·41 on the west side, a total of 1·84 inches, which agrees very well with 1·85 inches received in the adjacent 8-inch rain gauge. Thus the twin gauge used as a rain gauge is quite reliable as a measurer of rainfall.

6. The relation of the atmospheric deposits to each other and to the wind and rain are shown in a series of curves, numbered 1 to 19 (Figs. 1, 2, 3 and 4), which extend from May 1920 to March 1921, August and September being omitted as the records for these months were faulty. A vertical line has been drawn between October and November to separate the months previous to November—for which the observations are in some respects incomplete or doubtful—from the months included between November and March, for which the observations are complete and reliable. This division into two periods has another use inasmuch as it marks off a time of good trade, which ended with the coal strike

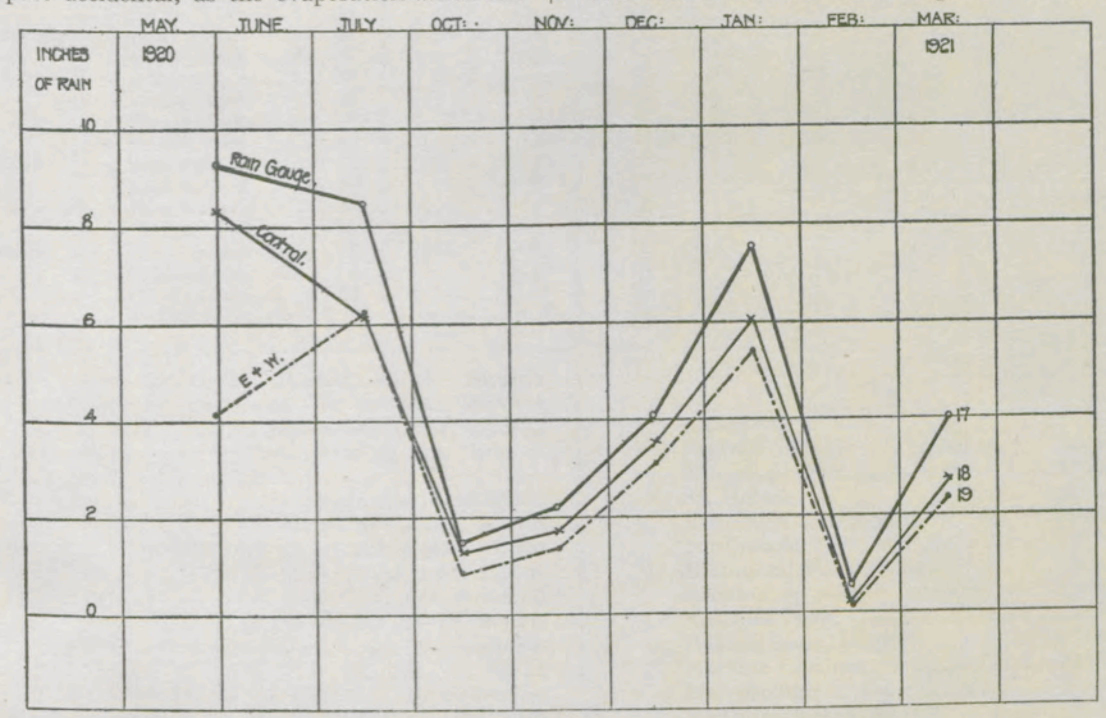


FIG. 4.

in October, from a time of bad trade, which has prevailed since then. The latter has been the cause of so much less pollution in the air that the total deposit has been little more than half its customary quantity during the past winter. Thus along with the other variables we must take into account the inequality in the supply of atmospheric impurities, a factor which has to be remembered particularly in comparing curves of pollution with curves of wind and rain.

Curves 1 and 2 show the fluctuations of the insoluble and soluble matter on the east side, and Curves 3 and 4 the same on the west side, and at once it is evident that there is an inverse relation between the insoluble matter on the east and on the west; such an inverse relation is not so easy to trace in the two curves of soluble matter. The sum of the insoluble and soluble on the east is plotted side by side with the sum of the insoluble and soluble on the west in Curves 5 and 6, and here again wherever one curve moves upwards the other curve moves downwards. The reason for this becomes clear when these curves are compared with the curves of days of east and west winds. As the number of days is approximately the same each month, a deficiency of days of easterly winds in any month must be accompanied by an excess of days of westerly winds (if the number of calm days is nearly negligible), and so, if the matter which falls from the atmosphere is deposited fairly regularly, day by day, it follows that curves of easterly and westerly deposits must be inversely related to one another.

As already mentioned the inverse relationship comes out prominently in the curves of total east and west deposit (Curves Nos. 5 and 6), and this result may be regarded as evidence that the twin gauge has in the main being giving a trustworthy record.

The next group of curves shows the variation of the sum of the east and west insoluble, soluble, and total matter collected in the twin gauge, and, for comparison, the same quantities registered by the control gauge.

Curves 13 to 16 show how the number of days of east winds and west winds and the east and west rainfall vary from month to month.

Lastly, there are three curves of rainfall: the upper one plotted from the daily observation of the rain gauge, the middle one from the monthly observations of the control gauge, and the lower one from the sum of the east and west twin receivers, and it will be seen, from the approximately equal separation of the curves, that the evaporation from the twin gauge is, month by month, nearly double of that from the control gauge, a fact to which reference has been made in a former paragraph.

RESULTS FOR YEAR ENDING MARCH 31st, 1921.

Table 1 shows the detail figures of deposit for two stations, representing high and low deposits respectively. As representing low deposits, Rothamsted station has been selected, as the returns were complete for the year. In previous reports Malvern has been given as representing low deposit, but the returns were not complete at the time of preparation of the report.

	Metric Tons per Sq. Kilometre.
Rochdale	24·85
Birmingham (Central)	21·18
Newcastle-on-Tyne	17·38

Table I.—*Monthly Deposit at two selected Stations.—Birmingham (Central) and Rothamsted.*

Month.	Station.	Rainfall in Millimetres.	Metric tons per square Kilometre.								
			Insoluble matter.			Soluble matter.		Total Solids.	Included in soluble matter.		
			Tar.	Carbonaceous other than tar.	Ash.	Loss on ignition.	Ash.		Sulphate (SO^3)	Chlorine (Cl)	Ammonia (NH^3)
1920.											
April ...	Birmingham ...	100	0·18	3·39	10·12	1·64	4·99	20·32	2·68	0·66	0·15
,, ...	Rothamsted ...	88	—	0·45	0·54	1·75	1·03	3·77	—	—	—
May ...	Birmingham ...	65	0·11	3·94	13·23	1·45	3·41	22·14	1·59	0·30	0·19
,, ...	Rothamsted ...	32	—	0·67	0·96	0·96	1·33	3·92	—	—	—
June ...	Birmingham ...	74	0·24	5·20	13·95	1·32	4·16	24·87	2·98	0·37	0·16
,, ...	Rothamsted ...	48	—	0·58	0·79	1·05	1·60	4·02	—	—	—
July ...	Birmingham ...	90	0·13	5·26	13·43	2·11	4·22	25·15	2·40	0·45	0·14
,, ...	Rothamsted ...	117	—	0·65	1·52	1·41	2·09	5·67	—	—	—
August ...	Birmingham ...	50	0·13	6·42	13·76	1·46	3·48	25·25	1·73	0·26	0·05
,, ...	Rothamsted ...	32	—	0·40	0·68	0·39	1·65	3·12	—	—	—
September ...	Birmingham ...	52	0·18	4·99	15·85	1·86	4·40	27·28	2·18	0·31	0·10
,, ...	Rothamsted ...	51	—	0·43	0·63	0·92	2·12	4·10	—	—	—
October ...	Birmingham ...	60	0·19	6·18	16·60	1·74	4·22	28·93	2·31	0·34	0·13
,, ...	Rothamsted ...	37	—	0·40	0·67	1·40	2·11	4·58	—	—	—
November ...	Birmingham ...	18	0·15	3·99	9·09	1·63	3·38	18·24	1·91	0·18	0·04
,, ...	Rothamsted ...	41	—	0·48	0·76	1·24	1·95	4·43	—	—	—
December ...	Birmingham ...	60	0·10	3·62	6·92	1·61	4·42	16·67	2·34	0·47	0·12
,, ...	Rothamsted ...	49	—	0·61	0·83	0·69	3·02	5·15	—	—	—
January 1921	Birmingham ...	58	0·12	2·12	8·43	1·28	3·62	15·57	1·85	0·35	0·12
,, ...	Rothamsted ...	60	—	0·37	0·43	0·71	2·84	4·35	—	—	—
February ...	Birmingham ...	3	0·12	2·84	9·18	0·80	2·10	15·04	1·10	0·15	0·01
,, ...	Rothamsted ...	5	—	0·30	0·40	0·75	1·89	3·34	—	—	—
March ...	Birmingham ...	27	0·14	2·46	7·90	1·29	2·88	14·67	1·19	0·32	0·08
,, ...	Rothamsted ...	25	—	0·46	0·61	1·06	2·11	4·24	—	—	—

Referring to Table II., in which the total solids deposited monthly for all stations are given, it will be seen that the highest mean monthly deposit for the year was at Rochdale with 24·85 metric tons per square kilometre, although this was followed closely by Birmingham (Central) with 21·18 metric tons per square kilometre. In the case of Liverpool, which shows a mean monthly deposit of 17·18 metric tons per square kilometre, the three months, April, May and June 1920 are missing, and this results in an abnormally high mean monthly deposit, as calculated from the nine remaining months, since April, May and June are normally months of very low deposit.

In the following list the stations shown in Table II. are arranged in the order of the mean monthly deposit :—

	Metric Tons per Sq. Kilometre.
Liverpool	17·18
Blythswood Square, Glasgow ...	14·44
Kingston-upon-Hull	13·53
St. Helens	12·37
Birmingham (Aston)	12·36
Southwark Park, London ...	12·19
Richmond Park, Glasgow ...	12·00
Archbishop's Park, London ...	11·81
Tolcross Park, Glasgow ...	11·70
Golden Lane, London ...	11·42
Botanic Gardens, Glasgow ...	11·29
Meteorological Office, London	11·26
Victoria Park, Glasgow ...	9·74
Bellahouston Park, Glasgow ...	9·54
Ruchill Park, Glasgow ...	9·05
Ravenscourt Park, London ...	9·04
Queen's Park, Glasgow ...	8·42
Wandsworth Common, London	8·24
Alexandra Park, Glasgow ...	8·20
Victoria Park, London ...	7·92

	Metric Tons per Sq. Kilometre.
Finsbury Park, London ...	7·48
Southport (Hesketh Park) ...	6·11
Southport (Woodvale Moss) ...	5·50
Rothamsted	4·22
Malvern	—

Comparison with Previous Figures.

Tables III. and IV., as in previous reports, show the deposits for the summer and winter months respectively of the years 1919–20 and 1920–21.

To assist in a comparison of the figures as set forth in Tables III. and IV., analyses have been prepared and are given in Tables A and B.

TABLE II.—*Total Solids deposited monthly at all Stations in Metric Tons per square Kilometre.*

Station	April.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Mean Monthly Deposit for Years.
London :													
Meteorological Office	14·86	13·12	15·71	18·33	10·91	12·14	10·03	9·67	10·36	5·77	6·79	7·42	11·26
Archbishop's Park	10·89	11·32	15·38	19·92	5·48	23·11	15·40	11·74	14·74	6·18	3·12	11·46	11·81
Finsbury Park ...	11·61	9·69	10·61	—	6·02	5·22	7·54	8·73	5·39	5·20	5·45	6·78	7·48
Ravenscourt Park	16·50	8·64	10·24	9·54	5·95	10·77	8·87	10·14	7·25	4·69	4·89	11·02	9·04
Southwark Park ...	11·62	10·46	12·19	13·05	6·49	14·63	9·62	12·52	16·91	9·58	5·80	22·30	12·19
Victoria Park ...	8·94	7·32	10·86	12·23	5·29	5·82	9·71	9·08	6·43	5·75	5·14	8·52	7·92
Wandsworth Common	7·47	6·68	6·81	12·61	5·05	10·71	12·40	7·04	12·19	4·70	4·99	8·28	8·24
Golden Lane ...	11·50	8·08	10·86	13·83	7·79	18·33	12·22	11·44	14·78	10·49	8·02	9·57	11·42
Malvern	1·53	1·36	2·15	2·61	1·22	2·43	3·07	3·69	—	—	—	—	—
St. Helens	24·04	22·14	8·26	11·94	16·99	7·37	5·46	13·08	12·51	11·90	5·46	9·31	12·37
Southport :													
Hesketh Park ...	6·67	7·35	7·45	11·09	5·54	5·82	2·67	4·46	9·24	8·12	0·99	3·97	6·11
Woodvale Moss ...	5·49	4·91	8·51	9·52	3·88	6·98	3·53	3·29	6·25	8·34	1·99	3·23	5·50
Rochdale	26·93	41·51	41·51	36·97	25·61	25·61	20·89	14·62	13·55	21·04	11·57	18·34	24·85
Rothamsted ...	3·77	3·92	4·02	5·67	3·12	4·10	4·58	4·43	5·15	4·35	3·34	4·24	4·22
Birmingham, Aston ...	14·51	—	—	18·84	15·65	12·20	9·30	10·32	9·74	9·52	9·14	14·35	12·36
Central	20·32	22·14	24·87	25·15	25·25	27·28	28·93	18·24	16·67	15·57	15·04	14·67	21·18
South Western ...	7·98	7·41	6·47	5·62	5·28	5·69	5·91	3·96	4·68	2·96	4·13	5·89	5·41
Kingston-upon-Hull ...	15·23	14·39	11·68	15·89	13·38	14·31	14·47	14·22	20·24	8·83	10·22	9·46	13·53
Liverpool	—	—	—	18·37	15·50	15·46	14·14	14·94	26·03	20·57	13·99	15·79	17·18
Newcastle-on-Tyne ...	13·30	33·40	18·36	14·05	14·17	15·20	24·56	12·38	18·35	11·45	10·58	12·83	17·39
Glasgow :													
Alexandra Park ...	5·98	10·25	13·88	9·64	9·00	9·07	3·30	7·86	8·55	9·90	4·29	7·68	8·20
Bellahouston Park	4·50	11·39	6·51	8·35	19·59	10·66	7·86	13·14	11·46	7·71	4·26	9·08	9·54
Blythswood Square	21·01	17·91	15·45	16·22	12·14	16·05	10·35	18·44	14·79	10·57	8·86	11·50	14·44
Botanic Gardens ...	6·84	15·63	13·05	18·00	10·31	12·70	5·93	13·40	11·95	12·66	6·02	9·09	11·29
Queen's Park ...	4·58	14·07	7·33	10·46	10·98	7·78	6·62	10·33	6·61	10·80	4·44	5·96	8·42
Richmond Park ...	5·95	9·06	9·68	10·88	14·81	16·20	11·80	19·42	15·41	11·24	8·70	10·89	12·00
Ruchill Park ...	6·39	12·62	8·92	8·91	9·30	7·97	5·10	11·32	12·39	9·69	5·78	9·57	9·05
Tolcross Park ...	8·87	12·42	10·72	17·86	17·36	11·48	6·60	14·48	6·70	12·02	8·85	13·14	11·70
Victoria Park ...	7·62	13·93	9·08	5·74	15·97	8·97	6·12	14·27	10·40	12·10	6·61	7·09	9·74
Stirling	—	—	—	—	—	—	7·18	10·70	7·87	—	—	—	—

TABLE A.—*Total Solids deposited in Summer Months, 1920, expressed as Percentages of Deposit in the same Months, 1919.*

Increased in 1920.	%	Diminished in 1920.	%
London :—		London :—	
Meteorological Office	207	Finsbury Park ...	94
Victoria Park ...	175	Ravenscourt Park	55
Golden Lane ...	110	Southwark Park	59
St. Helens	142	Glasgow :—	
Southport :—		Richmond Park	94
Hesketh Park ...	120	Ruchill Park ...	99
Woodvale Moss	117	Victoria Park ...	99
		Malvern	51

Increased in 1920.		Diminished in 1920.
Glasgow :—		
Alexandra Park...	113	
Bellahouston Park	122	
Blythswood Square	149	
Botanic Gardens	124	
Queen's Park ...	111	
Tolcross Park ...	109	
Rothamsted	111	

TABLE B.—*Total Solids deposited in Winter Months, 1920–21, expressed as Percentage of Deposit in the same Months, 1919–20.*

Increased in 1920–21.	%	Diminished in 1920–21.	%
London :—		London :—	
Southwark Park	107	Meteorological Office	83
Newcastle-on-Tyne	103	Finsbury Park ...	52
Glasgow :—		Ravenscourt Park	92
Blythswood Square	105	Victoria Park ...	69
Richmond Park ...	104	Wandsworth Common ...	93
		Golden Lane ...	92
		St. Helens	58
		Southport :—	
		Hesketh Park ...	73
		Woodvale Moss ...	87

Diminished in 1920–21.	
Rochdale	56
Rothamsted	98
Kingston-upon-Hull	93
Glasgow :—	
Alexandra Park	63
Bellahouston Park	94
Botanic Gardens	85
Queen's Park ...	96
Ruchill Park ...	91
Tolcross Park ...	90
Victoria Park ...	89

TABLE III.—*Summer Results. Comparison of Mean Monthly Deposits for each Station for Half Years,—April–September* 1920.

Station.	—	Rainfall in Millimetres.	Insoluble matter. Tar.	Insoluble matter. Carbonaceous other than tar.	Insoluble matter. Ash.	Soluble matter. Loss on ignition.	Soluble matter. Ash.	Total Solids.	Included in soluble matter. Sulphate (SO_3).	Included in soluble matter. Chlorine (Cl).	Included in soluble matter. Ammonia (NH_3).	No. of months used for average.
London :												
Meteorological Office	1919	46	0·11	1·50	1·93	1·87	1·45	6·85	0·72	0·54	0·05	6
	1920	56	0·43	3·76	3·94	2·74	3·47	14·18	1·08	1·22	0·02	6
Finsbury Park ...	1919	46	0·09	1·02	4·18	1·48	2·42	9·18	1·42	0·37	0·07	6
	1920	52	0·09	1·17	3·52	1·61	2·54	8·63	0·56	1·15	0·07	5
Ravenscourt Park ...	1919	41	0·16	3·31	10·36	1·98	2·73	18·53	1·66	0·52	0·18	5
	1920	59	0·22	1·72	3·94	1·70	2·70	10·28	0·89	1·26	0·12	6
Southwark Park ...	1919	45	0·06	3·76	7·71	4·30	3·60	19·43	3·75	0·64	0·29	5
	1920	52	0·13	2·42	4·98	1·46	2·41	11·40	0·84	0·82	0·10	6
Victoria Park ...	1919	33	0·03	0·56	1·43	1·08	1·68	4·78	1·21	0·28	0·11	6
	1920	53	0·08	1·42	2·96	1·69	2·28	8·41	0·91	1·26	0·10	6
Golden Lane ...	1919	41	0·08	2·28	4·05	1·19	3·02	10·61	1·54	0·54	0·62	6
	1920	50	0·04	2·96	3·69	1·31	3·73	11·73	1·24	1·39	0·18	6
Malvern	1919	46	—	0·18	0·52	0·64	2·36	3·69	1·30	0·27	0·11	6
	1920	69	—	0·16	0·25	0·38	1·10	1·87	0·41	0·10	0·01	6
St. Helens	1919	55	0·09	1·30	3·25	2·04	3·99	10·67	1·78	0·92	0·07	5
	1920	97	0·15	2·49	5·01	1·64	5·83	15·12	2·84	1·13	0·03	6
Southport :												
Hesketh Park ...	1919	46	0·02	0·51	1·48	0·96	3·16	6·12	1·07	0·46	0·04	6
	1920	85	0·04	0·56	0·66	1·85	4·21	7·32	0·72	1·43	0·05	6
Woodvale Moss ...	1919	40	—	—	—	—	—	5·58	—	—	—	6
	1920	75	—	—	—	—	—	6·55	—	—	—	6
Rothamsted	1919	40	0·03	0·47	0·65	0·91	1·65	3·69	—	—	—	6
	1920	61	—	0·53	0·85	1·08	1·64	4·10	—	—	—	6
Glasgow :												
Alexandra Park ...	1919	46	0·05	1·27	3·13	1·42	2·67	8·53	1·50	0·41	0·10	6
	1920	73	0·11	2·31	3·51	1·57	2·14	9·64	0·96	1·41	0·12	6
Bellahouston Park ...	1919	45	0·08	1·49	2·43	1·05	3·17	8·26	1·45	0·26	0·06	6
	1920	75	0·15	1·49	1·96	2·61	3·92	10·13	0·99	1·67	0·09	6
Blythswood Square	1919	56	0·10	1·79	4·06	2·01	3·10	11·06	1·62	0·28	0·14	5
	1920	83	0·21	2·95	6·31	2·80	4·19	16·46	1·42	1·81	0·23	6
Botanic Gardens ...	1919	53	0·05	1·31	3·25	1·81	3·86	10·28	1·89	0·22	0·06	6
	1920	72	0·25	2·10	4·87	2·18	3·35	12·75	1·03	1·54	0·17	6
Queen's Park ...	1919	52	0·03	1·11	2·57	1·08	3·46	8·28	1·52	0·19	0·06	6
	1920	79	0·22	1·49	2·72	1·62	3·15	9·20	0·98	1·33	0·37	6
Richmond Park ...	1919	49	0·06	2·06	3·62	1·85	4·03	11·82	1·80	0·31	0·10	6
	1920	74	0·18	2·00	4·16	1·71	3·05	11·10	1·01	1·67	0·12	6
Ruchill Park ...	1919	58	0·05	1·38	3·29	1·31	3·15	9·19	1·57	0·23	0·08	6
	1920	88	0·08	1·64	3·13	1·43	2·81	9·09	2·30	1·93	0·11	6
Tolcross Park ...	1919	55	0·09	2·00	4·38	1·54	4·04	12·05	1·93	0·23	0·08	5
	1920	77	0·36	2·31	4·88	2·20	3·31	13·10	1·06	1·19	0·12	6
Victoria Park ...	1919	54	0·04	1·21	3·15	1·77	4·01	10·18	2·29	0·23	0·11	6
	1920	76	0·21	2·16	3·26	1·47	2·95	10·05	1·12	1·30	0·39	6

TABLE IV.—*Winter Results. Comparison of Meaan Monthly Deposit for each Station for Half Years: October–March,* 1919–1920, 1920–1921.

Station.	—	Rainfall in Millimetres.	Insoluble matter. Tar.	Insoluble matter. Carbonaceous other than tar.	Insoluble matter. Ash.	Soluble matter. Loss on ignition.	Soluble matter. Ash.	Total Solids.	Included in soluble matter. Sulphate (SO_3).	Included in soluble matter. Chlorine (Cl).	Included in soluble matter. Ammonia (NH_3).	No. of months used for average.
						Tons per square kilometre.						
London: Meteorological Office	1919–1920	35	0·23	2·30	4·50	1·38	1·60	10·02	0·69	0·66	0·04	6
	1920–1921	27	0·20	1·68	3·67	1·12	1·67	8·34	0·74	0·64	0·06	6
Finsbury Park ...	1919–1920	44	0·09	1·49	4·72	2·06	4·02	12·37	2·15	0·52	0·08	6
	1920–1921	33	0·10	1·15	2·86	0·87	1·55	6·52	0·82	0·48	0·07	6
Ravenscourt Park	1919–1920	34	0·07	0·93	2·71	1·74	3·08	8·53	1·64	0·43	0·13	4
	1920–1921	32	0·15	1·59	3·53	1·04	1·50	7·81	1·02	0·48	0·09	6
Southwark Park	1919–1920	39	0·08	1·77	3·60	2·17	4·33	11·95	2·34	0·60	0·13	6
	1920–1921	27	0·39	3·69	5·28	1·27	2·17	12·79	1·15	0·53	0·09	6
Victoria Park ...	1919–1920	30	0·06	1·57	4·26	1·73	3·14	10·76	1·76	0·47	0·06	5
	1920–1921	31	0·13	1·74	3·08	0·94	1·54	7·44	0·94	0·44	0·06	6
			(1919–20 Results not very reliable.)									
Wandsworth Common	1919–1920	37	0·16	0·84	2·29	2·02	3·67	8·88	1·86	0·59	0·28	6
	1920–1921	24	0·31	2·18	3·37	1·09	1·33	8·27	0·67	0·54	0·06	6
Golden Lane ...	1919–1920	42	0·06	2·72	4·13	1·60	3·58	12·09	1·72	0·80	0·20	5
	1920–1921	31	0·07	2·77	3·71	1·19	3·35	11·09	1·45	0·75	0·13	6
Malvern	1919–1920	57	—	0·14	0·38	0·59	1·41	2·56	0·84	0·18	0·06	5
	1920–1921	—	—	—	—	—	—	—	—	—	—	—
St. Helens ...	1919–1920	88	0·22	2·53	4·51	0·75	8·46	16·47	1·76	1·29	0·10	6
	1920–1921	47	0·10	2·33	2·84	1·20	3·14	9·62	1·12	1·05	0·02	6
Southport: Hesketh Park ...	1919–1920	79	0·03	0·54	1·03	1·24	3·84	6·69	1·23	0·82	0·06	6
	1920·1921	50	0·07	0·60	0·78	1·04	2·42	4·91	0·70	1·01	0·02	6
Woodvale Moss	1919–1920	66	—	—	—	—	—	5·10	—	—	—	6
	1920–1921	42	—	—	—	—	—	4·44	—	—	—	6
Rochdale	1919–1920	136	—	—	—	—	—	29·95	—	—	—	5
	1920–1921	76	—	—	—	—	—	16·67	—	—	—	6
Rothamsted ...	1919–1920	48	—	0·45	0·50	1·29	2·22	4·46	—	—	—	—
	1920–1921	36	—	0·44	0·62	0·97	2·32	4·35	—	—	—	—
Kingston-upon-Hull	1919–1920	61	0·15	1·74	4·16	1·88	6·01	13·93	2·57	1·03	0·06	6
	1920–1921	33	0·15	2·37	4·13	1·74	4·51	12·90	2·20	0·56	0·07	6
Newcastle-on-Tyne	1919–1920	73	0·30	3·11	5·69	2·10	3·70	14·90	1·91	0·74	0·13	5
	1920–1921	47	0·30	3·27	6·81	1·47	3·19	15·04	1·30	0·56	0·09	6
Glasgow: Alexandra Park	1919–1920	81	0·05	1·19	2·65	2·84	3·92	10·65	1·92	1·14	0·12	5
	1920–1921	68	0·11	1·13	2·05	1·42	2·06	6·76	1·28	0·87	0·13	6
Bellahouston Park	1919–1920	88	0·05	0·88	1·67	2·62	4·27	9·49	1·89	1·49	0·06	6
	1920–1921	87	0·15	1·31	2·25	2·17	3·02	8·91	1·52	0·97	0·17	6
Blythswood Square	1919–1920	96	0·08	1·10	2·85	3·12	4·64	11·79	2·12	1·44	0·14	5
	1920–1921	77	0·19	2·53	3·98	1·99	3·72	12·42	2·02	1·09	0·16	6
Botanic Gardens	1919–1920	97	0·07	1·30	2·52	2·97	4·68	11·54	2·49	1·13	0·12	6
	1920–1921	80	0·11	2·06	2·45	1·44	3·78	9·84	1·44	0·84	0·13	6
Queen's Park ...	1919–1920	101	0·06	0·76	1·62	1·86	3·45	7·74	1·72	1·15	0·08	6
	1920·1921	73	0·12	1·13	2·02	1·19	2·99	7·46	1·21	0·73	0·09	6
Richmond Park	1919–1920	102	0·09	1·42	3·65	2·76	4·54	12·47	2·28	1·22	0·33	6
	1920–1921	76	0·17	2·53	3·93	1·72	4·56	12·91	2·09	0·83	0·15	6
Ruchill Park ...	1919–1920	97	0·07	1·39	2·39	2·54	3·56	9·95	2·34	1·11	0·12	5
	1920–1921	85	0·12	1·83	2·37	1·15	3·55	9·02	1·47	0·94	0·12	6
Tolcross Park ...	1919–1920	97	0·10	1·43	3·26	2·45	4·16	11·40	2·44	1·09	0·11	6
	1920–1921	91	0·15	1·74	2·52	2·04	3·85	10·30	1·63	0·81	0·11	6
Victoria Park ...	1919–1920	96	0·11	1·12	1·95	2·95	4·49	10·61	1·95	1·30	0·12	5
	1920–1921	86	0·12	1·59	2·21	1·44	4·07	9·43	1·57	0·97	0·14	6

In these tables the different stations are compared on the basis of total solids deposited, and in Table A in the left-hand column the stations are shown in which the deposits in the summer of 1920 were greater than in the previous summer; the figures opposite each station indicate the percentage ratio of the deposit in 1920 to that in 1919; for example, the figure opposite Meteorological Office, London, that is, 207 per cent., indicates that the deposit was 2·07 times the deposit in the previous summer.

The right-hand column gives a list of the stations showing a diminished deposit in the summer of 1920 as compared with the previous summer.

A consideration of this table shows that the number of stations having an increased deposit in 1920 was greater than the number having a smaller deposit. Referring now to Table B, in which a comparison of the winter months of 1920–21 is made with the previous winter, we note that out of a total of 23 stations the deposit in the winter of 1920–21 was less than in the previous winter in 19 cases. The deposit was greater in four, but the increase in these four stations did not, in any case, exceed 7 per cent.

It is thus curious to note that there was a fairly general increase in the summer deposits and a reduction in the winter deposits of the year 1920–21.

A great increase is shown in the Meteorological Office gauge during the summer months, and this is not due to an increase in any particular element of pollution but to an increase in practically all. Although the total solids in the summer of 1920 were 207 per cent. of those in the summer of 1919, it is of interest to observe that the rainfall in the summer of 1920, although slightly increased, was only 122 per cent. of that for the previous summer.

In Tables III. and IV., and their analyses A and B, certain stations are omitted as not having a sufficient number of months' records for comparison. These stations include the London County Council station at Archbishop's Park, London, a new station which commenced work in January 1920. This station was substituted for that at Embankment Gardens, which appears in previous reports, and which was abandoned owing to the site of the gauge not being such as to give reliable results.

Although there are three stations in Birmingham, they had ceased operations during the war and only commenced again in January 1920. Rochdale and Newcastle-on-Tyne recommenced observations in October 1919 and Kingston-upon-Hull in November 1919. The figures for the last three stations are not, therefore, available for comparison with the summer of 1920. Stirling sent only two records during 1919, that is for October and November, hence no comparison could be made with the present year.

It is also to be regretted that the two stations which were referred to in the last Annual Report as being about to commence observations, that is Wishaw and Worthing, have not yet been in a position to do so.

Classification under Letters A, B, C, D.

Stations have been classified as in previous reports into four groups under the above letters. The basis of comparison is again given below for convenience of reference.

Class A includes the stations which have less than 1 unit of deposit per square kilometre.

Class B, the stations which have between 1 and 3 units of deposit per square kilometre.

Class C, the stations which have between 3 and 5 units of deposit per square kilometre.

Class D, the stations which have 5 or more units of deposit per square kilometre.

The unit has been adjusted to suit each separate element, but the proportional division has been kept the same throughout. Thus for "total solids" the unit is 5 tons and the law of classification is:—

Class A, less than 5 tons per square kilometre per month.

Class B, from 5 to 15 tons per square kilometre per month.

Class C, from 15 to 25 tons per square kilometre per month.

Class D, 25 or more tons per square kilometre per month.

It will be understood that the figure 5 belongs to Class B, not Class A, and so on. The units and limits in the several cases are shown in tabular form below:—

Insoluble Matter.

—	Unit. Tons per sq. kilo. per m'th.	Limits. A. Less than.	B.	C.	D. Over.
Tar - -	0·05	0·05	0·05–0·15	0·15–0·25	0·25
Carbonaceous, other than tar ...	1	1	1–3	3–5	5
Ash	2	2	2–6	6–10	10
	Soluble Matter.				
Loss on Ignition ...	0·75	0·75	0·75–2·25	2·25–3·75	3·75
Ash	1·5	1·5	1·5–4·5	4·5–7·5	7·5
Total Solids...	5	5	5–15	15–25	25
Sulphates ...	1	1	1–3	3–5	5
Chlorine ...	0·3	0·3	0·3–0·9	0·9–1·5	1·5
Ammonia ...	0·05	0·05	0·05–0·15	0·15–0·25	0·25

The classification is based upon the figures given in Tables III. and IV. and, as in previous reports, has been summarised in Tables VII. and VIII.; the stations included in the latter two tables are those which have a complete 5 or 6 months' observations for the summer and winter.

TABLE V.—*Classification (Summer Months)—April–September* 1920.

Station.	Rainfall in Millimetres.	Insoluble matter. Tar.	Insoluble matter. Carbonaceous other than tar.	Insoluble matter. Ash.	Soluble matter. Loss on ignition.	Soluble matter. Ash.	Total solids.	Included in soluble matter. Sulphate (SO_3).	Included in soluble matter. Chlorine (Cl).	Included in soluble matter. Ammonia (NH_3).	Summary. A.	Summary. B.	Summary. C.	Summary. D.	No. of Months.
London :															
Meteorological Office	56	D	C	B	C	B	B	B	C	A	1	4	3	1	6
Archbishop's Park ...	55	C	B	B	B	B	B	B	C	B	0	7	2	0	6
Finsbury Park ...	52	B	B	B	B	B	B	A	C	B	1	7	1	0	5
Ravenscourt Park ...	59	C	B	B	B	B	B	A	C	B	1	6	2	0	6
Southwark Park ...	52	B	B	B	B	B	B	A	B	B	1	8	0	0	6
Victoria Park ...	53	B	B	B	B	B	B	A	C	B	1	7	1	0	6
WandsworthCommon	51	B	B	B	B	B	B	A	C	B	1	7	1	0	6
Golden Lane ...	50	A	B	B	B	B	B	B	C	C	1	6	2	0	6
Malvern	69	A	A	A	A	A	A	A	A	A	9	0	0	0	6
St. Helens	97	C	B	B	B	C	C	B	C	A	1	4	4	0	6
Southport :															
Hesketh Park ...	85	A	A	A	B	B	B	A	C	B	4	4	1	0	6
Woodvale Moss ...	75	—	—	—	—	—	B	—	—	—	0	1	0	0	6
Rochdale	127	—	—	—	—	—	D	—	—	—	0	0	0	1	6
Rothamsted	61	—	A	A	B	B	A	—	—	—	3	2	0	0	6
Birmingham, Aston ...	72	B	B	C	B	B	C	B	B	B	0	7	2	0	4
Central	72	C	C	D	B	B	C	B	B	B	0	5	3	1	6
South Western ...	77	A	A	A	B	B	B	B	A	B	4	5	0	0	6
Kingston-upon-Hull ...	57	B	B	B	B	C	B	B	B	B	0	8	1	0	6
Liverpool	96	C	B	B	C	C	C	C	B	C	0	3	6	0	3
Newcastle-on-Tyne ...	55	D	C	C	B	B	C	B	B	B	0	5	3	1	6
Glasgow :															
Alexandra Park ...	73	B	B	B	B	B	B	A	C	B	1	7	1	0	6
Bellahouston Park...	75	C	B	A	C	B	B	A	D	B	2	4	2	1	6
Blythswood Square	83	C	B	C	C	B	C	B	D	C	0	3	5	1	6
Botanic Gardens ...	72	D	B	B	B	B	B	B	D	C	0	6	1	2	6
Queen's Park ...	79	C	B	B	B	B	B	A	C	D	1	5	2	1	6
Richmond Park ...	74	C	B	B	B	B	B	B	D	B	0	7	1	1	6
Ruchill Park ...	88	B	B	B	B	B	B	B	D	B	0	8	0	1	6
Tolcross Park ...	77	D	B	B	B	B	B	B	C	B	0	7	1	1	6
Victoria Park ...	76	C	B	B	B	B	B	B	C	D	0	6	2	1	6

TABLE VII.—*Comparison of Totals of Classes A, B, C, D, for each Element of Pollution for the two half years, April to September* 1919 *and* 1920, *for* 19 *Stations.*

			A	B	C	D
Total solids ...		1919	2	15	2	0
		1920	1	16	1	1
Insoluble.	Tar	1919	5	12	1	0
		1920	3	5	7	3
	Carbonaceous other than tar	1919	3	13	2	0
		1920	2	15	1	0
	Ash	1919	4	12	1	1
		1920	3	14	1	0
Soluble.	Loss on ignition	1919	1	16	0	1
		1920	1	14	3	0
	Ash	1919	1	17	0	0
		1920	1	16	1	0
Sulphates ...		1919	1	16	1	0
		1920	9	9	0	0
Chlorine		1919	9	8	1	0
		1920	1	1	11	5
Ammonia		1919	2	13	1	2
		1920	3	10	3	2

The Stations used in Table VII. are those with five or six months of observations in the summer of 1919 and 1920.

	1919.	1920.
	No. of	Months.
London :—Meteorological Office ...	6	6
Finsbury Park	6	5
Ravenscourt Park	5	6
Southwark Park	5	6
Victoria Park	6	6
Golden Lane	6	6
Malvern	6	6
St. Helens	5	6
Southport :—Hesketh Park	6	6
Woodvale Moss	6	6
Glasgow :—Alexandra Park	6	6
Bellahouston Park ...	6	6
Blythswood Square ...	5	6
Botanic Gardens	6	6
Queen's Park	6	6
Richmond Park	6	6
Ruchill Park	6	6
Tolcross Park	5	6
Victoria Park	6	

TABLE VI.—*Classification (Winter Months)—October* 1920–*March* 1921.

Station.	Rainfall in Millimetres.	Insoluble matter. Tar.	Insoluble matter. Carbonaceous other than tar.	Insoluble matter. Ash.	Soluble matter. Loss on ignition.	Soluble matter. Ash.	Total solids.	Included in soluble matter. Sulphate (SO_3).	Included in soluble matter. Chlorine (Cl).	Included in soluble matter. Ammonia (NH_3).	Summary. A.	Summary. B.	Summary. C.	Summary. D.	No. of Months.
London :															
Meteorological Office	27	C	B	B	B	B	B	A	B	B	1	7	1	0	6
Archbishop's Park	29	C	C	B	B	B	B	B	B	B	0	7	2	0	6
Finsbury Park ...	33	B	B	B	B	B	B	A	B	B	1	8	0	0	6
Ravenscourt Park	32	C	B	B	B	B	B	B	B	B	0	8	1	0	6
Southwark Park ...	27	D	C	B	B	B	B	B	B	B	0	7	1	1	6
Victoria Park ...	31	B	B	B	B	B	B	A	B	B	1	8	0	0	6
WandsworthCommon	24	D	B	B	B	A	B	A	B	B	2	6	0	1	6
Golden Lane ...	31	B	B	B	B	B	B	B	B	B	0	9	0	0	6
Malvern ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
St. Helens ...	47	B	B	B	B	B	B	B	C	A	1	7	1	0	6
Southport :															
Hesketh Park ...	50	B	A	A	B	B	A	A	C	A	5	3	1	0	6
Woodvale Moss ...	42	—	—	—	—	—	A	—	—	—	1	0	0	0	6
Rochdale	76	—	—	—	—	—	C	—	—	—	0	0	1	0	6
Rothamsted ...	36	—	A	A	B	B	A	—	—	—	3	2	0	0	6
Birmingham, Aston	38	B	B	B	B	B	B	B	A	A	2	7	0	0	6
Central	38	B	C	C	B	B	C	B	B	B	0	6	3	0	6
South Western ...	41	A	A	A	A	B	A	A	A	A	8	1	0	0	6
Kingston-upon-Hull	33	C	B	B	B	C	B	B	B	B	0	7	2	0	6
Liverpool	45	B	B	C	C	C	C	B	D	B	0	4	4	1	6
Newcastle-on-Tyne ...	47	D	C	C	B	B	C	B	B	B	0	5	3	1	6
Glasgow :															
Alexandra Park ...	68	B	B	B	B	B	B	B	B	B	0	9	0	0	6
Bellahouston Park	87	C	B	B	B	B	B	B	B	C	0	7	2	0	6
Blythswood Square	77	C	B	B	B	B	B	B	C	C	0	6	3	0	6
Botanic Gardens ...	80	B	B	B	B	B	B	B	B	B	0	9	0	0	6
Queen's Park ...	73	B	B	B	B	B	B	B	B	B	0	9	0	0	6
Richmond Park ...	76	C	B	B	B	C	B	B	B	C	0	6	3	0	6
Ruchill Park ...	85	B	B	B	B	B	B	B	B	B	0	9	0	0	6
Tolcross Park ...	91	C	B	B	B	B	B	B	B	B	0	8	1	0	6
Victoria Park ...	86	B	B	B	B	B	B	B	C	B	0	8	1	0	6
Stirling	64	B	B	B	B	B	B	A	B	A	2	7	0	0	3

TABLE VIII.—*Comparison of Totals of Classes A, B, C, D, for each Element of Pollution for the two half-years, October to March* 1919–1920 *and* 1920–1921, *for* 20 *Stations.*

			A	B	C	D
Total solids ...		1919–1920	1	17	1	1
		1920–1921	3	15	2	0
Insoluble.	Tar	1919–1920	1	13	2	1
		1920–1921	0	10	5	2
	Carbonaceous other than tar	1919–1920	4	13	1	0
		1920–1921	2	14	2	0
	Ash	1919–1920	5	13	0	0
		1920–1921	2	15	1	0
Soluble.	Loss on ignition	1919–1920	0	10	8	0
		1920–1921	0	18	0	0
	Ash	1919–1920	0	13	4	1
		1920–1921	0	16	2	0
Sulphates ...		1919–1920	0	17	0	0
		1920–1921	3	14	0	0
Chlorine		1919–1920	0	6	11	0
		1920–1921	0	13	4	0
Ammonia ...		1919–1920	0	15	1	1
		1920–1921	2	12	3	0

List of Stations used in Table VIII.	No. of Months with Observations.	
	1919–20	1920–21
Kingston-upon-Hull	5	6
London :—Finsbury Park	6	6
Southwark Park	6	6
Victoria Park	5	6
Golden Lane	5	6
Newcastle-on-Tyne	5	6
Rochdale	5	6
Rothamsted	6	6
St. Helens	6	6
Southport :—Hesketh Park	6	6
Woodvale Moss	6	6
Glasgow :—Alexandra Park	5	6
Bellahouston Park ...	6	6
Blythswood Square ...	5	6
Botanic Gardens	6	6
Queen's Park	6	6
Richmond Park	6	6
Ruchill Park	5	6
Tolcross Park	6	6
Victoria Park	5	6

In Tables VII. and VIII. the stations used for comparison are those which were available for the previous year so as to permit of comparison with the current year. In making a selection of stations, all those having less than 5 months in the summer or winter respectively were excluded.

Tables VII. and VIII. have been further reduced to Table C, in which the classes A and B have been added together, and the classes C and D treated similarly. As the sum of the C's and D's varies directly with the amount of deposit, we may compare the stations by examining these columns; that is, an increase in the number of stations classed C and D means an increase of deposit; a diminution of the sum of C's and D's means a reduced deposit.

We may now compare the two years 1919–20 and 1920–21 upon this basis.

In making this comparison it must be remembered, however, that total solids gives the aggregate of all the other items. Further, the last three items—sulphates, chlorine and ammonia—are included already under "soluble matter."

We will deal with each of the items in column 1 of Table C separately:—

Total Solids.—The deposit of total solids was the same for the two years compared during both summer and winter months.

Tar.—In the summer of 1920 there was a very great increase in the amount of tar deposited. In the winter there was a similar, but not so marked, increase when compared with the previous year.

Insoluble Carbonaceous Matter other than Tar and Ash.—These show a reduction in the summer deposit and an increase in the winter.

Soluble Loss on Ignition—Ash—Chlorine.—All show an increased deposit in the summer 1920 and a reduced deposit in the winter 1920–21, when compared with the previous summer and winter.

Sulphates.—These show a small reduction in the deposit in the summer of 1920 compared with the previous summer, while the winter of 1920–21 gave the same deposit as in the previous winter.

Ammonia.—In both summer and winter of the current year the deposits were increased.

In making this comparison it is to be remembered that we have been comparing the deposit on the basis of the number of stations showing increase or diminution.

TABLE C.—*Comparison of Deposits for* 1919–20 *with* 1920–21.

——	Year.	April to Sept. 19 Stations.		Oct. to March. 19 Stations.	
		A & B	C&D	A&B	C&D
Total solids ...	1919–1920	17	2	18	2
	1920–1921	17	2	18	2
Insoluble. Tar	1919–1920	17	1	14	3
	1920–1921	8	10	10	7
Insoluble. Carbonaceous other than tar ...	1919–1920	16	2	17	1
	1920–1921	17	1	16	2
Insoluble. Ash	1919–1920	16	2	18	0
	1920–1921	17	1	17	1
Soluble. Loss on ignition ...	1919–1920	17	1	10	8
	1920–1921	15	3	18	0
Soluble. Ash	1919–1920	18	0	13	5
	1920–1921	17	1	16	2
Sulphates ...	1919–1920	17	1	17	0
	1920–1921	18	0	17	0
Chlorine	1919–1920	17	1	6	11
	1920–1921	2	16	13	4
Ammonia ...	1919–1920	15	3	15	2
	1920–1921	13	5	14	3

Comparison of Stations.

In Table D the stations giving the highest and lowest mean monthly deposit of the different elements of pollution are tabulated.

TABLE D.—*Highest and Lowest Mean Monthly Deposits in* 1920–21 *in Tons per Square Kilometre.*

——	Highest.		Lowest.	
Total solids	Rochdale	24·84	Rothamsted ...	4·22
	Birmingham :— Central	21·34	Birmingham :— South Western ...	5·41
Insoluble. Tar	Meteorological Office, London	0·31	Birmingham :— South Western ...	0·02
	Newcastle	0·29	Southport :— Hesketh Park; London :— Golden Lane	0·05
Insoluble. Carbonaceous other than tar ...	Birmingham :— Central	4·20	Rothamsted ...	0·48
	Newcastle	3·74	Southport :— Hesketh Park ...	0·58
Insoluble. Ash	Birmingham :— Central	11·54	Southport :— Hesketh Park ...	0·72
	Newcastle	7·94	Rothamsted ...	0·73
Soluble. Loss on ignition	Liverpool	2·41	Birmingham :— South Western ...	0·77
	Glasgow :— Bellahouston Park, Blythswood Sq. ...	2·39	Rothamsted ...	1·02
Soluble. Ash	Liverpool	5·11	London :— Archbishop's Park, Wandsworth Com.	1·90
	Kingston-upon-Hull	4·81	Victoria Park ...	1·91
Sulphates	Liverpool	2·61	London :— Finsbury Park ...	0·70
	Kingston-upon-Hull	2·19	Southport :— Hesketh Park ...	0·71
Chlorine	Liverpool	1·48	Birmingham :— South Western ...	0·19
	Glasgow :— Blythswood Sq. ...	1·45	Aston	0·25
Ammonia	Glasgow :— ... ... Victoria Park ...	0·26	St. Helens	0·02
	Queen's Park ...	0·23	Southport :— Hesketh Park ...	0·03

Reference to previous reports will show that in most instances Malvern gave the lowest deposit of all the stations, but during the current year the returns from Malvern were not sent in in time to be included in this table. The figures for this station for the summer and winter are, however, included in Tables III. and IV., so that reference can be made to these tables.

The highest deposits of total solids were shown in Rochdale and Birmingham (Central)—the lowest in Rothamsted and Birmingham (South Western).

Birmingham (Central) heads the list for insoluble carbonaceous and ash, Newcastle being the second highest. The two lowest stations for these elements of pollution were Rothamsted and Southport (Hesketh Park).

The highest deposit of tar was in the Meteorological Office gauge, London; the next highest being in Newcastle-on-Tyne. The lowest deposit of tar was found in Birmingham (South Western) and in Southport (Hesketh Park), and Golden Lane, London.

Liverpool showed the highest deposit of soluble loss on ignition, ash, sulphate and chlorine, but it must be kept in mind that sulphates and chlorine are already included under soluble loss on ignition, so that it might be put better if we say that Liverpool showed the highest deposit of soluble matter.

Glasgow provided the second highest deposit of soluble loss on ignition and chlorine and the highest and second highest of ammonia.

In four cases Rothamsted, which is an open agricultural district, showed the lowest or second lowest deposit; Birmingham (South Western) also ranks lowest or second lowest for four of the elements of pollution. Southport (Hesketh Park) is lowest or second lowest in five instances and London gauges give the lowest deposits in five cases.

Seasonal Variations.

TABLE IX.—*Comparison of Monthly Mean Deposit for Summer and Winter Months of the Year, 1920–1921.*

Station.	—	Rainfall in Millimetres.	Insoluble matter.			Soluble matter.		Total solids.	Included in soluble matter.			No. of months used for average.
			Tar.	Carbonaceous other than tar.	Ash.	Loss on ignition.	Ash.		Sulphate (SO_3).	Chlorine (Cl).	Ammonia (NH_3)	
					Tons per square kilometre.							
London :												
Meteorological Office	Apl.—Sept.	56	0·43	3·76	3·94	2·74	3·47	14·18	1·08	1·22	0·02	6
	Oct.—Mar.	27	0·20	1·68	3·67	1·12	1·67	8·34	0·74	0·64	0·06	6
Finsbury Park ...	Apl.—Sept.	52	0·09	1·17	3·52	1·61	2·54	8·63	0·56	1·15	0·07	5
	Oct.—Mar.	33	0·10	1·15	2·86	0·87	1·55	6·52	0·82	0·48	0·07	6
Archbishop's Park ...	Apl.—Sept.	55	0·18	2·98	5·53	1·52	2·97	13·18	1·11	1·15	0·09	6
	Oct.—Mar.	29	0·20	3·32	2·56	1·59	2·77	10·44	1·63	0·59	0·11	6
Ravenscourt Park ...	Apl.—Sept.	59	0·22	1·72	3·94	1·70	2·70	10·28	0·89	1·26	0·12	6
	Oct.—Mar.	32	0·15	1·59	3·53	1·04	1·50	7·81	1·02	0·48	0·09	6
Southwark Park ...	Apl.—Sept.	52	0·13	2·42	4·98	1·46	2·41	11·40	0·84	0·82	0·10	6
	Oct.—Mar.	27	0·39	3·69	5·28	1·27	2·17	12·79	1·15	0·53	0·09	6
Victoria Park ...	Apl.—Sept.	53	0·08	1·42	2·96	1·67	2·28	8·41	0·91	1·26	0·10	6
	Oct.—Mar.	31	0·13	1·74	3·08	0·94	1·54	7·44	0·94	0·44	0·06	6
Wandsworth Common	Apl.—Sept.	51	0·13	1·38	2·34	1·90	2·47	8·22	0·82	1·25	0·11	6
	Oct.—Mar.	24	0·31	2·18	3·37	1·09	1·33	8·27	0·67	0·54	0·06	6
Golden Lane ...	Apl.—Sept.	50	0·04	2·96	3·69	1·31	3·73	11·73	1·24	1·39	0·18	6
	Oct.—Mar.	31	0·07	2·77	3·71	1·19	3·35	11·09	1·45	0·75	0·13	6
Malvern	Apl.—Sept.	69	—	0·16	0·25	0·38	1·10	1·87	0·41	0·10	0·01	6
	Oct.—Mar.	—	—	—	—	—	—	—	—	—	—	—
St. Helens	Apl.—Sept.	97	0·15	2·49	5·01	1·64	5·83	15·12	2·84	1·13	0·03	6
	Oct.—Mar.	47	0·10	2·33	2·84	1·20	3·14	9·62	1·12	1·05	0·02	6
Southport :												
Hesketh Park ...	Apl.—Sept.	85	0·04	0·56	0·66	1·85	4·21	7·32	0·72	1·43	0·05	6
	Oct.—Mar.	50	0·07	0·60	0·78	1·04	2·42	4·91	0·70	1·01	0·02	6
Woodvale Moss ...	Apl.—Sept.	75	—	—	—	—	—	6·55	—	—	—	6
	Oct.—Mar.	42	—	—	—	—	—	4·44	—	—	—	6
Rochdale	Apl.—Sept.	127	—	—	—	—	—	33·02	—	—	—	—
	Oct.—Mar.	76	—	—	—	—	—	16·67	—	—	—	6
Rothamsted	Apl.—Sept.	61	—	0·53	0·85	1·08	1·64	4·10	—	—	—	6
	Oct.—Mar.	36	—	0·44	0·62	0·97	2·32	4·35	—	—	—	6
Birmingham, Aston ...	Apl.—Sept.	72	0·10	2·63	7·64	1·39	3·54	15·30	1·57	0·30	0·06	4
	Oct.—Mar.	38	0·08	1·72	5·17	1·00	2·42	10·39	1·24	0·21	0·04	6
Central	Apl—Sept.	72	0·16	4·87	13·39	1·97	4·11	24·50	2·29	0·39	0·13	6
	Oct.—Mar.	38	0·14	3·53	9·69	1·39	3·44	18·19	1·78	0·30	0·08	6
South Western ...	Apl.—Sept.	77	0·02	0·84	1·78	1·01	2·59	6·24	1·17	0·21	0·09	6
	Oct.—Mar.	41	0·03	0·60	1·76	0·53	1·67	4·59	0·70	0·17	0·03	6
Kingston-upon-Hull ...	Apl.—Sept.	57	0·07	1·88	5·22	1·86	5·12	14·15	2·19	0·74	0·08	6
	Oct.—Mar.	33	0·15	2·37	4·13	1·74	4·51	12·90	2·20	0·56	0·07	6
Liverpool	Apl.—Sept.	96	0·15	2·72	5·59	2·27	5·15	15·88	3·16	0·49	0·16	3
	Oct.—Mar.	45	0·19	2·83	6·99	2·48	5·08	17·57	2·34	1·96	0·11	6
Newcastle-on-Tyne ...	Apl.—Sept.	55	0·29	4·21	9·07	1·61	2·90	18·08	1·27	0·68	0·12	6
	Oct.—Mar.	47	0·30	3·27	6·81	1·47	3·19	15·04	1·30	0·56	0·09	6
Glasgow :												
Alexandra Park ...	Apl.—Sept.	73	0·11	2·31	3·51	1·57	2·14	9·64	0·96	1·41	0·12	6
	Oct.—Mar.	68	0·11	1·13	2·05	1·42	2·06	6·76	1·28	0·87	0·13	6
Bellahouston Park ...	Apl.—Sept.	75	0·15	1·49	1·96	2·61	3·92	10·13	0·99	1·67	0·09	6
	Oct.—Mar.	87	0·15	1·31	2·25	2·17	3·02	8·91	1·52	0·97	0·17	6
Blythswood Square ...	Apl.—Sept.	83	0·21	2·95	6·31	2·80	4·19	16·46	1·42	1·81	0·23	6
	Oct.—Mar.	77	0·19	2·53	3·98	1·99	3·72	12·42	2·02	1·09	0·16	6
Botanic Gardens ...	Apl.—Sept.	72	0·25	2·10	4·87	2·18	3·35	12·75	1·03	1·54	0·17	6
	Oct.—Mar.	80	0·11	2·06	2·45	1·44	3·78	9·84	1·44	0·84	0·13	6
Queen's Park ...	Apl.—Sept.	79	0·22	1·49	2·72	1·62	3·15	9·20	0·98	1·33	0·37	6
	Oct.—Mar.	73	0·12	1·13	2·02	1·19	2·99	7·46	1·21	0·73	0·09	6
Richmond Park ...	Apl.—Sept.	74	0·18	2·00	4·16	1·71	3·05	11·10	1·01	1·67	0·12	6
	Oct.—Mar.	76	0·17	2·53	3·93	1·72	4·56	12·91	2·09	0·83	0·15	6
Ruchill Park ...	Apl.—Sept.	88	0·08	1·64	3·13	1·43	2·81	9·09	2·30	1·93	0·11	6
	Oct.—Mar.	85	0·12	1·83	2·37	1·15	3·55	9·02	1·47	0·94	0·12	6
Tolcross Park ...	Apl.—Sept.	77	0·36	2·31	4·88	2·20	3·31	13·10	1·06	1·19	0·12	6
	Oct.—Mar.	91	0·15	1·74	2·52	2·04	3·85	10·30	1·03	0·81	0·11	6
Victoria Park ...	Apl.—Sept.	76	0·21	2·16	3·26	1·47	2·95	10·05	1·12	1·30	0·39	6
	Oct.—Mar.	86	0·12	1·59	2·21	1·44	4·07	9·43	1·57	0·97	0·14	6

Referring now to Table IX., in which the mean monthly deposits for summer and winter months of the year are compared, we may consider each of the elements of pollution separately, and for the purpose of simplifying this consideration Table E has been prepared, giving a summary of Table IX. :—

TABLE E.—*Summary of Table IX. Comparison of Summer and Winter Deposits for the year April 1920 to March 1921* :—

——	Winter Deposit greater in :	Deposits equal.	Summer Deposit greater in :
	Stations.	Stations.	Stations.
Rainfall	5	—	23
Total solids	5	—	23
Insoluble. Tar	12	2	11
Insoluble. Carbonaceous other than tar	9	—	17
Insoluble. Ash	7	—	19
Soluble. Loss on ignition	3	—	23
Soluble. Ash	7	—	19
Sulphates	16	—	9
Chlorine	1	—	24
Ammonia	6	1	18

Rainfall.—Out of 28 stations the rainfall was greater in the summer than in the winter in 23 and reference to last year's report will show that in 1919–20 out of 20 stations compared the rainfall was higher in the winter in 15 and higher in the summer in 5. It must be kept in view, however, that out of the 28 stations included, 8 were in London and 9 in Glasgow, thus giving these cities a preponderating position in governing the result as thus obtained.

Total Solids.—The relation of deposit in summer and winter is identical with that of rainfall, that is, 5 stations showed greater deposit in winter and 23 greater in the summer. The 5 stations showing the highest winter rainfall were all in Glasgow and in only one instance, that of Richmond Park, Glasgow, was the highest rainfall and highest deposit of total solids found in the winter months.

Tar.—Out of 25 stations 12 showed a greater winter deposit and 11 a greater summer deposit, and in 2 the winter and summer deposits were equal.

Insoluble Carbonaceous other than Tar.—Out of 26 stations, 9 showed a greater winter deposit and 17 a greater summer deposit. This is a curious result, but as pointed out in the 6th Report, the carbonaceous matters cover animal and vegetable dust as well as soot. In the comparison of the summer and winter of the year 1919–20, the deposit was also found to be greater in summer than in winter.

Insoluble Ash.—Out of 26 stations 7 gave a greater winter deposit and in 19 the summer deposit was the greater. Reference has previously been made to insoluble ash as a summer product, being to a great extent derived from dust raised by the wind.

Soluble Loss on Ignition.—Out of 26 stations 23 gave a higher deposit in summer and 3 a higher deposit in winter.

Soluble Ash.—Out of 26 stations 19 gave a higher deposit in summer and 7 in winter. In view of the relation established in previous reports between the deposit of soluble matter and rainfall, it will be of interest to enquire whether, in the case of the soluble matter, the stations showing a higher deposit are those showing a high rainfall.

There were 3 stations showing a higher soluble loss on ignition in the winter deposit, and out of these 3, 2—that is Liverpool and Archbishop's Park, London—both gave a lower winter rainfall. In the other case, that is Richmond Park, Glasgow, the summer and winter deposits of soluble matter and rain were so nearly alike as to make comparison useless.

Sulphates.—There was a greater deposit of sulphates in winter in 16 stations and a greater deposit in summer in 9, out of 25.

Chlorine.—In 24 out of 25 stations, the chlorine deposited was greater in the summer than in winter. This does not fit in very well with the theory that chlorine in the air is derived from sea-spray, as the time of year during which one would expect the greatest amount of spray is during the rough weather in winter; it would seem, therefore, that we must look to some other source for the chlorine.

Ammonia.—Out of 25 stations the ammonia deposited was greater in the summer in 18. In 6 stations the winter deposit was greater and in 1 case the summer and winter deposits were equal. Too much reliance should not be placed upon the figures for ammonia as the rainwater is allowed to stand in the bottles underneath the deposit gauges for a considerable time before collection, the bottles being changed at the end of each month. Thus, it is probable that ammonia is produced in the water by the growth of organisms.

Considering now the incidence of deposit in the different months of the year, reference must be made to Table X. for details. In this the stations have been divided into three groups—Group X for 24 stations having a minimum of 11 months observations in the year, the stations included being :—

London.—Meteorological Office, Archbishop's Park, Finsbury Park, Ravenscourt Park, Southwark Park, Victoria Park, Wandsworth Park, Golden Lane.

Malvern.

St. Helens.

Southport.—Hesketh Park.

Birmingham.—Central, South Western.

Kingston-upon-Hull.

Newcastle-on-Tyne.

Glasgow.—Alexandra Park, Bellahouston Park, Blythswood Square, Botanic Gardens, Queens Park, Richmond Park, Ruchill Park, Tolcross Park, Victoria Park.

TABLE X.—*Average Deposit of each Element of Pollution for each Month, reduced to a Standard of 30 Days for the following Groups :—X.—24 Stations; Y.—8 London Stations; Z.—4 Stations in Manufaturing Towns. Unit (except for Rainfall), ton per sq. kilometre.*

Group X.—24 Stations.

—	1920. April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1921. Jan.	Feb.	Mar.	Ratio. Max. to Min.
Rainfall in mm. ...	62	69	48	83	72	70	35	47	66	85	12	59	7·08
Total solids	10·58	12·07	11·10	12·02	10·20	11·65	9·46	11·38	10·96	8·44	6·92	9·23	1·74
In-soluble { Tar	·12	·13	·15	·15	·23	·15	·15	·17	·20	·10	·11	·15	2·30
In-soluble { Carbonaceous	2·08	2·23	2·15	1·99	1·88	2·26	2·28	2·26	2·62	1·30	1·48	1·66	2·16
In-soluble { Ash	4·43	4·76	4·55	3·86	3·17	4·15	3·49	3·58	3·54	2·28	2·92	3·64	2·09
Total Insoluble ...	6·63	7·12	6·85	6·00	5·28	6·56	5·92	6·01	6·36	3·68	4·51	5·45	1·93
Soluble { Loss on ignition	1·33	1·48	1·63	2·13	1·94	1·71	1·21	1·53	1·49	1·24	0·90	1·42	2·37
Soluble { Ash	2·63	3·47	2·63	3·89	2·99	3·39	2·33	3·83	3·11	3·52	1·51	2·35	2·58
Total soluble	3·96	4·95	4·26	6·02	4·93	5·10	3·54	5·36	4·60	4·76	2·41	3·77	2·50
Sulphates	1·14	1·29	0·84	1·18	1·04	1·32	1·08	1·55	1·59	1·43	0·79	1·17	2·01
Chlorine	0·63	1·43	1·09	2·12	0·76	0·96	0·48	1·16	0·73	0·80	0·24	0·58	8·83
Ammonia	0·09	0·24	0·10	0·12	0·09	0·12	0·08	0·09	0·12	0·13	0·03	0·09	8·00

Group Y.—8 London Stations.

—	1920. April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1921. Jan.	Feb.	Mar.	Ratio. Max. to Min.
Rainfall in mm. ...	65	18	40	82	43	75	27	25	47	44	6	25	13·66
Total solids	11·67	9·11	11·57	12·80	6·40	12·59	10·37	10·05	10·65	6·33	5·92	10·33	2·17
In-soluble { Tar ...	0·16	0·19	0·13	0·16	0·13	0·19	0·14	0·18	0·33	0·11	0·09	0·27	3·67
In-soluble { Carbonaceous	2·10	1·94	2·66	2·28	1·45	2·68	3·00	2·47	2·86	1·41	1·19	2·39	2·52
In-soluble { Ash	4·27	4·15	4·26	3·70	2·13	4·40	3·52	3·84	3·41	2·41	2·38	5·15	2·42
Total insoluble ...	6·53	6·28	7·05	6·14	3·71	7·27	6·66	6·49	6·60	3·93	3·66	7·81	2·13
Soluble { Loss on ignition	1·62	1·11	2·00	2·57	1·05	2·04	1·20	1·23	1·61	0·88	0·80	1·01	3·21
Soluble { Ash	3·52	1·72	2·52	4·08	1·64	3·29	2·52	2·32	2·43	1·52	1·45	1·51	2·80
Total soluble	5·14	2·83	4·52	6·65	2·69	5·33	3·72	3·55	4·04	2·40	2·25	2·52	2·96
Sulphates	1·41	0·55	0·51	1·21	0·40	1·33	1·07	1·22	1·40	1·02	0·75	0·75	3·53
Chlorine	0·78	0·69	1·49	2·06	0·91	1·49	0·69	0·52	0·70	0·47	0·26	0·55	7·93
Ammonia	0·13	0·07	0·09	0·13	0·06	0·13	0·07	0·09	0·14	0·09	0·03	0·08	4·67

Group Z.—Four Stations in Manufacturing Towns.

—	1920. April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1921. Jan.	Feb.	Mar.	Ratio. Max. to Min.
Rainfall in mm. ...	94	80	53	88	47	52	38	21	69	77	6	29	15·66
Total solids	18·22	22·27	15·79	16·22	16·89	16·04	17·79	14·48	16·40	11·56	11·05	11·20	2·02
In-soluble { Tar	C·19	0·18	0·15	0·18	0·14	0·15	0·17	0·27	0·16	0·15	0·13	0·13	2·06
In-soluble { Carbonaceous	3·52	3·35	3·06	2·88	4·05	2·98	3·58	3·34	3·32	2·27	2·35	2·19	1·85
In-soluble { Ash	8·07	9·50	7·81	6·96	8·32	7·52	8·25	5·98	5·35	3·97	5·80	5·48	2·39
Total insoluble ...	11·78	13·03	11·02	10·02	12·51	10·65	12·00	9·59	8·83	6·39	8·28	7·80	2·04
Soluble { Loss on ignition	2·24	1·49	1·41	2·00	1·14	1·71	2·00	1·32	1·94	1·55	0·78	0·96	2·87
Soluble { Ash	4·20	7·75	3·37	4·21	3·23	3·68	3·79	3·57	5·62	3·62	1·99	2·43	3·89
Total soluble	6·44	9·24	4·78	6·21	4·37	5·39	5·79	4·89	7·56	5·17	2·77	3·39	3·33
Sulphates	2·26	3·54	1·71	1·97	1·30	1·84	1·98	1·69	2·27	1·44	0·93	1·13	3·81
Chlorine	0·91	1·05	0·62	0·66	0·51	0·58	0·53	0·49	1·01	0·85	0·28	0·47	3·76
Ammonia	0·10	0·11	0·08	0·13	0·05	0·07	0·08	0·03	0·14	0·06	0·02	0·06	7·00

These stations include all with a sufficient number of months observations, that is, cities—manufacturing or otherwise—as well as country stations. Group Y. includes 8 London stations and may be taken as representing a city of mixed commercial, manufacturing, and residential type. The stations included in this group are Meteorological Office, Finsbury Park, Archbishop's Park, Ravenscourt Park, Southwark Park, Victoria Park, Wandsworth Common, and Golden Lane. Group Z includes 4 cities of mainly manufacturing type, *i.e.*, St. Helens, Kingston-upon-Hull, Newcastle-on-Tyne and Birmingham (Central).

Table X. has been further summarised in Table F. in which the months of highest and second highest, lowest and second lowest deposit for each element of pollution are shown. Referring to Table F :—

TABLE F.—*Analysis of Table X. showing months of Highest and Lowest Deposit for each element of Pollution.*

Group X.—24 stations—Commercial, manufacturing and residential :—

—	Highest.	Second Highest.	Lowest.	Second Lowest.
Rainfall	Jan.	July	Feb.	Oct.
Total solids ...	May	,,	,,	Jan.
Tar	Aug.	Dec.	Jan.	Feb.
Carbonaceous other than tar ...	Dec.	Oct.	,,	,,
Ash	May	June	,,	,,
Total insoluble ...	,,	,,	,,	,,
Loss on ignition	July	Aug.	Feb.	Oct.
Ash	,,	Nov.	,,	,,
Total soluble ...	,,	,,	,,	,,
Sulphates ...	Dec.	,,	,,	June
Chlorine	July	May	,,	Oct.
Ammonia ...	May	Jan.	,,	,,

Group Y.—8 London stations :—

—	Highest.	Second Highest.	Lowest.	Second Lowest.
Rainfall	July	Sept.	Feb.	May
Total solids ...	,,	,,	,,	Jan.
Tar	Dec.	March	,,	,,
Carbonaceous other than tar ...	Oct.	Dec.	,,	,,
Ash	March	Sept.	,,	,,
Total insoluble ...	,,	,,	,,	Aug.
Loss on ignition	July	,,	,,	Jan.
Ash	,,	April	Mar.	Feb.
Total soluble ...	,,	Sept.	Feb.	Jan.
Sulphates ...	April	Dec.	Aug.	June
Chlorine	July	June, Sept.	Feb.	Jan.
Ammonia ...	Dec.	April, July, Sept.	,,	Aug.

Group Z.—4 Manufacturing towns :—

—	Highest.	Second Highest.	Lowest.	Second Lowest.
Rainfall	April	July	Feb.	Nov.
Total solids ...	May	April	,,	March
Tar	Nov.	,,	Feb. March	Aug.
Carbonaceous other than tar ...	Aug.	Oct.	March	Jan.
Ash	May	Aug.	Jan.	Dec.
Total insoluble ...	,,	,,	,,	March
Loss on ignition	April	July, Oct.	Feb.	,,
Ash	May	Dec.	,,	,,
Total solids ...	,,	,,	,,	,,
Sulphates ...	,,	,,	,,	,,
Chlorine	,,	,,	,,	,,
Ammonia ...	Dec.	July	,,	Nov.

Rainfall.—In Group X the highest rainfall occurred in January with 85 mm. and the lowest in February with 12 mm.

In Group Y the highest rainfall occurred in July with 82 mm. and the lowest in February with 5·9 mm.

In Group Z the highest rainfall occurred in April with 93 mm. and the lowest in February with 5·9 mm.

The figures for all other deposits are in metric tons per square kilometre.

Total Solids.—In Group X the highest deposit was in May with 12·07 and the lowest in February with 6·92.

In Group Y the highest deposit was in July with 12·80 and the lowest in February with 5·92, in both cases corresponding with the highest and lowest rainfall.

In Group Z the highest deposit was in May with 22·27 and the lowest in February with 11·05. Thus the highest does not correspond with the highest rainfall which occurred in April, but the lowest deposit corresponds with the lowest rainfall.

Tar.—In Group X the highest deposit was in August with 0·23 and the lowest in January with 0·10.

In Group Y the highest deposit was in December with 0·33 and the lowest in February with 0·09.

In Group Z the highest deposit was in November with 0·27 and the lowest in February and March, both with 0·13.

Carbonaceous other than Tar.—In Group X the highest deposit occurred in December with 2·62 and the lowest in January with 1·30.

In Group Y the highest deposit occurred in October with 3·00 and the lowest in February with 1·19.

In Group Z the highest deposit occurred in August with 4·05 and the lowest in March with 2·19

Thus the highest deposit did not in any case occur during the month of highest rainfall, the lowest deposit in London corresponded with the lowest rainfall, but not in Group X or Group Z.

Insoluble Ash.—In Group X the highest deposit occurred in May with 4·76 and the lowest in January with 2·28.

In Group Y the highest deposit occurred in March with 5·15 and the lowest in February with 2·38.

In Group Z the highest deposit occurred in May with 9·50 and the lowest in January with 3·97.

Here, again, the highest deposit did not coincide with the highest rainfall, but in London the lowest occurred with the lowest rainfall.

Loss on Ignition.—In Group X the highest deposit occurred in July with 2·13 and the lowest in February with 0·90.

In Group Y the highest deposit occurred in July with 2·57 and the lowest in February with 0·80.

In Group Z the highest deposit occurred in April with 2·24 and the lowest in February with 0·78.

Thus in Groups Y and Z the highest deposit occurred with the highest rainfall and in all three groups the lowest deposit occurred with the lowest rainfall.

Soluble Ash.—In Group X the highest deposit occurred in July with 3·89 and the lowest in February with 1·51.

In Group Y the highest deposit occurred in July with 4·08 and the lowest in March with 1·51.

In Group Z the highest deposit occurred in May with 7·75 and the lowest in February with 1·99.

In the London stations the highest deposit, therefore, occurred with the highest rainfall, and in Groups X and Z the lowest deposit occurred with the lowest rainfall.

Sulphates.—In Group X the highest deposit occurred in December with 1·59 and the lowest in February with 0·79.

In Group Y the highest deposit occurred in April with 1·41 and the lowest in August with 0·40.

In Group Z the highest deposit occurred in May with 3·54 and the lowest in February with 0·93.

Here in no case did the highest deposit occur with the highest rainfall, but in Groups X and Z the lowest deposit occurred with the lowest rainfall.

Chlorine.—In Group X the highest deposit occurred in July with 2·12 and the lowest in February with 0·24.

In Group Y the highest deposit occurred in July with 2·06 and the lowest in February with 0·26.

In Group Z the highest deposit occurred in May with 1·05 and the lowest in February with 0·28.

In Group Y the highest deposit occurred with the highest rainfall and in all groups the lowest deposit occurred with the lowest rainfall.

Ammonia.—In Group X the highest deposit occurred in May with 0·24 and the lowest in February with 0·03.

In Group Y the highest deposit occurred in December with 0·14 and the lowest in February with 0·03.

In Group Z the highest deposit occurred in December with 0·14 and the lowest in February with 0·02.

In no case did the highest deposit occur with the highest rainfall, but in all cases the lowest deposit occurred with the lowest rainfall.

Referring now to Table X: in the last column the ratio of maximum to minimum deposit is given and it is somewhat remarkable how many of these figures fall between 2 and 4. In London the highest rainfall was 13·9 times the lowest, in the manufacturing towns it was 15·75 times the lowest, and in the mixed group of towns (Group X) it was 7·08.

Chlorine and ammonia both show a considerable variation between the maximum and minimum deposits, and in the case of the former it is noticeable that the highest deposit occurred in the summer and the lowest in the winter.

SUSPENDED IMPURITY IN LONDON.

The method of measuring suspended impurities by means of an automatic instrument, which filters a measured volume of air through a definite sized disc of white filter paper has been fully described in the Fourth Annual Report.

Several instruments have been made and put into operation, so that continuous records of atmospheric impurity are now available for several months of the year dealt with in this report. An instrument has been set up at the Meteorological Office, South Kensington, one at Kew Observatory, and one at 47, Victoria Street, Westminster, the records of which are now available for examination. Records are also being taken in Glasgow and Rochdale, but these are not yet available for comparison.

It will be remembered that the method of estimating impurities by this method involves the use of a calibrated scale of shades, the numbers of which indicate the quantity of impurity, and for the instrument using a one-eighth inch diameter filtering disc the unit of shade has been ascertained to be approximately 0·32 mgs. per cubic metre.

The available figures have been tabulated, and from these tables, mean hourly values of suspended impurity have been obtained. These mean hourly values when plotted over their corresponding time give curves of impurity from which the distribution over the twenty-four hours can be seen.

In this way curves have been prepared, such as shown in Figs. 5 and 6. The former shows three such curves for the air of Westminster during foggy days. The days have been divided into weekdays (excluding Saturdays and Sundays), Saturdays and Sundays, as the week falls naturally into these three groups: weekdays, when all industries and factories are operating in their normal way; Saturdays, when most factories are closed during the afternoon; and Sundays when practically all are closed, and the impurities derived from smoke must arise almost entirely from domestic fires.

In Fig. 6 the same groups of days are plotted; but in this case days without abnormal fog have been selected for reasons which will appear later, as it seems probable that these records will throw definite light upon the source of impurities. In dividing the days into foggy and non-foggy, a

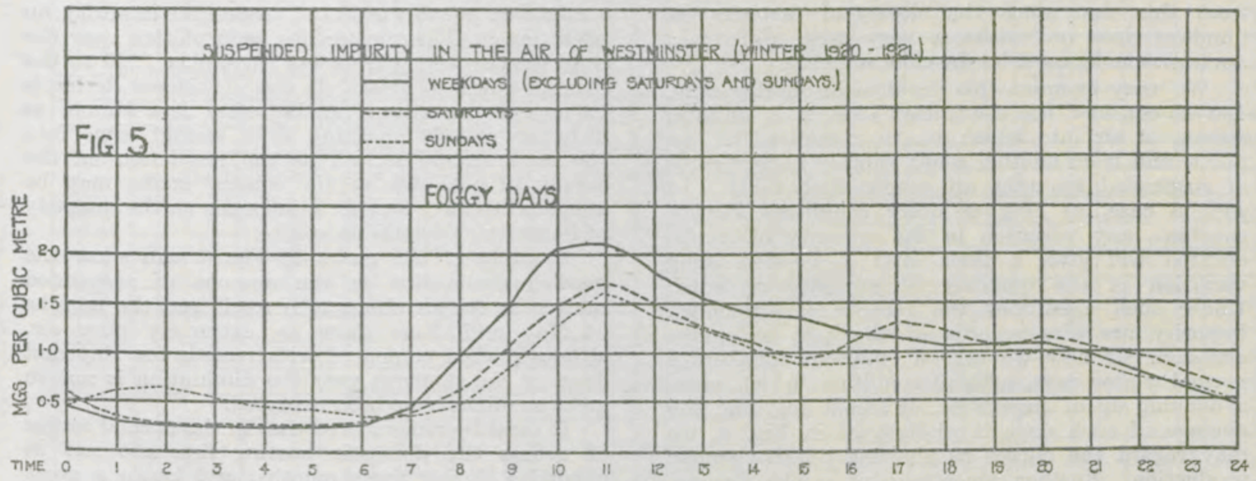


Fig. 5.

SUSPENDED IMPURITY IN THE AIR OF WESTMINSTER. (WINTER 1920 - 1921.)

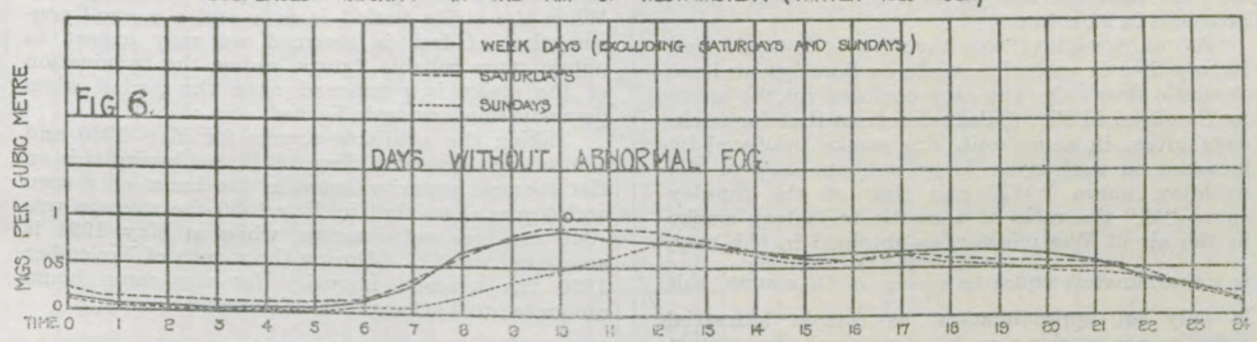


Fig. 6.

definite standard had to be selected, and, for this purpose, days which showed a maximum impurity not exceeding Shade 4, that is, 1·28 mgs. per cubic metre, were ranked as "without abnormal fog"; the days showing a maximum impurity exceeding this figure at any time during the twenty-four hours were grouped under "foggy days."

Referring to Figs. 5 and 6 it will be observed that certain features are common to all curves. The air is purest between midnight and early morning, about 6 to 7 o'clock. On weekdays and Saturdays at about 6 a.m. or a little before, and on Sundays at about 7 a.m., a rapid increase in the amount of impurity begins. This continues until a maximum for the day is reached, on weekdays and Saturdays about 10 o'clock or a little later, and on Sundays at about 11 to 12 o'clock. In all cases the quantity of suspended matter begins to fall off rapidly after this maximum, which seldom lasts for an hour, usually less; and in the afternoon the quantity continues to fall until a second, but lower, maximum appears about 4 or 5 o'clock, which may be continued until about 8 o'clock, after which there is sometimes a still more rapid drop from 10 p.m. till midnight, when the quantity again reaches a minimum.

It is evident from this that the quantity of impurity present bears a close relationship to human activities. The most noticeable fact is the uniformity with which the impurity commences to increase at the time when fires are lighted in the morning and the almost complete absence of impurity during the period from midnight to 6 or 7 a.m., when both domestic and factory fires are out of operation.

The peak in the afternoon, about 4 to 5 p.m., suggests a tea-time rise, and the falling off in the evening, about 8 to 10 p.m., is evidently connected with the reduction and final letting out of fires.

From the fact that the greatest quantity of impurity is, in all cases, found in the forenoon, corresponding to the time when the fires are attaining their full working heat, although during the afternoon when fires are still in operation, the impurity rapidly diminishes, it may be legitimately inferred that the main source of smoke impurities is from fires during the process of attaining their full heat.

From Fig. 5 it is obvious that there is not a very great difference between the amount of impurity present in the air on ordinary weekdays and on Saturdays or Sundays, and it is fair to conclude from this that since the closing of factories on Sundays does not make a very great difference, domestic smoke must be the chief source.

We may examine this problem in another way. Let us consider the elementary case of a uniform stream of air into which smoke is emitted at one point, and from another point down-stream records of suspended impurity are continuously taken. In such a case, as long as other conditions remain constant, any variation in the quantity of smoke emitted will give, a little later, a corresponding variation in the quantity of impurity recorded. Under such conditions the records of suspended impurity are also records of the rate of smoke emission. If now we take a sufficient number of normal winter days, without conditions which cause a banking up of impurities, or smoke fog, and the average of such days is plotted, as in Fig. 5, we may regard the curves as showing relative smoke production. Further, since rate of smoke production multiplied by time gives total smoke produced, in some unit, the areas enclosed between the curves and the base line are proportional to total smoke produced in 24 hours.

As on weekdays we have both domestic and factory fires in operation, while on Sundays we have domestic fires only, the area enclosed by the curve for Sundays, in Fig. 5, deducted from that for weekdays gives, in some unit, the smoke produced by factories on weekdays. If we call the area of the weekday curve "W," and that of the Sunday curve "S," the ratio of domestic to factory smoke in the air of Westminster, as obtained in this way, is approximately equal to $\frac{S}{W-S}$. Of course, this is only an approximation, as certain industrial furnaces are working on Sundays, and also certain fires which would rank as domestic, such as office fires, are not in operation on Sunday.

The curves in Fig. 5 give a mean of 46 weekdays and 11 Sundays, and the ratio of factory to domestic smoke obtained in the above way from these curves is as 1 to 2·25.

The records from the instrument at the Meteorological Office, South Kensington, were treated in the same way, and the ratio obtained from them comes out as 1 to 2·15. Thus it appears that, in London, the domestic fire is responsible for something over two-thirds of the total smoke.

These figures are obtained from the records of October to March, and therefore apply to the winter period only.

It is not suggested that this ratio holds good for other cities as, doubtless, in a manufacturing city it would be different.

Referring now to Fig. 6, for foggy days, it is noticeable that the characteristics of the curves are very similar to those for ordinary days. The air never clears so completely during the night, and the peaks on the curves are more marked.

When further data are available it is anticipated that more light will be thrown upon other aspects of the question, such as the effect of rain or snow in clearing the air, and the influence of wind direction.

In Fig. 7 the maximum suspended impurity on each day in Westminster has been plotted over the date for the period from 1st November 1920 to the time of going to press. It was considered desirable to include the data available after 31st March, as although strictly speaking these should come into the next annual report, as the restriction on the supply of coal due to the miners' strike may be supposed to have had some influence on the quantity of impurity derived from smoke.

A study of the curve in Fig. 7 will show the marked diminution in the amount of suspended matter in the air about 30th April, and the months of May and June show an extremely pure air, although when compared with records for May and June of the previous year the diminution is not so great as might have been expected.

It must be remembered that in the normal course of events the domestic heating fires are not in operation during these months, and hence a great diminution due to the absence of smoke is to be expected in any case. Further diminution due to the reduced supply of coal requires investigation. When the strike period is over and a normal consumption of fuel is resumed we may expect to obtain more reliable figures, unless the termination of the strike is postponed until the period when domestic fires are again lighted.

Taking the available figures for May 1920 and comparing these with May 1921, and basing this on the average impurity between the hours of 9 a.m. and 5 p.m.; we find in May 1920 the average was ·346 mg. per cubic metre, while in May 1921 it amounted to ·227. During the month of November 1920 the average impurity for the same hours amounted to 1·41 mg. per cubic metre.

EFFECT OF SUSPENDED IMPURITY ON HEALTH.

Owing to the absence of statistics bearing upon the effect of suspended matter in the air on human health, it was thought advisable to attempt to bring out the connection, if any, which existed between these two. For this purpose the statistics of daily deaths in London for the quarter ending 31st December 1920 were obtained from the Registry Department, Somerset House, through the kindness of Dr. Stevenson. These figures included deaths from all causes, and although suspended impurity would only affect deaths from respiratory diseases it was thought that some indication might be obtained by a comparison of total deaths daily with the quantity of impurity present in the air.

The difficulty of establishing any relation is enhanced by the fact that should impurity in the air have any effect upon the death-rate, such an effect would not appear until some unknown and uncertain period after the variation in the impurity. Curves were prepared in which the daily deaths of London were plotted over the same base as figures for maximum suspended impurity in the air. As death-rate may be supposed to vary in some way with the temperature a curve showing the minimum

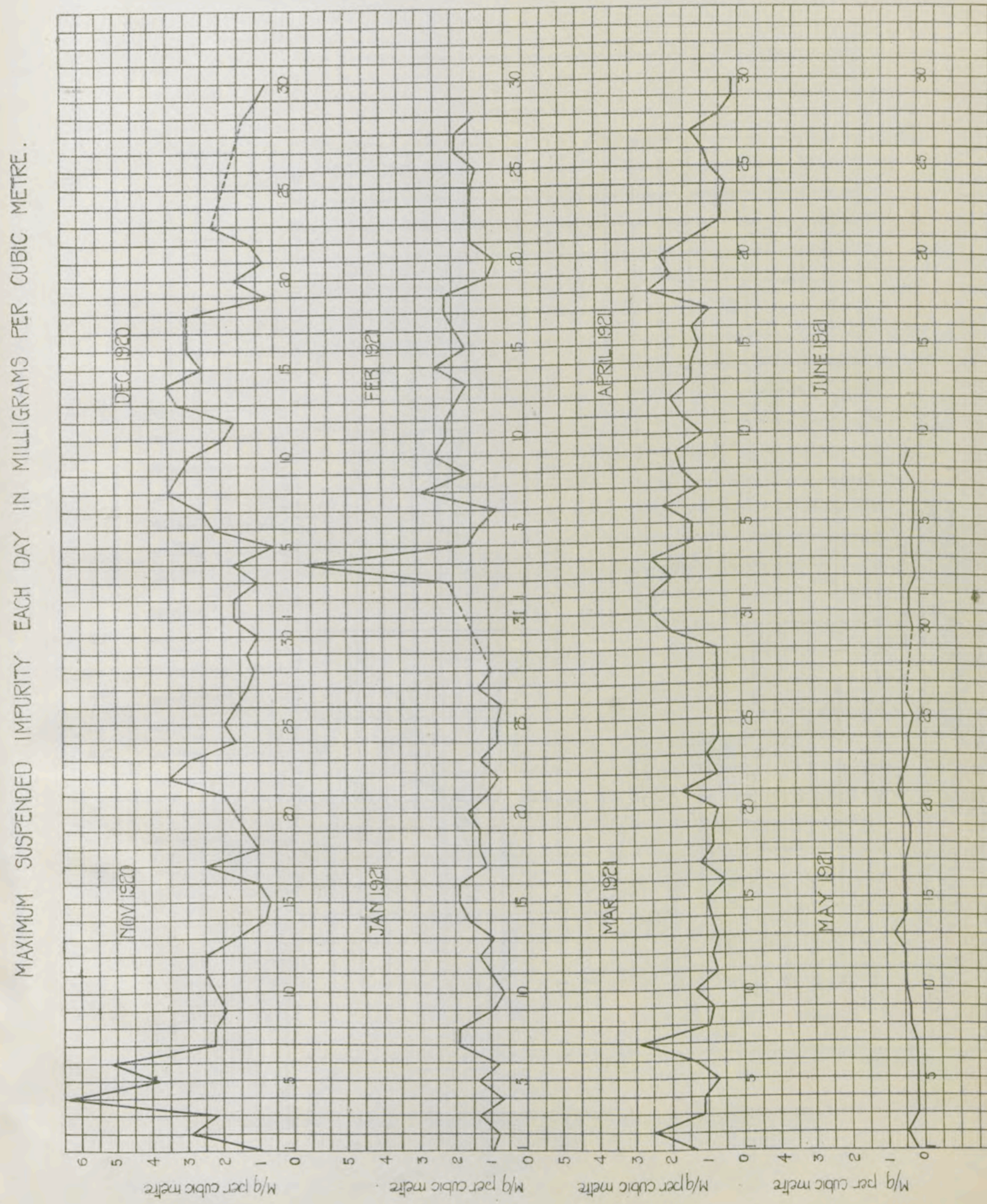
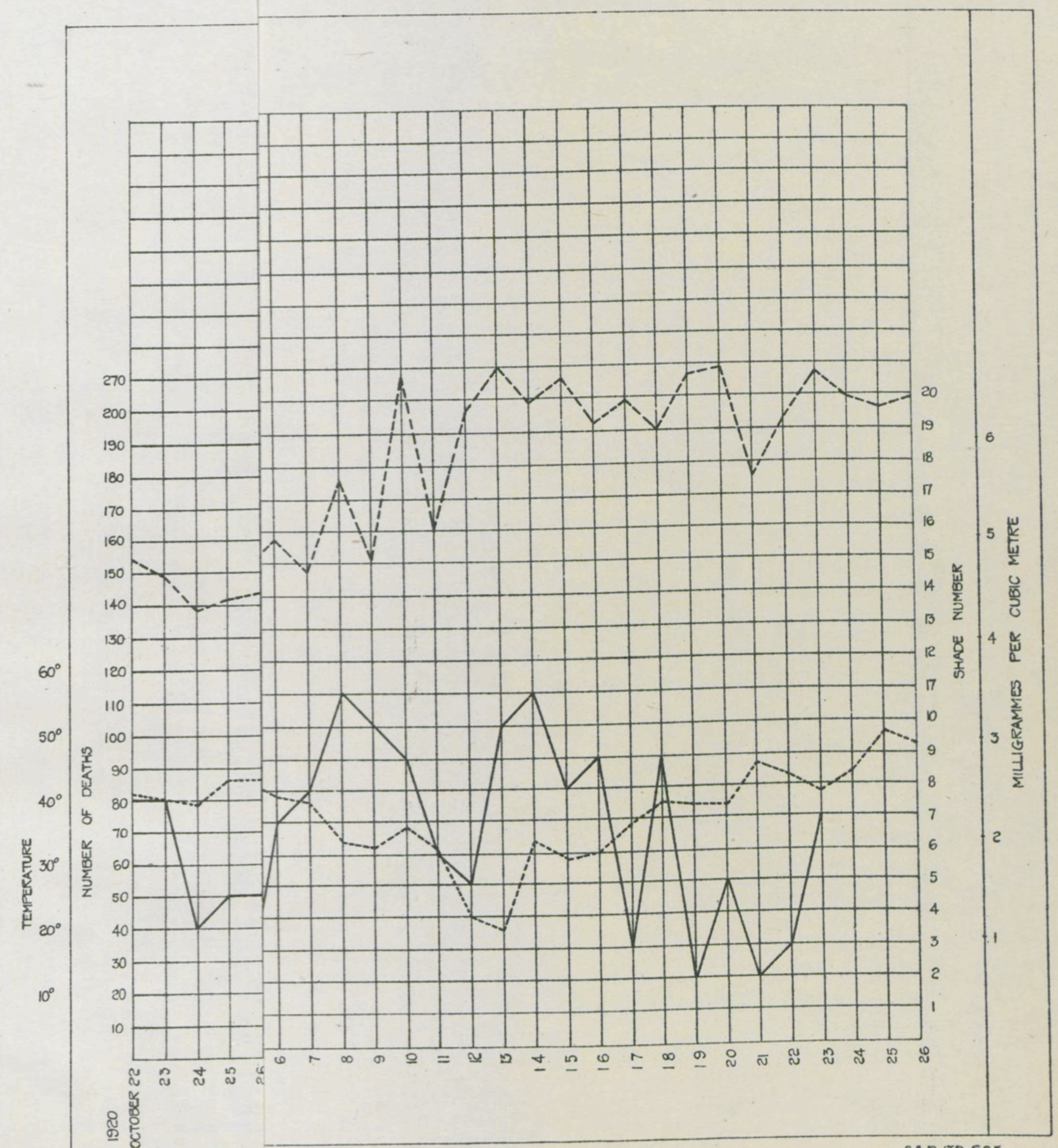


FIG. 7.



22382.6646/893.1000.2'22.

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temperature for each day was also included. Figures available admitted such a curve being plotted for all days between 22nd October 1920 and 26th December 1920, and the result is shown in Fig. 8.

It was thought that by reducing the figures to a six-day average some relation might be apparent and this was done and curves plotted, with the result as shown in Fig. 9.

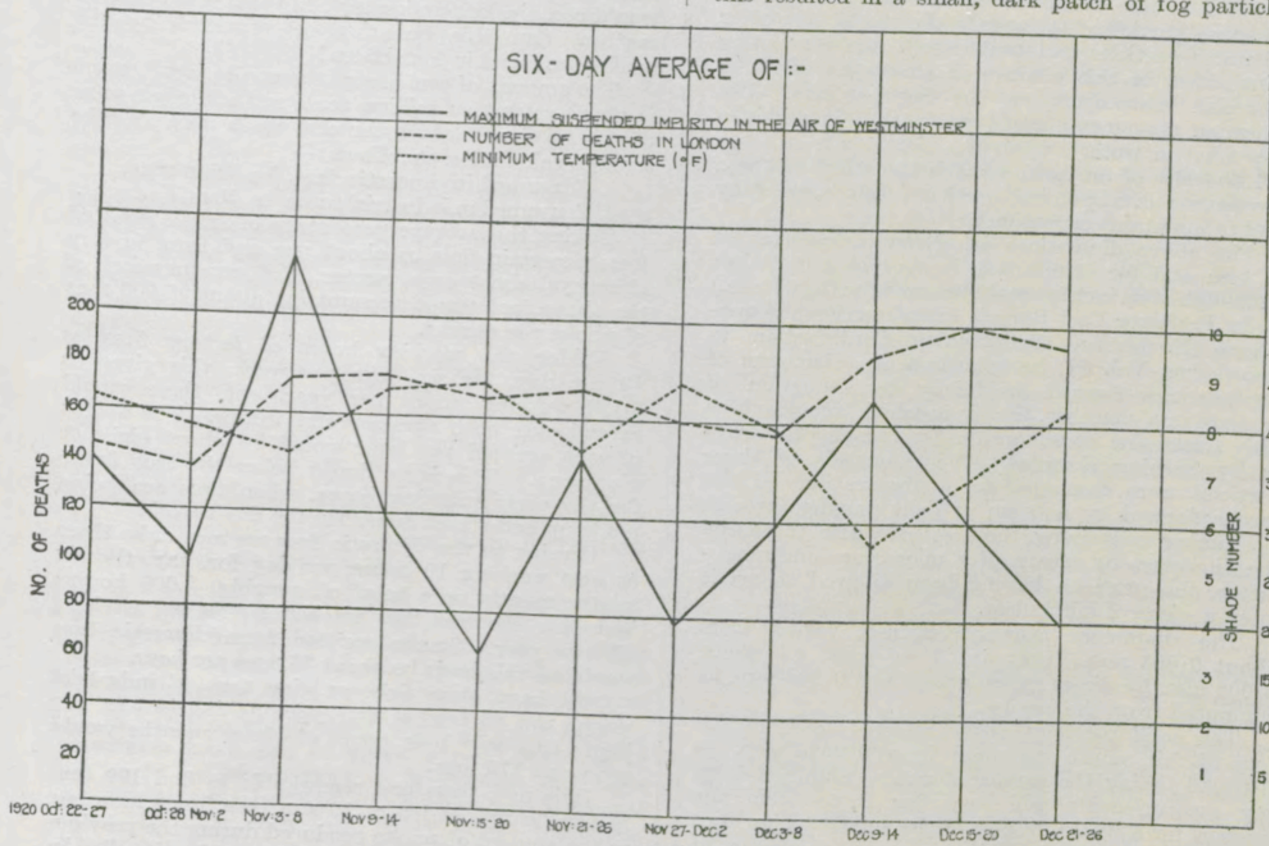

FIG. 9.

Referring to this figure there is a tendency noticeable for the death-rate to have a maximum when the impurity is highest, or rather a little later than the maximum impurity. There is, however, the complicating factor that the minimum temperature is also lowest at the same points, and on the whole there is no very obvious relationship to be observed between the quantity of impurity in the air and the number of deaths in London. It may be that with observations extended over a longer period some relation would be noticeable. It would be naturally expected that if the death-rate were affected by impurity this would show up most in the case of deaths from respiratory diseases, and an attempt was made to correlate these with impurity, with unsuccessful results which may be due partly to the fact that the deaths occurring actually in London were not available; the figures available were for deaths of Londoners occurring anywhere.

THE NOVEMBER FOGS IN LONDON.

By Dr. J. S. Owens.

Fog Nuclei.

During the fog of 5th November 1920 I obtained a sample of the solid particles by causing a small jet of air to impinge upon a glass microscope slide; this resulted in a small, dark patch of fog particles being deposited upon the slide. On examining these under a microscope, magnification about 1,000 diameters, I found a large mass of black particles scattered over the slide. There was an indication that the larger of these were made up of smaller particles which had stuck together, evidently under the influence of the jet, as in some slides I noticed a radial arrangement of these larger masses. There were plenty of small individual particles visible, and I measured the diameter of these and found that they varied between about 1/100,000th and 1/20,000th of an inch. The large masses of particles above referred to were up to 1/3,000th of an inch in diameter. In this experiment the slide was dry, but I took a sample in a similar way using a drop of thick paraffin under the jet; the result was not apparently different from the first.

During these fogs the wind was from the east and the fog extended into the country. In a sample taken in the same way at Cheam, Surrey, about

12 miles out—south-west—during a thick white fog on 6th November, I found again the same crowds of solid particles adhering to the slide and the maximum size was approximately 1/20,000th of an inch, many of them being of this diameter. There were also smaller particles down to about 1/100,000th of an inch. This was taken on a dry slide. Later in the day the fog cleared, leaving a bluish haze. I took a sample again during this haze, and found the same particles, apparently the nuclei left after the water particles had evaporated. An interesting point arises in this connection as to the effect of Brownian movements on the fog particles. The Brownian movements are quite marked in particles suspended in water; when the diameter is as large as 1/20,000th of an inch, what is the effect of these movements on suspended particles, that is, do they tend to maintain suspension?

The above dimensions are given in fractions of an inch and for comparison it may be noted that 1/25,400th of an inch is equal to one micron (0·001 mm.)

In Professor Carl Barus's experiments on Atmospheric Nucleation (Smithsonian Contribution to Knowledge, Vol. 34) he measured the diameters of fog particles formed artificially by reduction of pressure in a chamber, the air in which was provided with nuclei for condensation by means of X-rays or by burning charcoal. The diameters of these particles were computed from observations of the corona formed by a beam of light passing through a chamber containing the fog. He also measured the diameters by means of a microscope and micrometer, the particles having been allowed to settle upon a piece of oiled glass.

The diameters thus ascertained varied from about 0·003 mm., that is, 3 microns, to about 0·008 mm. by direct measurement and 0·006 mm. as computed from the corona.

The solid particles above referred to from the fogs of this month measured from 0·0013 mm. to 0·00026 taking the smaller diameter obtained from my measurements and assuming it to form the nucleus for a water droplet of the smallest diameter, that is, 0·003 mm. This gives the thickness of water-film surrounding the nucleus approximately 0·0014 mm.

Sources of Solid Particles in London Fogs.

The records of smoke fogs taken during November 1920 on the automatic fog recorder show that they may come on in about 3 to 4 hours; that is, the air at 6 a.m. may be comparatively clear and at 9 to 10 a.m. be laden with smoke fog.

It is of interest to enquire whether the quantity of smoke emitted during this time in London is sufficient to account for the quantity of impurity found in the fog.

The scale of densities used with the automatic recorder shows that when the air in London is fairly clear for winter the amount of suspended matter is of the order of 1 mg. per cubic metre. It may fall much below this on clear nights between midnight and 6 a.m.

During a dense fog the quantity rises to about 5 mg. per cubic metre, an increase of 4 mg. in, say, 4 hours. It is noteworthy how very small a quantity of impurity is sufficient to cause a dense fog, and this is doubtless due to the extremely small dimensions of the individual particles.

To obtain an approximation to the weight of impurity represented by such a fog suspended over London, we may make a rough calculation based upon an area of 120 square miles and a height of 400 feet. With 5 mg. per cubic metre this volume would contain, approximately, 190 tons of suspended matter. Can this quantity be provided by the smoke produced in four hours?

The amount of coal brought annually into London is about seventeen million tons, and although some of this no doubt leaves the city again we may take a rough calculation as follows:—

Consumed in domestic fires, 7 million tons.
Consumed in industrial furnaces, 10 million tons.

Taking the average percentage of smoke emitted from domestic fires as about one and from factory chimneys about one-quarter, the consumption of the above fuel would account for about 95,000 tons of smoke per annum.

Taking the working hours of factory fires as 10 per day, for six days per week, this gives us 3,120 working hours per year, and these would extend over both summer and winter. The weight of soot emitted per hour would be about eight or nine tons. This is no doubt below the true figure for the early morning hours, when fires are being made up and steam raised for the day's work.

Turning to the domestic fires we may take them as also working 10 hours per day for, say, the six winter months or a total of, roughly, 2,000 hours; including the fact that kitchen ranges are working all the year. Smoke emitted from domestic fires would on this basis be about 35 tons per hour.

We have thus eight or nine tons of industrial smoke and 35 tons of domestic, making 44 tons per hour; this over four hours of winter months would represent 176 tons.

It is not, therefore, remarkable to find 190 tons hanging over London at 10 a.m. on a foggy morning, as the amount of smoke produced during the previous four hours is sufficient to account for it all. In view of the fact that domestic smoke contains about 30 per cent. of tar, while factory smoke contains much less, say 1 per cent., it is probable that a larger proportion of domestic soot sticks to the chimney and thus the proportion found in the air would be reduced.

DUST IN EXPIRED AIR.

By Dr. J. S. Owens.

The efficacy of the air passage as a trap for the removal of suspended matter in the air has been generally assumed to be very high. Tyndall is quoted as stating that expired air was optically pure, and generally speaking the assumption is made that air entering the lungs through the nose is purified from all suspended matter before it reaches the deeper parts of the lungs.

Having some doubts as to the truth of this assumption I made a few experiments to ascertain what the facts of the case were. Using the standard instrument described in the Third Report I tested, on 17th November last, a sample of air during a slight smoke haze in London. The air was found to contain, approximately, 1·92 mgs. per cubic metre. I then filled a small rubber balloon with ordinary "tidal" expired air, taking care that the balloon was washed out by filling with expired air and emptying several times before testing. It was then blown up with air breathed in through the nose as in ordinary respiration, the balloon was fixed on the filter and a record obtained from the contained expired air. This was found to contain 1·28 mgs. per cubic metre.

Thus in ordinary breathing the expired air contained about 70 per cent. of the suspended impurity which entered during inspiration. Doubtless some of the suspended matter in the expired air was deposited on the walls of the balloon, but this would be a very small percentage of the total and would not invalidate the general results.

A similar experiment was then made, but in this case instead of "tidal" air, "reserve" air was used; the balloon was thoroughly washed out with "reserve" air and then filled after the end of a long expiration, the air in each case being drawn in through the nose. The balloon was attached to the instrument and a record obtained which showed that the "reserve" air contained about 60 per cent. of the dust in the inspired air.

It was subsequently found that the presence of dust in quantity in reserve air was mainly a result of the deep inspirations necessary to fill the lungs during the process of blowing up the balloon with reserve air, as this could not be done in one expiration.

In order to check these observations I used an apparatus by means of which a very small jet of air could be blown upon a microscope slip; the jet was about 1/100 inch in diameter and impinged upon the slide at a distance of about 1/16 inch. The result of causing such a jet of air to strike the slide is that a certain proportion of the suspended particles strike and adhere to the slide, so that a few cubic centimetres of ordinary London air directed against the slide are sufficient to produce a black spot, quite visible to the naked eye.

Using this instrument I repeated the observations both with expired "tidal" air and with expired "reserve" air, taking all precautions to avoid fallacies in the experiment. In each case from the expired air I obtained a black deposit upon the slide. A sample of ordinary London air projected against the slide was examined microscopically, and it was found that the particles were all black and varied in diameter between 1/100,000 and 1/20,000 of an inch. Slides obtained from expired air were also examined and the deposit was found to consist of similar black particles of similar dimensions.

It seems certain, therefore, that the suspended matter in the air of London is not entirely removed by the action of the respiratory passages, but only about 30 per cent. is so removed.

VISIBILITY.

The research on visibility and its relation to suspended impurity in the air was under the consideration of the Committee, and arrangements were made for co-operation with the "Illuminating Engineering Society," as they had also under consideration a research into the obstruction of light by suspended matter in the air.

Professor Morris, as Chairman of the Research Committee, was elected a member of the Technical Sub-Committee in view of the above co-operation. It was thought advisable that the research should be limited to definite problems in the first instance, which problems could be clearly defined, and the following were decided upon as the most important for investigation:—

(1) Visibility of lights and its relation to suspended matter.
(2) Visibility of illuminated surfaces as affected by suspended matter.
(3) Discrimination between suspended solid impurity and water fog and their effect upon light obstruction.
(4) Discrimination of dark or coloured objects against a light background by daylight, such, for example, as chimney stacks or trees against the sky as a background.
(5) The measurement of light obstructed by suspended matter.

It was decided to attempt first a measurement of the amount of light obstructed by suspended matter and the method of doing this which was ultimately decided on was to measure the brightness of a uniformly illuminated area at different distances, the area to be sufficiently large to fill the field of view of the photometer when at its maximum distance. The idea underlying this method is that the falling off of brightness, as observed in this way, would not be affected by distance except in so far as the light would be obstructed by the medium.

This result is brought about since the area of the surface viewed through a given opening varies as the square of the distance from the opening, while the light received from each unit of area falls off in the same ratio; thus the observed brightness of the source should remain constant for different distances if viewed through a perfectly transparent medium.

NOTES ON THE RELATION OF VISIBILITY TO SUSPENDED IMPURITY.

By Dr. J. S. Owens.

Assuming uniformity of size and distribution of particles consider a beam of light passing through them.

Let L units of light per second enter each unit of sectional area of the impure air, then, if the projected area of each particle be equal to A, and the number of particles in the path of the beam be equal to B, the light obstructed will be proportional to the total areas of all particles in the path, that is, AB. Assuming that no particle is in the shadow of another, the light obstructed will be equal to LAB per unit of sectional area, and in such a case the amount of light passing would be equal to L (1 − AB).

It is certain, however, that the suspended particles are not so arranged that no particle is in the shadow of another; further, there is no certainty that they are of uniform dimensions. Hence, this method of obtaining the amount of light stopped would not be applicable practically.

If, however, we ascertain that unit length of column, of unit sectional area, containing a known quantity of suspended matter, obstructs or cuts off a definite proportion of the light which has its path through it, it may fairly be assumed that a second unit length of column behind the first will again reduce the amount of light which has its path through it by a similar proportion. It might also, I think, be fairly assumed that if the number of particles of suspended impurity contained in any unit length of column be doubled, the amount of light obstructed by that column will also be doubled. It would seem, then, that a method might be evolved in this way for obtaining the relationship between a quantity of suspended impurity in the air and the amount of light obstructed by it. Certain assumptions would, of course, have to be made; for example, supposing the light obstructed by unit quantity of suspended matter be measured, and then the quantity of suspended matter be increased, it is assumed that the additional suspended impurity would be similar in dimensions of particles to that used for ascertaining the obstruction due to unit quantity. It would also have to be assumed that the nature or dimensions of particles did not vary appreciably at different times.

The existence of water vapour in the air is a complicating factor which would have to be eliminated in some way.

Several possible methods suggest themselves for this purpose; for example, if an apparatus could be arranged so that before measuring the obstruction of light due to suspended solid matter, the water fog could be dissipated by, for example, heating a column of air in a hot-water jacketed tube, through which the light used for measuring is passed.

Again, a method in which a simultaneous estimation is made of the quantity of solid matter suspended and the quantity of water present might provide a means of separating these two; for example, if a measurement of light obstructed is made at the same time, and it was known from previous measurements that the quantity of suspended impurity present would account for a certain amount of light obstruction, then the balance of light obstruction would presumably be due to the amount of water present.

A point, however, which has to be considered is whether the measurement of light obstructed is a fair measurement of visibility. This might be true if the rays of light travelled straight from their source to the eye or the photometer used for measuring, but it is probable that the light received by a photometer from a distant source, after passing through air containing suspended particles, is not composed entirely of direct rays, but some part of the illumination is due to scattered rays reflected again from the suspended particles to the photometer.

It is a well-known phenomenon that the visibility of a distant object viewed through air containing suspended matter is profoundly affected if a bright transverse beam illuminates the suspended particles. Such a beam is an effective obstacle to visibility through it, although it does not affect in any way the amount of light reaching the eye from the distant object.

Again, there is the possible effect of suspended matter on the colour of the transmitted light, which effect is dependent on the size of the particles; for example, with sufficiently finely divided matter the light rays of short wave length near the blue end of the spectrum will be obstructed more than the red, whereas, if the same quantity of suspended matter be present, only more coarsely divided, this selective action will not take place.

Leaving these points out of consideration for the moment, we may consider the effect of suspended matter on the obstruction of light. Suppose a beam of light passes through impure air, and that in passing through unit thickness some of it is absorbed by the suspended particles and only $\frac{1}{n}$ th of the light which enters is passed through.

Let L units of light per second fall on unit area of such a column of air, then, after passing through unit distance only $\frac{L}{n}$ units emerge. This quantity of light falls upon the second layer of unit thickness where again $\frac{1}{n}$th is absorbed, so that the quantity passed will amount to $\frac{1}{n} \times \frac{L}{n} = \frac{L}{n^2}$ and so on. This result may be tabulated somewhat as follows :—.

In 1st unit of distance.	Units received.	Units passed.	Units absorbed.
(1)	L	$\frac{L}{n}$	$L\,(1 - \frac{1}{n})$
(2)	$\frac{L}{n}$	$\frac{L}{n^2}$	$L\,(1 - \frac{1}{n^2})$
(3)	$\frac{L}{n^2}$	$\frac{L}{n^3}$	$L\,(1 - \frac{1}{n^3})$

and generally, if x is the number of units of thickness passed through, each unit of which passes $\frac{1}{n}$th of the light reaching it, then after passing through x units of distance the amount of light emerging will be $\frac{1}{n^x}$ of the total, and the amount absorbed will be $L\,(1 - \frac{1}{n^x})$.

In the above, instead of calling x the unit of distance, we may call it unit of quantity of impurity

for example, the amount contained in unit distance through which the light passes, with the same result.

This takes no account of the falling off of illumination through distance, that is, it assumes a parallel beam. In examining the effect of impurity on visibility, the divergence of the beam must be taken into account. When light is emitted from a point source, the same quantity of light will fall on the surface of all spheres surrounding the source, at whatever distance. Therefore, the quantity per unit of area will vary inversely as the surface of the sphere, or inversely as the square of the radius, or distance from the source. Suppose, then, the light is viewed through a long column of impure air of uniform sectional area; for example, an imaginary column of diameter equal to the pupil of the eye.

Let this column be divided into sections of unit length commencing at the source of light, and suppose, in the first instance, that the eye is placed behind section 1, and that in pure air it would there receive L units of light per second, while in impure air containing suspended particles, it receives only $\frac{1}{n}$th of this or $\frac{L}{n}$. If, now, the eye is moved back behind section 2, in the absence of impurity it would receive $\frac{L}{2^2}$ units, but in passing through section 1 the suspended matter cuts off some, and only $\frac{1}{n}$th of the light passes into section 2, that is, $\frac{L}{2^2} \times \frac{1}{n}$. Again, $\frac{1}{n}$th of this quantity is all that passes through section 2, or $\frac{L}{2^2} \times \frac{1}{n} \times \frac{1}{n}$, or $\frac{L}{2^2} \times \frac{1}{n^2}$. Similarly for Section 3, in pure air $\frac{L}{3^2}$ would pass through it to the eye, but $\frac{1}{n}$th of this only passes section 1, that is, $\frac{L}{3^2} \times \frac{1}{n}$th and $\frac{1}{n}$th of this quantity passes section 2, or $\frac{L}{3^2} \times \frac{1}{n^2}$ and again $\frac{1}{n}$th of the latter quantity passes section 3, or $\frac{L}{3^2} \times \frac{1}{n^3}$.

Generally, therefore, at section No. x, the light lost in passing through the column of x units in length will be $L\,(1 - \frac{1}{x^2 n^x})$.

In this way x may be taken as units of impurity present, the unit being the quantity of suspended matter which allows to pass $\frac{1}{n}$th of the light, which has its path through it and cuts off $1 - \frac{1}{n}$.

In view of the effect upon visibility of the scattering of light by suspended particles, it would seem necessary to eliminate this factor in order to get any useful results in measurements. It appears probable, therefore, that to get a measure of visibility, in which the peculiarities of the human eye play an important part, it would be best to make observations directly of some illuminated object at a suitable distance and to compare the brilliancy of such an object with some standard previously adjusted to represent what the brilliancy should be if the object had been viewed through air containing no suspended impurity. This method would appear to be more promising than to examine the amount of light falling upon a photometer from a distant source as the quantity reaching the photometer, as already pointed out, would not be a true measure of the visibility of the object, since the latter depends upon the passage of unobstructed rays in a direct line to the eye.

The problem which we are now attempting to solve may be defined as "to ascertain the effect on visibility of suspended impurities in the air." It is obvious that visibility involves not only the light emitted from an object which reaches the eye, but also the capacity of the eye to perceive. It will be useful first to consider what we mean by visibility, and how it comes about that objects are visible and distinguishable from each other.

Perception of Light and Shade.

Suppose a piece of white paper be examined against a white background, it may be quite impossible to distinguish its presence, although it may be well illuminated, if the background and the paper present exactly the same appearance to the eye, then the paper will, to all intents and purposes, be invisible. Strictly speaking, the paper is visible but it is unrecognisable, since there is nothing to distinguish it from its surroundings. The classic researches on the sensitiveness of the eye in perceiving light and shade were made by Koenig and Brodhun. They measured the percentage change in brightness which was detectable by the eye for a wide range of blue and red light. The result showed that the sensitiveness of the eye increased very rapidly as the illumination rose to about one-half a foot-candle, after this there was still further increase of sensitiveness up to about three foot-candles, beyond which further increase of illumination made little increase in the sensitiveness. The same was also demonstrated by experiments with the Lummer and Brodhun photometer, described in the "Illuminating Engineering." Vol. 3, 1910.

Illumination.

If the paper above referred to is illuminated to a greater or less extent than the background, it becomes visible and distinguishable from the background. The capacity to distinguish a slight difference in the illumination does not depend upon the amount of the difference, but upon the ratio it bears to the total illumination. It has been found, for example, that the percentage change in tone which can be perceived by the human eye is, under favourable conditions, about one-half per cent., but may be, in unfavourable conditions, as much as ten per cent. This percentage change is known as Fechner's fraction, and it varies with the individual and with the order of illumination. Thus the perception of an object by the human eye depends upon the factors of light and shade.

Form.

Another factor affecting the capacity to recognise objects is the perception of form, and this is found to vary in a very remarkable way with the illumination. It was examined by Lapôte and Broca by reading print under different illuminations, when it was found that the acuteness of vision, depending here upon the recognition of particular forms or letters, falls off very rapidly when the illumination fell to less than one-half a foot-candle; also, on increasing the illumination a point was reached at from two to four foot-candles, beyond which very little increase in the acuteness of vision resulted. Thus, the maximum acuteness for recognition of form may be said to be when the illumination of the object is about four foot-candles.

Perception of Colour.

This plays an important part in visibility as difference in colour alone would be sufficient to distinguish or make an object visible. The sensitiveness of the human eye differs greatly in different individuals. Generally speaking, however, it has been found that a certain minimum quantity of light is necessary for the perception of any colour; for example, as the light fades, reds first become invisible as such, and show nearly black, while the blue-greens are still visible. Further reduction of light causes all colours to disappear and merge into a uniform grey. The degree of sensitiveness of the human eye to different colours is not the same, as in a very faint light the blue-greens are more recognisable than the reds, to which the eye is comparatively insensitive in weak lights. Thus, if a white light is gradually reduced by any cause it would appear to follow that, before becoming invisible, the light would become bluish in tint.

The fact that the human eye is not achromatic has an effect, also, upon visibility. The eye is commonly short-sighted for violet. The result of this is that it cannot focus widely different colours simultaneously. When viewing near objects there is little difference to be detected between the sharpness of the objects illuminated by the light of different colours, since the observer can accommodate. When viewing objects at a distance, however, those illuminated by the blue light become blurred. Luckiesh (*Electric World*, 11th November 1911) found that monochromatic light generally gave more acute vision than white light, and that the maximum degree of acuteness was given by yellow.

It is obvious from the above that there are many points of importance to be kept in mind in attempting to relate the degree of visibility to the quantity of suspended impurities in the air. On the whole it would seem best to aim, in the first instance, at examining the visibility of some object when viewed directly by the naked eye. It would also seem advisable that such an object should be illuminated by ordinary white light. Variations in sensitiveness of different individuals may be examined by making a series of observations by individuals with different degrees of sensitiveness.

The Scattering of Light by Suspended Matter.

When a distant object is viewed through air containing suspended impurity, if this object is simply a light at night and there are no other sources of light illuminating the suspended matter between the observer and the object, the visibility will depend to a great extent upon the proportion of the object which is obscured by the intervening particles of the suspended matter; although in the case of a light there will be an illumination of the suspended particles which also affects the visibility. On the other hand, when the object is viewed in daylight as in the case of any distant objects looked at in daylight the conditions are different, should there be suspended matter in the air, for not only is there the effect of obscuring the object viewed by the intervening particles, but there is a much more important effect resulting from the illumination of these particles by the light from other sources.

During a mist a bright beam of light passing between the observer and the object effectually reduces the visibility. This illumination appears to operate in at least two ways:—

(1) The visibility or otherwise of an object depends upon the contrast with its surroundings, and, when depending upon difference of illumination, that is upon light and shade, this difference must be a certain percentage of the total illumination; for example, suppose an object differs from its surroundings by 1 per cent. in the illumination, the object receiving 99 and the background 100 units of light. If now the field of view be more highly illuminated, the difference remaining constant, the object may become invisible owing to the fact that the percentage difference between it and its surroundings is not sufficient under the new conditions of increased illumination: Or, if a veil of illuminated haze be hung between the observer and the object, say a dark body viewed against the sky, the illumination of the background may be apparently unaffected while the object becomes lighter in shade and, as the haze increases, ultimately merges into the background, all contrast being lost.

(2) Another effect must apparently arise from the fact that, before the suspended matter is illuminated, each particle acts simply as an opaque body, its effect being proportional to its area as projected upon the object, the particles themselves being invisible individually. On the other hand when such particles are illuminated from the observer's side each one becomes a point source of light, but such points are not visible to the eye as points, but as discs due to diffraction and other causes, so when the particles are illuminated in this way they become suddenly increased in area as viewed by the eye, and thus doubtless have an obscuring power proportional to the increased area. This follows from the well-known fact that no optical instruments, however perfect, can form an image of a point of light but always show a "false" disc, and the human eye is not different in this respect from other optical instruments.

It is certain, however, that the illumination of suspended matter by light falling upon the observer's side of the suspended particles is a very important factor to be considered in connection with visibility.

RESEARCH WORK ON MEASUREMENT OF ACIDITY.

Research work on the measurement of acidity has been continued on lines similar to those described in the Sixth Annual Report, but since no definite conclusion has been reached it has for the sake of economy been deemed advisable not to publish a detailed account of the work in the present report, but to withhold it until the end of the research.

The work was resumed in September last by Mr. G. M. Watson.

Briefly, it has been concluded that for the measurement of acidity in the suspended matter of the air, the colorimetric method as first tried was unsuitable, and attention has been concentrated on estimation by means of electrical conductivity. This method is extremely sensitive—so much so that it has been necessary to use silica apparatus, the alkali dissolved in a few minutes from a glass vessel being, in many cases, sufficient to invalidate completely the experiments.

Owing to failure to discover a filtering medium of sufficient neutrality to be of use, an electrical means of collecting the suspended matter from the air has been under examination for the purpose. When air was drawn as rapidly as possible through a powder filter for 24 hours, 60 cubic feet of air being dealt with, the collected dirt did not, in any case, produce as great an effect upon the conductivity of the water into which it was introduced as did the filtering medium itself. Even powdered silica could not be obtained of sufficient neutrality to use, and it was impossible to increase the quantity of dust by passing a larger volume of air, since the resistance to passage of air offered by the powder was too great.

The electrical method of precipitation mentioned in the Fifth Report could not be used, because a silent discharge was produced, quite invisible, but giving rise to ozone and oxides of nitrogen which completely spoiled the experiments.

It has been found, however, that by passing air over the surface of a very small quantity of conductivity water in a flat silica dish, the water being electrified statically by means of a Wimshurst machine, it is possible to collect the suspended matter from it without production of oxides of nitrogen, and to estimate the collected dirt by means of electrical conductivity.

The conductivity of the water is determined in the usual way after the introduction of gold-plated electrodes constructed of long lengths of fine wire, and by this means the presence of the most minute quantity of electrolyte can be detected. For instance, simply touching the surface of the water by means of a glass rod cleaned in any ordinary way produces a distinct change in the resistance of the system.

There is definite indication that this method might be used for estimation of gaseous acid as well as suspended, and the possibility of differentiating between these two forms of impurity by means of one piece of apparatus is being investigated.

Experimental difficulties in connection with any apparatus of this sensitiveness are great; but should it be possible to find a practical application of the method, it will afford a very rapid means of estimating electrolyte in the suspended matter of the air.

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