The soil in its relation to disease : a report of observations / by T. R. Lewis, and D. D. Cunningham.

THE SOIL IN ITS RELATION TO DISEASE.

A REPORT OF OBSERVATIONS

BY

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CONTENTS.

THE present Report embodies the results of observations which have been carried out with a view of determining to what extent peculiar conditions or changes of condition in the soil in Calcutta affect the prevalence of disease in general, and of certain diseases in particular.

Soil-conditions in relation to disease.

The phenomena forming the subjects of observation were:—

(1) The amount of moisture in the soil;
(2) The temperature of the soil; and
(3) The amount of carbonic acid in soil-air.

As is well known, marked attention has lately been directed to the importance of soil-meteorology as affecting the prevalence of disease, and it formed one of the subjects to which our attention was directed by the Army Sanitary Commission and by Dr. Parkes. Most careful observations have been published by Dr. Max von Pettenkofer and other savants regarding it—indeed, it was at the special suggestion of Dr. von Pettenkofer that some of the observations here recorded were undertaken.

Observations on water-level.

Observations on the varying conditions of soil-moisture as indicated by water-level and rain-fall have been carried out in many places in India for some years, and although, owing to the difficulties incident on the beginning of any entirely new series of

observations, the results have not as yet been so generally satisfactory as might have been desired, still a large number of thoroughly trustworthy data have been already accumulated regarding the matter. These will be made the subject of a special Report hereafter; in the meantime, we have limited ourselves to the consideration of the phenomena observed during a complete year in Calcutta, where the observations have been conducted so as to furnish data for comparison with similar observations which have been, and may still be, recorded elsewhere in India.

Temperature of the soil and carbonic acid in the soil-air.

Observations on the temperature and carbonic acid-contents of the soil have never, so far as we are aware, been carried out in this country, and even in Europe they have been made only in a few isolated localities. We would therefore take the present opportunity of pointing out their value and of pressing on the attention of the Meteorological Department the importance of investigating and recording some of the more prominent features of sub-soil phenomena.

From an etiological point of view it is obviously quite insufficient to be informed merely of atmospheric meteorology and to remain in total ignorance of telluric conditions. This view of the case is becoming more and more realized in Europe, and the value and importance of acquiring the necessary data in this country cannot be over-estimated.

Period specially reviewed.

We have thought it better to confine our attention to the consideration of the phenomena presented by a period during which our observations on soil-conditions were most numerous and of the most varied nature, but data regarding water-level and soil temperature for a considerably longer period are given in the accompanying tables.

The period specially considered ranges from the month of July 1873 to August 1874, and for this period full details are given regarding the temperature and carbonic acid-contents of the soil at 3 and 6 feet from the surface. The coincident phenomena of rain-fall, atmospheric temperature, and velocity of wind are also given, together with the statistics of total mortality; of mortality from cholera; and of the prevalence of fever and dysentery.

Figures regarding all these phenomena will be found in the tables (I—VI) and the relations which they bear to one another are, moreover, graphically represented in a series of diagrams of graduated curves. An additional diagram has also been constructed showing the monthly fluctuation in the carbonic acid of the soil-air as compared with the results of the experiments conducted in Munich by von Pettenkofer.

(1.)—Mode in which the Observations have been conducted and the sources of the various Data.

It will be convenient, before proceeding to describe the results of the observations, to give a brief account of the sources from which the data were derived and the means by which they were obtained.

(*a*)—*Carbonic Acid of the Soil-Air.*

Means adopted in estimating the amount of carbonic acid in the soil-air.

The data on this point were obtained by our own observations. During a considerable portion of the period under review the experiments were made with regard to one locality only, but subsequently another series was undertaken so as to ascertain the amount of carbonic acid in two localities separated from each other by about 50 yards.

The depths selected for observations were in both cases 3 and 6 feet respectively: observations at a lower level were not attempted, as it did not seem to be desirable to go deeper into a soil such as that of Calcutta where the water-level is for a considerable portion of the year so superficial as to cause saturation of the soil at a short distance beneath the surface.

Description of apparatus employed to obtain the air from the soil;

The method adopted for conveying the air from the soil at these depths was very simple. Two lead tubes were procured, and at one end of each a hollow perforated bulb was soldered. A pit was dug in the soil—the ordinary alluvial soil of Calcutta—perfectly free from all sources of surface pollution, and which had probably

not been disturbed for a quarter of a century. One of these tubes was passed through the bottom of an ordinary flower pot, inverted, and perforated in numerous places. Below and surrounding this pot fragments of earthen-ware were arranged so as to keep the earth from plugging the orifices in the bulbous extremity of the leaden tube. The pit was now filled up to within 3 feet of the surface and the other tube introduced and similarly protected from being plugged by the fine soil; the earth was then heaped up and well beaten down, until it reached the level of the surface.

The other pit was of a similar kind, and the leaden pipes were introduced and protected in the same manner. The observations in each case were not undertaken until a considerable period had elapsed, so as to allow the soil to regain its ordinary condition.

The tubes were then conducted into a room and attached to an aspirator capable of holding thirty-eight and a half litres.

The remarks made by Dr. von Pettenkofer with reference to the ease with which air could be made to pass either way through the tubes which he had introduced into the earth apply with equal force to our own tubes. Air could be blown through the tubes with the greatest ease, so much so that we could not for certain distinguish the pipes which had been lodged in the earth from a pipe of similar length placed alongside them, but with both its ends opening into the free air, by blowing alternately through them. This fact of itself testifies to the readiness with which intercommunication occurs between the atmosphere and the sub-soil air.

and to determine the amount of carbonic acid present in it.

Attached to the aspirator—intervening between it and the pipe leading into the soil—were the usual appliances for estimating the amount of carbonic acid by the Baryta process, as devised by von Pettenkofer many years ago, and which is fully explained in all modern treatises on chemistry. Briefly described, the method consists in causing the air under examination to pass through a flask containing a solution of baryta of known alkalinity, and subsequently ascertaining how much of the alkalinity has disappeared (by the passage through it of air containing carbonic acid) by means of a standard solution of oxalic acid—turmeric paper being employed in preference to litmus for ascertaining the precise stage when the solution becomes neutral.

This information having been obtained, the precise amount of carbonic acid was calculated by the method usually adopted in connection with volumetric analyses. As it is unnecessary to reproduce all these figures, we have confined ourselves to giving tables of the amount of carbonic acid per 1,000 volumes of soil-air at 0° C. and at 760 m. m. barometric pressure. Our acknowledgments are due to Mr. C. H. Wood, the Officiating Professor of Chemistry at the Medical College, for valuable aid in indicating the simplest and most accurate method of recording the data required in connection with this matter.

(*b*)—*Soil Temperature.*

The arrangements adopted in connection with the observations of soil temperature.

The data recorded on this point are also the result of our own observations and were obtained in the following manner:—A shallow shaft or well was sunk to a depth of slightly over 6 feet in the ordinary alluvium of Calcutta. The shaft having been made of sufficient capacity to allow of easy entrance, was lined with bricks and mortar. An opening was left in the floor to allow of easy drainage of any surface water which might obtain entrance, and two openings were left in the brick-work of one side of the shaft at depths of 3 and 6 feet, respectively, leading into wide tubes of perforated zinc, which penetrated the soil horizontally from the outer surface of the brick-work and terminated in open extremities in the earth.

These tubes were of sufficient diameter to allow of a narrow board, carrying the thermometers, being pushed into them. The thermometer board had a wooden plug and handle which fitted into the mouth of the tube whilst the opening in the brick-work was closed by an accurately adjusted wooden cover, and further secured by being coated externally with moist clay.

A thick wooden lid, covered by a layer of turf, closed the mouth of the shaft, and the entrance of rain or access of sun to the cover was prevented by means of a thatch roof about 5 feet above the ground.

Observations were made daily at 11 A. M., and the thermometers immediately returned to their places in the perforated zinc tubes let into the earth, care being taken to raise the temperature of the minimum and to depress that of the maximum, respectively, considerably above and below the temperature of the soil.

(*c*)—*Open-Air Temperature*; (*d*)—*Rain-fall; and* (*e*) *Wind-velocity.*

Source of Meteorological data.

The figures in Tables I—VI, upon which the charts are based, of daily and average weekly atmospheric temperature; of rain-fall; and of the velocity of the wind were obtained from the "Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta" as published in the Proceedings of the Asiatic Society of Bengal; but the monthly statements in Table VII of the atmospheric temperature and rain-fall are from the Annual Reports of the Meteorological Reporter to the Government of Bengal.

(*f*)—*Water-level.*

The water-level observations taken at Alipore.

The observations on the fluctuation in the water-level are those which have been registered under the superintendence of Dr. Sidney Lynch at the Alipore Jail. The data extend from February 1872 to the present time. The *weekly* averages in the variations of level for one year's observations, the year specially under review, have been given; but only the monthly fluctuation for the remaining periods (Table VII page 142) as the daily figures, or even those of the weekly mean of the observations, would occupy too great space.

(*g*)—*Statistics of Disease.*

The statistics of total mortality, cholera mortality, fevers and dysentery.

The figures of general mortality and of mortality from cholera which are given in Tables I to VI are those furnished to the Office of the Health Officer of Calcutta. Those regarding fever and dysentery are derived from the Hospital Registers of the Presidency and Alipore Jails; they represent, not the mortality, but the number of cases, and were selected as being presumably more accurate than those furnished by the Police to the Municipality. As the population of the jails averages only about 3,000, it was not considered large enough to furnish information with regard to the general prevalence of cholera with sufficient distinctness. We are under great obligations to both Dr. Sidney Lynch of the Alipore, and Dr. Coull Mackenzie of the Presidency Jails, for the valuable aid which they have given us on very many occasions in connection with our work and for the many data which they have always most readily placed at our disposal.

Having made these introductory explanations with regard to the data which we have brought together, we now proceed to consider the result of the observations as shown in the accompanying tables and diagrammatic charts.

Weekly averages of the amount of Carbonic Acid in the Soil; Soil Temperature, &c., in relation to disease—Table I, July and August 1873.

Date.		Vols. of Carbonic Acid per 1,000 Vols. of Soil-Air.		Temperature of the Soil.				Mean temperature (open air).	Rainfall in inches.	Distance of water-level from surface in feet and inches: weekly averages (at Alipore.)	Weekly returns of deaths from Cholera. (Total reported in Calcutta.)	Weekly returns of sickness from		Weekly returns of deaths from all causes in Calcutta per 1,000 population.
		At 3 feet from surface.	At 6 feet from surface.	At 3 feet from surface.		At 6 feet from surface.						Dysentery. (In Presidency and Alipore Jails.)	Malarious fevers. (In Presidency and Alipore Jails.)	
				Maximum.	Minimum.	Maximum.	Minimum.							
1873.				°F.	°F.	°F.	°F.	°F.						
July	1 ...	...	...	...	...	...	...	85·2	0·05″					
"	2 ...	...	...	...	...	...	...	83·7	0·13					
"	3 ...	...	...	84·8	81·8	82·5	81·4	83·0	0·51					
"	4 ...	3·342	7·411	84·8	81·4	82·7	80·8	83·1	0·16					
"	5 ...	3·488	6·394	84·2	81·1	82·6	81·4	81·5	0·42	15′ 0″	13	22	12	19·24
"	6 ...	...	...	83·9	81·0	82·7	81·5	83·0	0·04					
"	7 ...	...	...	83·6	80·7	82·5	81·4	83·8	0·35					
"	8 ...	...	...	83·6	80·5	82·5	81·3	83·8	0·42					
"	9 ...	3·923	8·573	83·8	80·7	82·5	81·3	83·5	...					
"	10 ...	5·667	8·664	83·5	80·6	82·7	81·0	84·8	0·41					
"	11 ...	5·522	7·847	84·0	80·4	82·1	81·0	83·3	0·5					
"	12 ...	3·923	7·411	83·5	80·7	82·4	81·0	82·4	1·10	14′ 11″	11	22	25	19·76
"	13 ...	4·068	7·266	...	...	...	...	82·8	0·10					
"	14 ...	5·086	7·411	...	...	...	..	81·3	0·19					
"	15 ...	5·667	7·701	82·9	80·4	82·5	80·6	82·6	0·16					
"	16 ...	5·958	7·701	82·5	80·1	82·5	80·6	84·0	1·07					
"	17 ...	5·667	7·266	82·8	80·1	82·9	81·5	84·5	0·48					
"	18 ...	5·667	7·266	...	...	...	...	80·5	1·80					
"	19 ...	6·248	7·701	82·5	80·2	82·5	81·2	83·6	0·31	14′ 6″	14	34	27	19·76
"	20 ...	...	...	82·7	80·1	82·0	81·4	85·5	0·07					
"	21 ...	6·380	8·573	82·8	80·1	82·0	81·3	84·2	0·66					
"	22 ...	4·923	7·701	83·1	80·3	81·9	81·6	85·6	...					
"	23 ...	5·376	7·411	82·8	80·4	81·8	81·4	83·4	0·33					
"	24 ...	6·394	6·830	...	...	...	...	83·6	0·38					
"	25 ...	6·248	7·266	82·8	80·2	81·8	81·3	83·9	0·02					
"	26 ...	6·248	7·120	...	...	...	...	85·1	...	14′ 2″	15	35	26	19·24
"	27 ...	...	...	82·9	80·3	82·2	81·2	82·4	2·05					
"	28 ...	6·539	7·120	83·5	80·0	81·8	81·2	81·1	3·26					
"	29 ...	6·539	7·556	82·6	80·0	82·2	81·3	81·8	0·73					
"	30 ...	5·958	6·103	82·8	79·8	82·0	81·1	84·4	...					
"	31 ...	5·958	7·701	82·3	79·5	81·8	81·0	83·0	...					
August	1 ...	...	...	82·5	79·6	82·2	81·0	81·8	0·74					
"	2 ...	6·539	7·411	82·0	79·6	81·7	81·0	82·5	0·08	13′ 5″	15	23	50	19·24
"	3 ...	...	...	...	...	...	...	83·6	0·13					
"	4 ...	7·266	7·266	...	...	...	...	84·5	0·07					
"	5 ...	9·009	9·155	82·7	79·5	81·9	80·8	82·3	0·11					
"	6 ...	9·300	10·608	82·1	79·6	81·8	81·8	81·2	0·34					
"	7 ...	10·317	10·463	82·3	79·7	81·6	81·0	81·3	0·05					
"	8 ...	9·881	10·027	82·3	79·5	81·7	80·9	82·7	...					
"	9 ...	10·027	9·736	...	...	...	...	83·3	...	12′ 9″	4	55	34	19·76
"	10 ...	9·881	9·737	81·9	79·5	82·2	80·5	80·9	0·3					
"	11 ...	9·445	9·591	...	...	...	...	80·2	1·12					
"	12 ...	9·300	9·736	82·2	79·2	81·9	80·6	79·5	1·61					
"	13 ...	9·155	10·608	81·5	79·0	81·6	80·4	80·2	1·27					
"	14 ..	9·881	11·044	81·5	78·8	81·7	80·5	82·1	0·70					
"	15 ...	9·881	11·188	81·6	78·8	81·9	80·3	83·3	0·11					
"	16 ...	10·753	12·206	82·1	78·9	81·8	80·0	84·2	0·07	11′ 7″	14	46	44	23·92
"	17 ...	10·027	11·196	81·5	79·0	81·4	80·4	84·9	...					
"	18 ...	...	...	81·8	79·0	81·1	80·4	83·3	0·10					
"	19 ...	10·753	12·061	81·8	79·2	81·5	80·5	84·0	0·93					
"	20 ...	10·899	12·352	81·8	79·1	82·0	80·5	83·9	0·37					
"	21 ...	11·625	13·514	82·0	79·3	82·0	80·5	86·5	...					
"	22 ...	11·770	13·660	81·5	79·5	81·8	80·5	86·0	...					
"	23 ...	10·608	11·916	81·9	79·6	82·1	80·5	83·8	0·04	11′ 0″	3	34	55	24·96
"	24 ...	10·608	12·206	81·8	79·6	81·5	80·4	85·3	...					
"	25 ...	11·334	11·770	81·8	79·7	81·2	80·5	86·1	0·14					
"	26 ...	12·642	12·497	82·3	79·7	81·7	80·5	85·5	0·04					
"	27 ...	11·334	12·497	82·1	79·9	81·5	80·6	85·7	...					
"	28 ...	10·753	12·206	82·0	79·4	81·3	80·7	83·2	0·31					
"	29 ...	12·642	12·061	82·3	79·7	81·2	80·8	82·7	0·70					
"	30 ...	11·044	10·463	82·7	79·7	81·2	80·8	83·0	0·40	10′ 8″	4	23	41	27·04
"	31 ...	...	...	...	...	...	...	84·3	0·48					

Weekly averages of the amount of Carbonic Acid in the Soil; Soil Temperature, &c., in relation to disease—Table II
September and October 1873.

Date.	Vols. of Carbonic Acid per 1,000 Vols. of Soil-air.		Temperature of the Soil.				Mean temperature (open air).	Rainfall in inches.	Distance of water-level from surface in feet and inches: weekly averages (at Alipore).	Weekly Returns of deaths from Cholera. (Total reported in Calcutta.)	Weekly Returns of Sickness from		Weekly Returns of deaths from all causes in Calcutta per 1,000 of population.
	At 3 feet from surface.	At 6 feet from surface.	At 3 feet from surface.		At 6 feet from surface.						Dysentery. (In Presidency and Alipore Jails.)	Malarious fevers. (In Presidency and Alipore Jails.)	
			Maximum.	Minimum.	Maximum.	Minimum.							
1873.			° F.	° F.	° F.	° F.	° F.						
September 1 ...	11·189	11·770	82·5	79·8	81·4	80·8	83·9	0·09					
„ 2 ...	10·899	12·352	81·8	79·8	81·4	80·9	83·0	0·10					
„ 3 ...	10·608	12·206	82·5	79·8	81·3	80·7	84·0						
„ 4 ...	10·899	11·916	81·8	79·8	82·1	80·5	83·4	0·11					
„ 5 ...	10·753	11·916	82·3	79·8	81·6	80·1	82·7	0·70					
„ 6 ...	11·916	11·625	82·6	79·8	81·5	80·1	78·6	2·32	10′ 5″	5	22	37	23·40
„ 7 ...	11·480	12·352	82·5	79·5	81·4	80·7	82·0	0·19					
„ 8 ...	10·899	12·061	82·1	79·4	81·3	80·4	85·0						
„ 9 ...	...	...	81·8	79·6	81·5	80·4	86·0						
„ 10 ...	11·625	12·061	82·5	79·8	81·5	80·5	85·0	0·29					
„ 11 ...	11·625	12·497	82·3	79·9	81·3	80·7	84·6	0·29					
„ 12 ...	...	...	82·2	80·0	81·2	80·8	82·1	0·72					
„ 13 ...	11·044	12·206	82·7	80·0	81·7	80·9	81·7	0·75	9′ 9″	9	25	52	23·40
„ 14 ...	...	...	...	...	...	...	81·3	0·13					
„ 15 ...	11·334	11·916	...	...	...	...	83·5	0·15					
„ 16 ...	11·625	12·497	82·5	79·8	81·7	80·6	84·9	0·06					
„ 17 ...	11·480	12·642	81·8	79·9	81·4	80·8	84·0						
„ 18 ...	10·899	...	81·8	80·0	81·7	80·5	84·6						
„ 19 ...	11·770	12·352	82·2	81·7	81·3	80·5	84·8						
„ 20 ...	11·770	12·788	81·9	80·1	81·4	80·6	85·0	...	10′ 1″	4	20	51	24·96
„ 21 ...	...	...	...	...	...	...	86·1						
„ 22 ...	12·061	12·788	82·8	80·1	81·5	81·0	86·6						
„ 23 ...	11·916	11·625	82·2	80·1	81·5	80·7	86·8						
„ 24 ...	12·206	12·788	...	...	...	...	87·0						
„ 25 ...	11·334	12·061	82·2	80·3	81·5	81·0	83·7						
„ 26 ...	10·753	10·899	82·2	80·4	81·6	80·9	85·8						
„ 27 ...	10·463	11·334	82·3	80·4	81·4	80·9	86·6	...	10′ 3″	6	8	45	23·92
„ 28 ...			82·2	80·5	81·4	80·6	86·5						
„ 29 ...			82·6	80·6	81·5	80·9	86·6						
„ 30 ...			...	...	...	...	84·6						
October 1 ...			82·3	80·3	81·6	80·9	84·9						
„ 2 ...			82·3	80·5	81·6	81·0	84·8						
„ 3 ...			82·5	80·0	81·5	81·0	85·7	2·05					
„ 4 ...			81·8	78·1	81·4	80·8	83·9	...	10′ 8″	8	20	38	27·56
„ 5 ...			...	...	...	...	84·4						
„ 6 ...			81·7	79·5	81·4	80·9	82·6						
„ 7 ...			...	...	...	...	82·1						
„ 8 ...			81·7	78·9	81·3	80·6	81·8						
„ 9 ...			80·5	78·4	81·4	80·3	81·5						
„ 10 ...			79·9	78·3	81·2	80·2	82·6						
„ 11 ...			80·0	78·2	81·0	80·2	79·4	0·20	10′ 11″	6	16	53	24·96
„ 12 ...			80·1	78·1	80·9	80·1	80·4	0·07					
„ 13 ...			80·1	77·9	80·8	80·0	80·9	0·08					
„ 14 ...	9·685	11·705	...	...	...	...	81·2						
„ 15 ...			80·1	77·9	80·8	79·9	82·3						
„ 16 ...			79·5	77·8	80·7	79·9	82·9						
„ 17 ...			79·7	77·8	80·8	79·8	82·6						
„ 18 ...			79·8	77·8	80·5	79·8	83·5	...	11′ 9″	5	22	47	25·67
„ 19 ...			...	...	...	...	83·7						
„ 20 ...			79·8	77·9	80·5	79·6	84·3						
„ 21 ...			...	...	...	...	84·6						
„ 22 ...			79·6	77·9	80·5	79·8	83·8						
„ 23 ...			...	...	...	...	81·8						
„ 24 ...			79·6	78·0	80·4	79·6	81·9						
„ 25 ...			80·1	78·0	80·4	79·0	82·0	...	12′ 3″	4	14	42	27·04
„ 26 ...			79·4	78·0	80·3	79·0	80·4						
„ 27 ...			79·8	78·0	80·8	79·3	80·6						
„ 28 ...			78·9	77·8	80·1	79·0	77·5						
„ 29 ...			78·6	77·4	80·1	79·1	77·8						
„ 30 ...			78·3	77·0	79·9	79·0	78·3						
„ 31 ...			77·7	76·5	79·8	78·7	77·8						

Weekly averages of the amount of Carbonic Acid in the Soil; Soil Temperature, &c., in relation to disease—Table III, November and December 1873.

Date.	Vols. of Carbonic Acid per 1,000 Vols. of Soil-air.		Temperature of the Soil.				Mean temperature (open air).	Rainfall in inches.	Distance of water-level from surface in feet and inches: weekly averages (at Alipore).	Weekly Returns of deaths from Cholera. (Total reported in Calcutta.)	Weekly Returns of sickness from		Weekly Returns of deaths from all causes in Calcutta per 1,000 of population.
			At 3 feet from surface.		At 6 feet from surface.						Dysentery. (In Presidency and Alipore Jails.)	Malarious fevers. (In Presidency and Alipore Jails.)	
	At 3 feet from surface.	At 6 feet from surface.	Maximum.	Minimum.	Maximum.	Minimum.							
1873.			° F.	° F.	° F.	° F.	° F.						
November 1 ...			77·5	75·8	79·6	78·8	76·2	...	12′ 4″	4	13	38	27·04
„ 2 ...			77·2	75·2	79·4	78·2	78·2						
„ 3 ...			76·5	74·7	79·1	78·0	78·1	0·01					
„ 4 ...			76·6	74·9	79·2	78·0	80·8						
„ 5 ...			76·9	75·0	78·9	78·0	82·0						
„ 6 ...			77·2	75·4	79·5	78·1	82·5						
„ 7 ...			77·6	75·7	79·5	78·1	82·6						
„ 8 ...			77·8	76·1	79·1	78·0	81·4	...	12′ 4″	2	21	56	27·56
„ 9 ...			...	...	...	...	79·2						
„ 10 ...	9·685	11·705	77·8	76·2	79·1	78·0	75·8						
„ 11 ...			77·6	75·7	79·1	77·9	73·9						
„ 12 ...			77·1	75·0	79·2	77·8	74·3						
„ 13 ...			76·5	74·5	78·7	77·5	74·9						
„ 14 ...			75·8	74·1	78·7	77·5	75·3						
„ 15 ...			75·5	73·8	78·6	77·1	76·2	...	12′ 11″	5	22	45	30·9
„ 16 ...			75·6	73·9	78·3	77·1	74·5						
„ 17 ...			75·2	73·7	77·5	77·0	74·3						
„ 18 ...			75·4	73·3	78·1	76·9	72·9						
„ 19 ...			75·7	73·0	78·5	76·8	74·0						
„ 20 ...			75·6	72·8	78·6	76·8	73·5						
„ 21 ...	10·172	11·480	74·5	72·8	77·8	76·5	73·0						
„ 22 ...	8·719	10·899	...	...	...	...	73·0	...	13′ 4″	5	24	63	35·88
„ 23 ...	8·137	10·608	74·3	72·4	77·6	76·0	72·6						
„ 24 ...	7·556	9·881	74·5	72·5	77·3	75·9	74·2						
„ 25 ...	7·120	10·172	74·5	72·2	77·4	75·0	74·5						
„ 26 ...	7·120	11·625	74·1	72·3	77·5	75·4	75·0						
„ 27 ...	7·556	12·788	74·2	72·4	77·1	75·7	73·7						
„ 28 ...	7·847	11·625	74·5	72·2	77·3	75·5	71·9						
„ 29 ...	7·266	11·625	74·5	70·4	77·1	75·5	69·4	...	13′ 5″	5	31	44	35·88
„ 30 ...	7·556	11·625	73·7	72·0	76·8	75·0	69·0						
December 1 ...	6·975	11·770	73·8	71·5	76·8	75·0	73·1						
„ 2 ...	7·266	12·206	73·5	71·6	76·7	75·1	74·4						
„ 3 ...	6·975	11·916	73·6	71·7	76·9	75·0	73·9						
„ 4 ...	7·120	11·625	73·7	71·9	76·5	74·8	72·8						
„ 5 ...	6·975	11·916	73·8	71·8	76·8	74·9	71·9						
„ 6 ...	7·411	11·480	73·8	71·8	76·6	74·9	71·8	...	13′ 8″	9	28	50	34·84
„ 7 ...	...	...	73·5	71·5	76·5	74·5	72·8						
„ 8 ...	6·539	12·206	73·5	71·5	76·5	74·6	71·0						
„ 9 ...	6·830	12·061	73·7	71·4	76·1	74·5	71·8						
„ 10 ...	6·830	11·770	73·5	71·0	76·1	74·6	72·7						
„ 11 ...	6·975	11·916	73·2	71·1	73·0	74·6	72·3	0·82					
„ 12 ...	6·975	11·770	73·1	71·5	76·1	74·5	73·8						
„ 13 ...	7·120	11·334	73·1	71·3	76·0	73·9	69·9	...	13′ 10″	5	32	42	30·16
„ 14 ...	...	...	73·1	71·0	75·8	74·2	68·4						
„ 15 ...	6·830	11·916	72·5	70·5	75·8	74·0	68·7						
„ 16 ...	7·120	11·625	72·1	69·9	75·7	73·9	69·7						
„ 17 ...	6·539	11·334	71·8	69·8	75·6	73·4	69·6						
„ 18 ...	...	...	71·3	69·4	75·5	73·5	69·6						
„ 19 ...	6·975	11·334	71·3	69·2	75·5	73·5	69·3						
„ 20 ...	...	...	71·3	69·0	75·1	73·5	69·4	...	14′ 2″	3	39	34	30·9
„ 21 ...	6·975	11·625	70·8	68·9	75·1	73·0	69·1						
„ 22 ...	7·120	12·261	...	...	...	...	67·5						
„ 23 ...	6·975	12·061	70·7	68·8	74·9	73·0	68·0						
„ 24 ...	7·266	11·770	70·6	68·4	74·9	72·8	67·8						
„ 25 ...	...	...	70·7	68·2	74·8	72·8	66·9						
„ 26 ...	...	...	70·1	68·2	74·5	72·6	67·6						
„ 27 ...	7·701	11·770	70·1	67·9	74·4	72·6	68·1	...	14′ 1″	12	28	40	30·16
„ 28 ...	...	...	69·6	68·0	74·3	72·5	69·8						
„ 29 ...	...	...	70·7	68·0	74·1	72·1	67·3						
„ 30 ...	7·266	10·753	69·9	68·1	74·3	72·0	63·9						
„ 31 ...	...	...	70·1	68·0	74·0	72·0	63·4						

Weekly averages of the amount of Carbonic Acid in the Soil; Soil Temperature, &c., in relation to disease—Table IV, January and February 1874.

Date.	Vols. of Carbonic Acid per 1,000 Vols. of Soil-air (estimated in two localities, Nos. 1 & 2.)				Temperature of the Soil.				Mean temperature (open air).	Rainfall in inches.	Distance of water-level from surface in feet and inches: weekly averages (at Alipore).	Prevalence of various Diseases.			
	No. 1.		No. 2.		At 3 feet from surface.		At 6 feet from surface.					Weekly Returns of deaths from Cholera. (Total reported in Calcutta.)	Weekly Returns of sickness in the Presidency and Alipore Jails from		Weekly Returns of deaths from all causes per 1,000 of population in Calcutta.
	3 feet from surface.	6 feet from surface.	3 feet from surface.	6 feet from surface.	Maximum.	Minimum.	Maximum.	Minimum.					Dysentery.	Malarious fevers.	
1874					°F.	°F.	°F.	°F.	°F.						
Jan. 1	5·736	10·608	...	...	...	...	...	...	61·4						
„ 2	...	...	5·376	7·701	70·2	67·4	73·8	71·9	67·1						
„ 3	...	10·899	...	...	69·6	67·3	73·7	71·9	69·9	...	14′ 4″	7	30	36	27·04
„ 4	...	...	...	...	69·6	67·4	74·0	71·8	68·2						
„ 5	...	...	6·539	7·847	69·7	67·8	73·8	71·5	64·5						
„ 6	6·394	10·172	...	...	69·5	67·5	73·5	71·3	61·9						
„ 7	...	...	5·958	7·120	69·5	68·8	73·2	70·5	61·0						
„ 8	6·103	10·899	...	...	68·8	66·3	73·4	70·8	61·7						
„ 9	...	...	6·394	7·120	68·2	66·0	72·8	70·7	62·3						
„ 10	6·884	11·044	...	...	67·7	65·6	72·7	70·2	65·3	...	14′ 6″	11	18	46	25·67
„ 11	...	...	...	...	68·2	65·5	72·7	70·0	69·0						
„ 12	...	...	6·830	7·701	68·9	65·7	72·7	70·5	71·9						
„ 13	7·411	12·206	...	...	68·2	66·0	72·9	70·7	68·2						
„ 14	...	...	6·103	7·847	68·9	66·6	72·8	70·5	61·4						
„ 15	6·975	12·061	...	...	...	...	...	...	61·0						
„ 16	...	...	6·394	8·283	68·2	65·5	72·7	69·8	63·3						
„ 17	6·684	12·206	...	...	68·3	65·2	72·4	69·5	65·9	...	14′ 9″	6	12	27	27·56
„ 18	...	...	6·539	7·701	68·1	65·5	72·1	70·0	65·2						
„ 19	6·394	12·061	...	...	67·9	65·7	72·5	69·9	66·6						
„ 20	...	...	5·812	7·847	67·5	65·4	72·1	69·4	64·6						
„ 21	6·684	12·206	...	...	67·8	65·6	71·9	69·4	67·4						
„ 22	...	...	5·958	7·266	67·7	65·4	72·1	69·9	69·9						
„ 23	6·539	12·642	...	...	67·8	65·9	72·1	69·8	72·5						
„ 24	...	...	5·958	7·701	68·9	66·4	72·5	69·6	72·3	...	14′ 9″	23	18	29	27·54
„ 25	...	...	...	...	69·7	67·6	72·6	70·0	63·6	0·49					
„ 26	5·376	11·044	4·359	6·248	69·5	67·6	72·8	70·0	64·8						
„ 27	5·086	10·608	...	...	69·8	67·1	72·7	70·0	65·4						
„ 28	...	...	3·342	5·812	70·8	66·8	72·7	69·9	66·9						
„ 29	4·940	10·317	...	...	68·7	66·5	72·7	69·8	69·7						
„ 30	...	...	...	...	68·7	66·4	72·6	70·0	71·8						
„ 31	...	10·463	...	6·248	69·3	66·5	72·8	70·0	73·1	...	14′ 10″	27	13	28	27·04
Feb. 1	...	...	...	...	69·8	67·4	72·8	70·0	68·2	0·80					
„ 2	4·650	10·463	6·830	4·068	70·0	68·0	72·8	70·0	70·0	0·15					
„ 3	...	...	...	...	70·3	68·5	72·8	70·3	71·0						
„ 4	5·376	10·463	4·650	5·958	70·1	68·1	72·7	70·1	70·5						
„ 5	...	...	...	...	69·8	67·9	73·1	70·2	67·4	2·01					
„ 6	5·522	10·463	...	...	70·2	67·7	72·8	70·3	64·8	0·16					
„ 7	...	...	4·214	6·539	70·6	67·4	73·0	70·0	66·1	...	14′ 10″	46	18	30	28·00
„ 8	...	...	...	...	69·8	67·0	72·9	70·0	66·4						
„ 9	...	10·027	...	...	69·4	66·6	72·9	70·0	68·2						
„ 10	...	...	3·342	6·103	68·8	66·8	72·5	69·8	73·4						
„ 11	4·940	10·027	...	...	68·9	67·3	72·8	70·0	76·5						
„ 12	...	...	...	...	69·8	68·4	72·8	70·0	77·3						
„ 13	5·231	7·411	...	...	71·2	68·8	72·8	70·3	71·1						
„ 14	...	...	4·940	5·522	71·5	68·1	72·8	70·5	71·2	0·63	14′ 10″	47	21	25	27·58
„ 15	6·103	8·719	...	...	...	...	...	...	66·3						
„ 16	...	...	4·795	6·684	70·7	68·1	72·8	70·0	66·7						
„ 17	6·539	7·992	...	...	70·4	67·4	72·7	70·0	68·8						
„ 18	...	...	5·086	6·103	69·4	66·7	72·6	69·8	71·1						
„ 19	...	8·573	...	...	69·4	67·0	72·8	70·0	74·6						
„ 20	...	...	5·231	6·103	69·6	67·0	72·8	70·1	75·5						
„ 21	5·522	9·736	...	...	70·3	67·7	73·2	70·1	78·0	...	14′ 10″	43	16	41	27·04
„ 22	...	...	...	...	71·2	68·3	73·2	70·2	78·2						
„ 23	...	...	4·504	6·248	71·5	69·0	73·5	70·6	76·5						
„ 24	6·394	8·573	...	...	72·0	69·8	73·4	70·6	75·0						
„ 25	...	...	...	5·376	71·8	70·0	73·1	70·7	77·2						
„ 26	6·103	9·591	...	...	71·9	70·2	73·5	70·9	77·4	0·02					
„ 27	...	...	4·214	7·120	72·8	70·2	73·5	70·9	77·4						
„ 28	...	...	...	...	72·5	70·3	73·5	71·1	75·9	...	14′ 10″	37	23	37	22·54

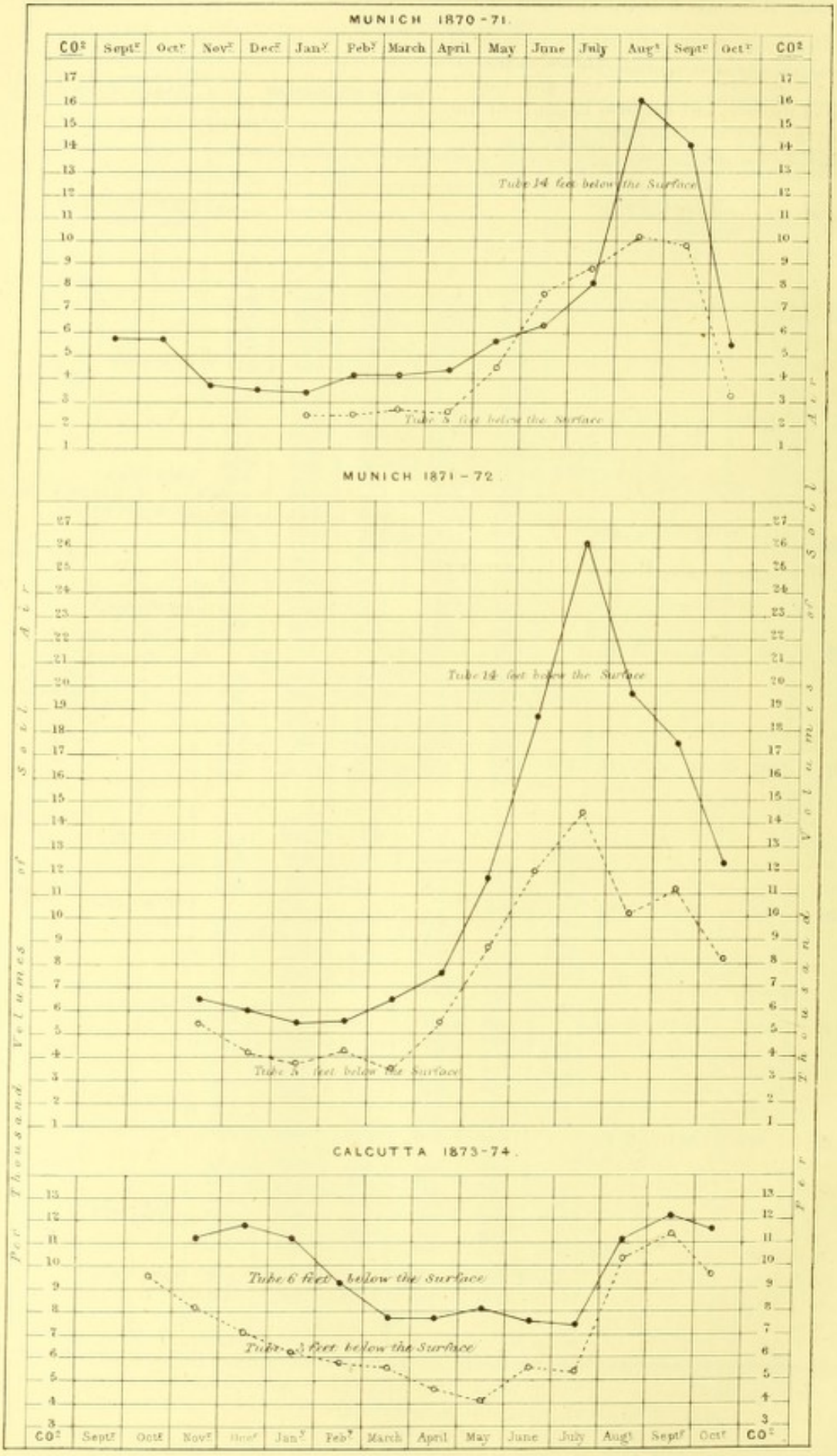
Weekly averages of the amount of Carbonic Acid in the Soil; Soil Temperature, &c., in relation to disease—Table V, March and April 1874.

Date.	Vols. of Carbonic Acid per 1,000 vols. of Soil-air (estimated in two localities, Nos. 1 and 2).				Temperature of the Soil.				Mean temperature (open air).	Rainfall in inches.	Distance of water-level from surface in feet and inches: weekly averages (at Alipore.)	Prevalence of various Diseases.			
	No. 1.		No. 2.		At 3 feet from surface.		At 6 feet from surface.					Weekly Returns of deaths from Cholera. (Total reported in Calcutta.)	Weekly Returns of sickness in the Presidency and Alipore Jails from		Weekly Returns of deaths from all causes per 1,000 of population in Calcutta.
	3 feet from surface.	6 feet from surface.	3 feet from surface.	6 feet from surface.	Maximum.	Minimum.	Maximum.	Minimum.					Dysentery.	Malarious fevers.	
1874.					° F.	° F.	° F.	° F.	° F.						
March 1	6·539	8·137	...	...	72·5	70·6	73·8	70·7	74·5						
„ 2	...	...	4·650	5·958	72·3	70·7	73·8	71·0	75·8						
„ 3	6·394	...	...	...	73·1	70·5	73·6	71·0	76·7						
„ 4	...	...	4·795	6·830	...	...	...	...	78·2						
„ 5	5·958	8·428	...	...	73·8	70·5	74·1	71·0	76·7						
„ 6	...	...	4·795	5·958	73·7	71·3	74·0	71·0	75·2						
„ 7	6·394	8·428	...	...	73·8	71·7	74·2	71·5	76·7	0·41	14′ 10″	40	18	44	20·04
„ 8	...	...	...	...	...	...	...	...	75·5	0·78					
„ 9	...	...	4·214	5·667	73·3	68·7	74·2	71·2	78·3						
„ 10	4·940	6·539	...	...	73·9	71·4	74·5	71·8	79·0	0·09					
„ 11	...	...	4·650	5·812	73·7	72·4	74·3	71·4	76·3						
„ 12	4·650	8·573	...	...	73·8	72·1	74·6	71·6	74·0						
„ 13	...	...	5·376	5·667	73·9	71·5	74·8	71·6	74·1						
„ 14	5·667	8·137	...	...	73·4	71·1	74·8	71·5	76·8		14′ 11″	38	26	46	27·56
„ 15	...	...	...	...	73·4	71·0	74·3	71·8	79·8						
„ 16	...	...	4·940	6·103	...	...	...	...	72·8	0·40					
„ 17	5·231	6·539	...	...	73·8	71·0	74·7	72·0	74·6	0·10					
„ 18	...	...	4·940	5·958	...	...	...	...	78·7						
„ 19	5·959	7·266	...	...	...	...	...	...	78·0						
„ 20	...	...	5·086	6·103	73·7	71·6	74·7	71·8	77·2						
„ 21	6·684	8·283	...	...	73·7	71·9	74·7	72·0	78·6		15′ 0″	44	26	50	27·04
„ 22	...	...	...	...	...	...	...	...	79·0						
„ 23	...	...	4·940	5·958	...	...	...	...	79·6						
„ 24	...	...	...	...	75·3	72·7	74·9	72·1	81·5	0·16					
„ 25	5·086	6·830	...	...	75·7	73·1	75·1	72·4	82·7						
„ 26	...	...	4·359	5·667	75·8	73·6	75·0	72·6	81·8						
„ 27	...	...	...	...	76·3	74·0	75·2	73·1	81·8						
„ 28	4·940	7·556	...	...	76·6	74·4	75·2	72·9	80·5		15′ 0″	40	18	49	27·58
„ 29	...	...	...	...	76·8	74·7	75·5	72·8	81·9						
„ 30	...	...	5·086	5·667	76·4	74·5	75·7	73·0	83·6						
„ 31	5·376	8·283	...	...	77·1	74·9	75·9	73·1	84·0						
April 1	...	...	4·795	5·958	77·5	75·2	75·8	73·3	84·5						
„ 2	4·940	7·992	...	...	77·6	75·1	76·1	73·5	84·3						
„ 3	...	...	4·795	5·812	77·7	76·1	76·2	73·5	82·6						
„ 4	...	...	...	...	78·5	76·0	76·5	74·0	84·6		15′ 1″	58	20	41	28·62
„ 5	5·086	7·992	...	...	79·2	76·7	76·3	74·0	83·8						
„ 6	...	...	4·940	6·394	78·7	77·1	76·8	74·0	82·8						
„ 7	...	...	...	...	79·1	76·8	76·8	74·2	82·5						
„ 8	4·940	7·847	...	...	79·7	76·8	77·0	74·7	82·4						
„ 9	...	...	...	...	79·3	77·2	77·1	74·3	83·7						
„ 10	...	...	5·231	6·684	79·3	77·4	77·3	74·8	84·7						
„ 11	4·795	7·266	...	...	79·7	78·0	77·5	75·0	86·7		15′ 0″	60	25	30	27·55
„ 12	...	...	...	...	79·8	78·2	78·0	75·1	88·3						
„ 13	...	...	...	...	80·8	78·3	78·1	75·0	86·8						
„ 14	...	...	...	...	81·5	79·0	77·9	75·2	87·4						
„ 15	...	...	5·231	6·103	81·9	79·0	78·2	75·5	86·2						
„ 16	4·504	7·847	...	...	81·8	79·5	78·1	75·9	85·6						
„ 17	...	...	5·522	6·830	81·7	79·5	78·7	76·0	86·7						
„ 18	4·214	7·992	...	...	81·9	79·7	78·5	76·0	87·1		15′ 2″	36	26	29	26·52
„ 19	...	...	...	...	...	...	...	...	86·4						
„ 20	...	...	...	...	82·3	80·0	79·0	76·0	86·2						
„ 21	...	...	...	...	82·6	80·2	79·0	76·2	85·8						
„ 22	...	...	5·522	5·812	82·5	80·3	79·1	76·7	87·3						
„ 23	4·940	8·283	...	...	82·9	80·7	79·2	76·9	87·5						
„ 24	...	...	...	...	82·8	80·9	79·5	77·0	84·8	0·20					
„ 25	...	...	5·812	6·830	82·8	80·9	79·5	77·0	87·5		15′ 1″	54	21	37	28·08
„ 26	...	...	...	...	...	...	...	...	85·3						
„ 27	...	...	...	...	82·7	80·8	79·9	77·1	84·3	0·25					
„ 28	...	...	...	...	82·8	80·8	79·8	77·2	80·8	0·21					
„ 29	4·795	6·830	...	...	81·9	80·3	79·9	77·5	84·3						
„ 30	...	...	6·103	6·830	81·9	79·8	79·8	77·4	82·8	0·81					

Weekly averages of the amount of Carbonic Acid in the Soil; Soil Temperature, &c., in relation to disease—Table VI, May and June 1874.

Date.	Vols. of Carbonic Acid per 1,000 Vols. of Soil-air (estimated in two localities, Nos. 1 and 2).				Temperature of the Soil.				Mean temperature (open air).	Rainfall in inches.	Distance of water-level from surface in feet and inches: weekly averages (at Alipore).	Prevalence of various Diseases.			
	No. 1.		No. 2.		At 3 feet from surface.		At 6 feet from surface.					Weekly returns of deaths from Cholera. (Total reported in Calcutta.)	Weekly Returns of sickness in the Presidency and Alipore Jails from		Weekly Returns of deaths from all causes per 1,000 of population in Calcutta.
	3 feet from surface.	6 feet from surface.	3 feet from surface.	6 feet from surface.	Maximum.	Minimum.	Maximum.	Minimum.					Dysentery.	Malarious fevers.	
1874.					° F.	° F.	° F.	° F.	° F.						
May 1	4·504	8·137	...	...	81·9	79·4	79·9	77·5	82·9						
„ 2	...	...	...	...	81·5	79·2	79·9	77·5	89·9		15′ 2″	93	18	33	33·80
„ 3	...	...	...	...	81·3	79·4	79·9	77·6	87·3						
„ 4	...	...	...	...	81·8	79·7	79·9	77·8	86·0						
„ 5	...	...	...	...	81·8	79·9	80·0	77·6	86·9						
„ 6	...	...	5·958	6·539	81·9	80·1	80·1	77·5	87·0						
„ 7	4·068	7·411	...	...	...	...	...	...	87·8						
„ 8	...	...	...	...	82·5	80·1	80·1	77·9	88·4						
„ 9	...	...	...	...	83·0	80·3	80·2	77·6	87·2	0·08	15′ 2″	70	28	30	26·52
„ 10	...	...	...	...	82·8	81·0	80·5	77·7	86·6						
„ 11	...	...	...	...	82·8	81·2	80·5	78·0	88·4	0·04					
„ 12	...	...	...	...	82·8	81·3	80·4	78·1	88·6	0·08					
„ 13	...	...	5·812	7·556	82·9	81·5	80·9	78·1	83·4						
„ 14	4·359	8·428	...	...	84·9	81·2	80·5	78·3	86·6						
„ 15	...	...	5·812	7·701	83·3	81·2	80·6	78·5	87·8						
„ 16	...	...	...		83·4	81·4	80·8	78·5	89·1		15′ 2″	50	26	28	27·56
„ 17	...	...	...	...	83·5	81·7	81·0	78·5	89·3						
„ 18	4·504	8·283	...	...	83·8	82·0	81·1	78·5	89·6						
„ 19	...	...	...	...	84·2	82·0	81·1	78·9	90·2						
„ 20	...	...	...	...	84·9	82·7	81·3	78·9	89·2						
„ 21	...	...	6·103	7·992	84·9	83·0	81·6	79·0	90·0						
„ 22	...	...	...	...	84·8	83·1	81·9	79·0	89·6						
„ 23	...	...	...	...	85·1	83·3	81·9	79·0	88·2		15′ 2″	37	26	30	27·04
„ 24	...	...	...	...	...	...	...	...	87·4						
„ 25	...	...	...	...	84·9	83·3	81·5	79·6	86·2	0·04					
„ 26	3·051	8·428	...	...	84·9	83·2	81·5	79·6	83·7	0·85					
„ 27	...	...	5·376	7·847	85·1	82·7	81·8	79·4	86·6						
„ 28	...	...	...	...	84·8	82·0	81·8	79·5	84·2						
„ 29	...	...	...	...	84·7	82·0	81·9	79·5	85·5						
„ 30	...	...	...	...	83·5	81·7	82·0	79·5	84·0	0·07	15′ 2″	32	20	37	22·88
„ 31	...	...	...	...	83·3	81·6	81·8	79·5	86·3						
June 1	5·376	9·300	...	...	83·8	81·5	81·9	79·4	87·8						
„ 2	...	...	5·667	7·411	83·3	81·4	81·7	79·4	86·6	0·02					
„ 3	...	...	...	...	83·9	81·8	81·7	79·4	85·2	0·27					
„ 4	...	...	...	...	84·5	82·0	81·8	79·4	81·9	0·02					
„ 5	5·522	9·009	...	...	84·8	81·5	82·0	79·5	84·2	0·08					
„ 6	...	...	3·778	7·120	...	...	...	...	81·2	1·17	15′ 2″	27	24	22	22·4
„ 7	...	...	...	...	83·5	80·9	81·8	79·3	82·5	0·06					
„ 8	...	...	...	...	82·5	80·5	81·9	79·0	81·8	0·08					
„ 9	5·812	9·009	...	...	82·5	80·4	81·9	79·0	82·5	0·12					
„ 10	...	...	...	...	82·1	80·2	81·2	79·0	80·7	1·47					
„ 11	...	...	...	...	81·9	80·0	81·5	79·0	83·7						
„ 12	...	...	4·940	6·539	...	...	...	...	85·8	0·05					
„ 13	...	...	...	...	81·8	80·0	81·7	79·0	86·9		15′ 2″	20	5	57	18·72
„ 14	...	...	...	...	82·1	80·1	81·5	79·0	85·4	0·58					
„ 15	6·103	8·864	...	...	82·8	80·2	81·2	79·0	83·3	0·03					
„ 16	...	...	...	...	82·9	80·1	81·7	79·0	84·1	0·14					
„ 17	...	...	...	...	82·2	80·2	81·5	79·0	81·9	0·61					
„ 18	...	...	5·376	6·684	81·8	80·3	81·6	79·0	79·6	0·26					
„ 19	...	...	...	...	81·5	79·0	81·5	79·5	82·5	0·06					
„ 20	...	...	...	..	81·2	78·8	81·2	79·6	84·9		15′ 2″	25	17	32	19·24
„ 21	...	...	...	...	...	...	...	...	86·7						
„ 22	5·812	8·719	...	...	81·8	79·0	81·6	79·6	86·0						
„ 23	...	...	...	...	81·7	79·4	81·9	79·7	85·1	0·18					
„ 24	...	...	...	...	81·8	79·5	81·2	79·4	82·3	0·21					
„ 25	...	...	5·086	5·958	81·9	79·5	81·7	79·8	83·9	0·09					
„ 26	...	...	...	...	81·5	79·3	81·8	79·7	83·9						
„ 27	5·231	7·992	...	...	81·9	79·3	81·9	79·6	81·0	0·08	15′ 2″	18	23	43	19·69
„ 28	...	...	...	...	...	...	...	...	83·6	0·03					
„ 29	...	...	4·650	6·248	81·6	79·0	82·1	79·8	82·1	1·28					
„ 30	...	...	...	...	81·6	78·9	81·4	79·9	83·5						

DIAGRAM I.



AMOUNT OF CARBONIC ACID AT VARIOUS DEPTHS IN THE SOIL OF MUNICH AND CALCUTTA.

(2).—The fluctuations in the amount of Carbonic Acid in the Soil.

The carbonic acid taken as an index of organic changes.

It may be premised that the estimation of the amount of carbonic acid in the soil was not undertaken under the idea that this gas itself exerts much influence on the prevalence of disease, but because its amount may be taken as a convenient and fairly accurate index of the degree of the various organic processes taking place between the water-level and the surface.

(*a*)—*Average amount of Carbonic Acid in the Soil of Calcutta as compared with that of Munich.*—(*Diagram I.*)

The depths at which the observations were taken.

The levels at which the observations were made were not the same in the two localities, those in Calcutta being made at 3 and 6 feet from the surface; those in Munich at 5 and 14 feet. This must be taken into account in the comparison; still, allowing all due weight to this circumstance, very considerable differences are evident in the results.

The upper layer.

In Calcutta, the *maximum* in the upper layer occurred in September, with 11 volumes per 1,000. In Munich, the *maxima* in the two years shown in the diagram occurred in August and July respectively, with 10 and 14 volumes per 1,000. The *minimum* in the upper layer in Calcutta occurred in May with 4 volumes per 1,000. In Munich, in January and in March, with 2 and 3 volumes per 1,000, respectively.

The lower layer.

The *maximum* in the lower layer occurred in Calcutta in September, with 12 volumes per 1,000. In Munich, the *maxima* occurred in August and July, with 16 and 26 volumes per 1,000. In Calcutta, the *minimum* occurred in July with 7 volumes per 1,000; but in Munich in January and February with 3 and 5 volumes per 1,000, respectively.

(*b.*)—*The fluctuations in the amount of Carbonic Acid in the Soils of Calcutta and Munich compared.*

The upper layer.

In Calcutta, beginning with November, in the upper layer we find a gradual and continuous fall until May; a slight rise in June; a slight fall in July followed by a great and rapid rise in August and September. In Munich, beginning with the same month, we find slight falls to the minima in January and February; a slight rise and fall in March and April, respectively, followed by a rapid rise to the maxima.

The lower layer.

In Calcutta, in the lower layer, again starting from November, we find a slight rise in December followed by a fall until March and April, succeeded by a slight rise in May and a fall thence to a minimum in July; the minimum being followed by a rapid rise to the maximum in September. In Munich, there is first a fall to the minima in January and February, and thence a continuous rise to the maxima.

Both localities agree pretty closely in the period at which the maxima occur, but the course of the fluctuations is otherwise very different, for while the minima in Calcutta occur in May and July, those in Munich occur in January, February and March,

There is also an agreement in the approximation of the periods of maxima and minima in the upper and lower layers of the two localities. There is considerable difference in regard to the relative amounts which the volumes of carbonic acid in the upper and lower levels bear to one another, but this cannot be regarded as of any importance, as it may have been due to the fact that the levels of observation were not identical.

There is, however, one point in regard to this relation in which a distinct difference can be traced in the two localities, for, whilst in Munich the quantities of carbonic acid in the two layers approach one another most closely when low, and are most remote when at a maximum, the reverse is the case in Calcutta—the difference in amount being least during the period of maxima, and great when the amount of carbonic acid is low.

In Munich, the points of maxima and minima appear to be determined by temperature, whereas in Calcutta, as we shall see further on, this is not the case—moisture being the apparent determinant.

(c)—The quantities of Carbonic Acid present at different times in the Upper and Lower Layers of Soil in Calcutta.—(Diagrams II and IV.)

The quantities of carbonic acid estimated in the first locality. Tubes No. 1.

The diagram illustrating the proportion of carbonic acid present in the layers of soil of the first locality selected for observation (Tubes No. 1) shows the weekly averages of the gas in 1,000 volumes of soil-air. There is not much calling for comment on this point, as the principal phenomena of the fluctuations in amount of carbonic acid have been already pointed out.

One curious phenomenon appears in regard to both layers of soil, namely, a sudden short rise in the amount of carbonic acid during the month of January. The amount of carbonic acid present in the upper layer in July 1874 was almost identical with that at the corresponding period of the previous year; while that in the lower layer was greater in the second than in the first year. In the upper layer a rapid rise is visible in June 1874, whilst in the lower the amount continued low until the close of the observations. So far as the evidence goes, it would appear that the period of minimum begins later, and is continued to a later date in the lower than in the upper layer.

The sudden depression in the upper layer in May is very remarkable, and no corresponding phenomenon occurred in the case of the lower layer. Various of these special phenomena characterising the separate layers may, apparently, be explained, as will appear further on, but in the meantime attention is merely directed to them.

The amount of carbonic acid estimated in the second locality. Tubes No. 2.

The relations between the quantities of carbonic acid estimated in the upper and lower layers of soil in the second locality selected for observation—the set of tubes No. 2, Diagram IV—resembled those in the former locality, in so far that the amount of gas present in the lower layer of soil continuously exceeded that in the upper one. The absolute differences in the quantities present in the layers were, however, less.

The absolute minimum in the upper layer occurred in January with 3·8 volumes per 1,000, but second periods of extreme depression occurred in February and July. The maximum for the period of observation occurred in January—6 volumes per 1,000.

There were two periods of maximum amounts of carbonic acid in the lower layer, the first in January—7 volumes per 1,000; the second in May, also with 7 volumes per 1,000.

The absolute minimum occurred in August with 5 volumes per 1,000, but there was a previous period of depression in January and March, also with 5 volumes per 1,000. In both layers there was a rise in January.

Comparison of amounts of carbonic acid present in the layers of soil in the two localities.

Both localities agreed in constantly showing a larger quantity of carbonic acid in the lower than in the upper layer. For purposes of more exact comparison, attention must be confined to the period during which both localities were subjected to observation. When this is done it appears that the absolute quantities of carbonic acid present in the second locality were, as a rule, less than those in the first, but that the periods of relative depression and elevation in amount of carbonic acid exhibited a general coincidence in both places. In the second locality not only were the amounts of carbonic acid less, but the fluctuations in the quantities present at different times were also less than in the first locality. This comes out very clearly in the following statement:—

Layer.	First Locality.		Second Locality.	
	Maximum. Vols. per 1000.	Minimum. Vols. per 1000.	Maximum. Vols. per 1000.	Minimum. Vols. per 1000.
Upper	7	3	6	3
Lower	12	7	7	5

DIAGRAM II.

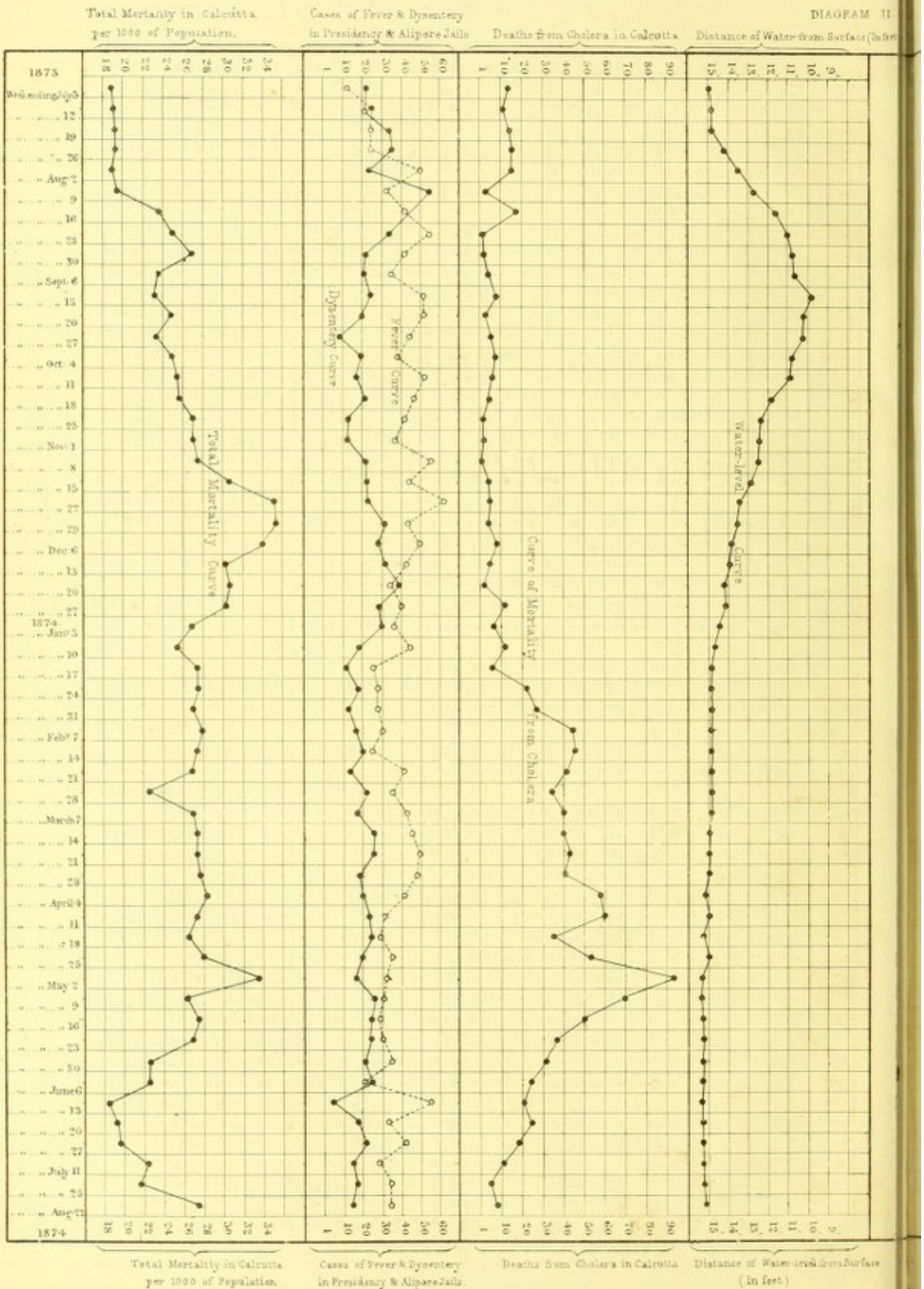
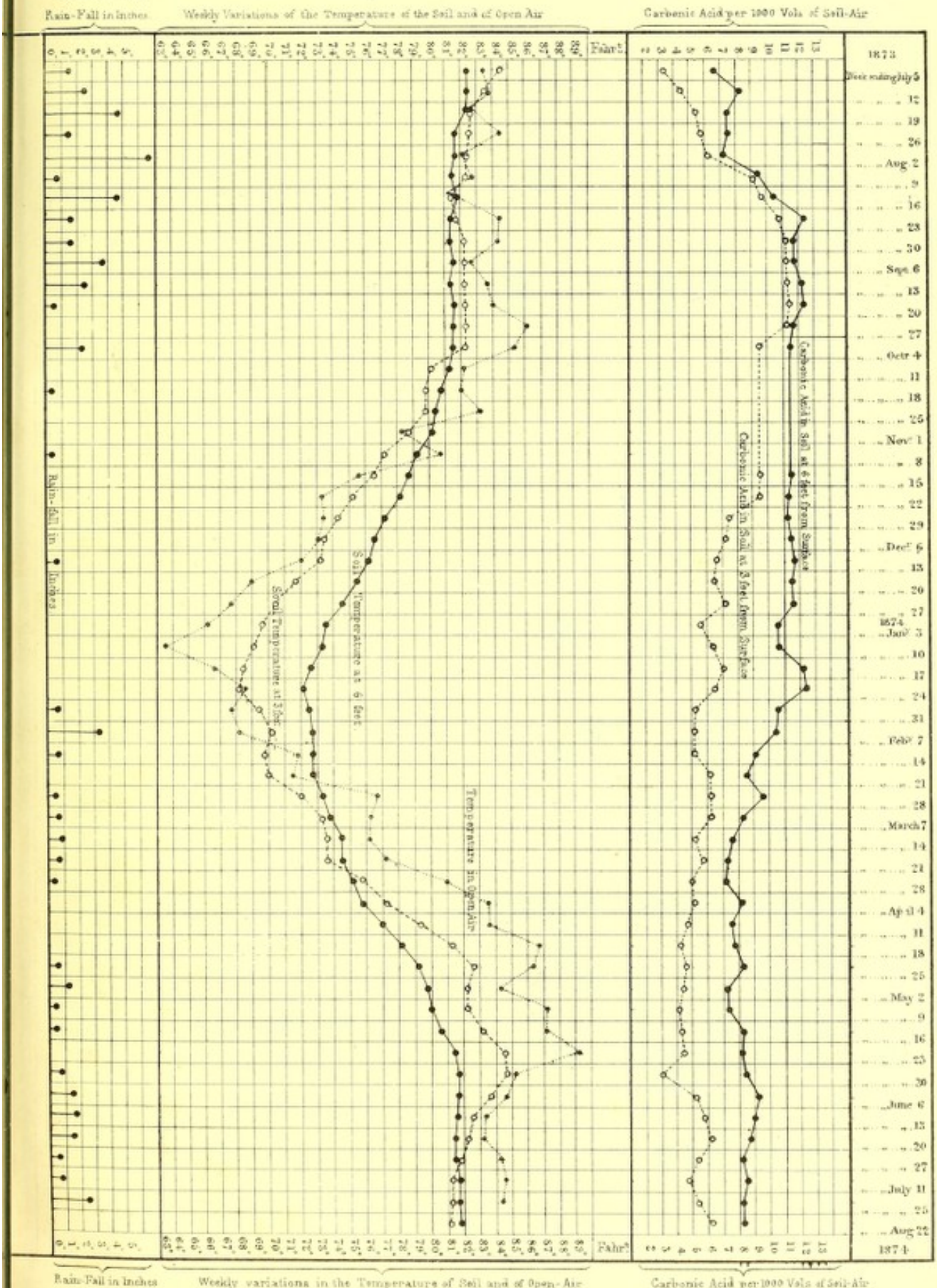

Total Mortality in Calcutta per 1000 of Population.
Cases of Fever & Dysentery in Presidency & Alipore Jails
Deaths from Cholera in Calcutta
Distance of Water from Surface (in feet)
1873
Week ending July 5
12
19
26
Aug. 2
9
16
23
30
Sept. 6
13
20
27
Oct. 4
11
18
25
Nov. 1
8
15
22
29
Dec. 6
13
20
27
1874
Jan. 3
10
17
24
31
Feb. 7
14
21
28
March 7
14
21
28
April 4
11
18
25
May 2
9
16
23
30
June 6
13
20
27
July 11
18
25
Aug. 22
1874
Total Mortality Curve
Dysentery Curve
Fever Curve
Curve of Mortality from Cholera
Water-level Curve
Total Mortality in Calcutta per 1000 of Population.
Cases of Fever & Dysentery in Presidency & Alipore Jails.
Deaths from Cholera in Calcutta
Distance of Water-level from Surface (in feet)

DIAGRAM III.


Rain-Fall in Inches
Weekly Variations of the Temperature of the Soil and of Open Air
Carbonic Acid per 1000 Vols of Soil-Air
Fahr.
Rain-fall in Inches
Soil Temperature at 1 feet
Soil Temperature at 6 feet
Temperature in Open Air
Carbonic Acid in Soil at 6 feet from Surface
Carbonic Acid in Soil at 3 feet from Surface
1873
Week ending July 5
" " " 12
" " " 19
" " " 26
" " Aug 2
" " " 9
" " " 16
" " " 23
" " " 30
" " Sept 6
" " " 13
" " " 20
" " " 27
" " Octr 4
" " " 11
" " " 18
" " " 25
" " Novr 1
" " " 8
" " " 15
" " " 22
" " " 29
" " Decr 6
" " " 13
" " " 20
" " " 27
1874
" " Janr 3
" " " 10
" " " 17
" " " 24
" " " 31
" " Febr 7
" " " 14
" " " 21
" " " 28
" " March 7
" " " 14
" " " 21
" " " 28
" " April 4
" " " 11
" " " 18
" " " 25
" " May 2
" " " 9
" " " 16
" " " 23
" " " 30
" " June 6
" " " 13
" " " 20
" " " 27
" " July 11
" " " 25
" " Aug 22
1874
Rain-Fall in Inches
Weekly variations in the Temperature of Soil and of Open-Air
Carbonic Acid per 1000 Vols of Soil-Air

The only point of interest which calls for special remark in regard to this comparison is the demonstration which it affords of the occurrence of local variations in the amount of carbonic acid present in the soil of localities in close proximity to one another, and to all appearance extremely similar in their nature. The sites of observation were not more than 50 yards apart, and were both situated at similar and corresponding distances from the walls of one and the same building. The processes going on in the soil in the two places must have differed materially, in degree at all events, if not in kind; and if such processes occurring in the soil have any influence on health, it is obvious that people inhabiting one end of the building must have been exposed to different hygienic conditions from those living at the other end. Such an observation is of special interest in connection with the extremely marked, and frequently apparently inexplicable, localisation in the distribution of cholera within narrow limits—even within the limits of individual buildings.

Importance of observations showing difference in processes occurring in the soil of adjacent localities.

(*d*)—*Comparison of the amount of Carbonic Acid present in the Soil with the Temperature of the Soil at similar depths.*—(*Diagram III.*)

On consulting the tables and diagrams it becomes at once clearly evident that the amount of carbonic acid present in the soil at various times is not determined by the mere coincident temperature of the soil. Maximum temperature coincides with minimum amount of carbonic acid at one period, and with a very large amount of carbonic acid at another. The lines of temperature neither directly nor conversely correspond with those of carbonic acid. There is, however, one curious phenomenon which comes out very distinctly during the period over which the observations extend, and this is that the periods of maximum difference in the quantities of carbonic acid in the two layers of soil coincide with the periods of maximum difference of temperature in these layers. The minimum difference in the quantities of carbonic acid occurred in August and September, and during the same period the minimum difference of temperature also occurred. The two periods of maximum difference between the amounts of carbonic acid in the two layers of soil were first in December, January and February, and second in May; at both of these periods maximum differences in temperature were also present. Whether this be a mere coincidence we do not feel prepared to say, but it may be pointed out that if the conditions of temperature be in any way causatively related to the differences between the quantities of carbonic acid present in the layers of soil, the essential element is the *difference* of temperature, not the absolute temperature of either layer individually. The coincidence of maximum differences of temperature and carbonic acid occurred at one time when the temperature of the lower layer of soil exceeded that of the upper one, and at another when the reverse relation prevailed.

Amounts of carbonic acid not determined by soil-temperature.

(*e*)—*Comparison of the amount of Carbonic Acid present in the Soil with the Atmospheric Temperature.*—(*Diagram III.*)

No clear relation of any kind can be observed to exist between the atmospheric temperature and the amount of carbonic acid present in the soil – periods of extreme elevation and depression of the latter occurring coincidently with conditions of temperature showing no corresponding changes.

Absence of connection between atmospheric temperature and amount of carbonic acid in the soil.

(*f*)—*Comparison of the amount of Carbonic Acid in the Soil with the Rain-fall.*—(*Diagram III.*)

In this case a general coincidence of conditions appears very distinctly, the principal periods of rain-fall coinciding with the principal periods of elevation in amount of carbonic acid, and the main periods of depression in the latter coinciding with periods of drought. This general coincidence is, however, much closer and more marked in reference to the carbonic acid in the upper than to that in

Connection of carbonic acid in the soil with rain-fall;

the lower layer of soil, for the amount of carbonic acid in the latter continues high long after the cessation of the rains, and shows no immediate rise corresponding with their commencement in the following season.

(g)—Comparison of the amount of Carbonic Acid in the Soil with Water-Level.—(Diagrams II—III.)

and with water-level.

Here also a general coincidence appears, but in this case the coincidence is closer in regard to the lower than to the upper layer, as was seen to be the case with the rain-fall. The elevation of water-level begins later and lasts longer than the period of extreme elevation in the carbonic acid of the upper layer of soil.

(h)—Comparison of the amount of Carbonic Acid with the Velocity of the Wind.—(Diagram IV.)

Influence of velocity of wind slight, if any.

The velocity of the wind does not appear to exert any very distinct influence on the amount of carbonic acid in the soil. It is, however, possible that the extreme and continued elevation in velocity of the wind during April and May may have been influential in producing the sudden depression in the amount of carbonic acid in the upper layer of the soil of the first locality in the latter month. There was no corresponding depression in the upper layer of the other locality, but as the latter was much more sheltered than the first locality, the discrepancy rather goes to support the idea that the wind may have had some effect. The question also arises, whether the marked elevation in amount of carbonic acid in both localities in January may not have been partially dependent on the long continuance of still weather, and consequent diminished ventilation of the soil, which preceded it.

(3.)—Temperature of the Soil.—(Diagram III.)

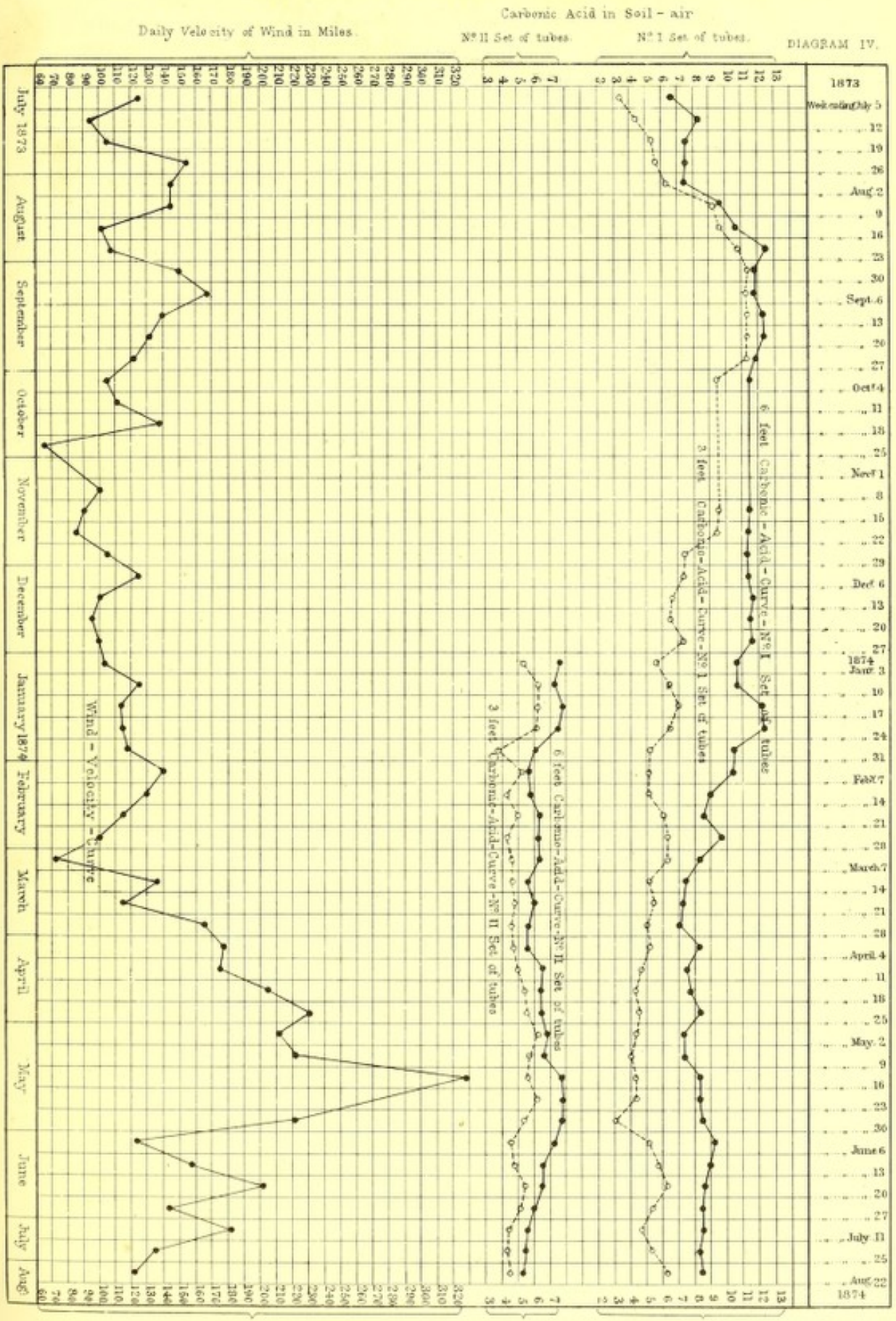
Little need be said regarding this, as the principal phenomena appear very clearly in the diagram. So long as the weather remains dry, the fluctuations in temperature in the upper layer of soil follow those of atmospheric temperature very regularly; but on the occurrence of rain this correspondence ceases. The fluctuations in the temperature in the lower layer are naturally much less marked and sudden, and the line of elevation and depression follows a long, gentle curve. The maxima of temperature in the two layers approach more closely than the minima, a point in which the relations of temperature correspond with those of carbonic acid. During the cold weather the temperature of the lower layer considerably exceeds that of the upper one. These relations are reversed during the hot weather. A period ensues on the onset of the rains, in which the temperatures of both layers are nearly alike—sometimes one, sometimes the other showing a slight excess—and this is followed by a prolonged and continuous fall of the temperature of the upper layer beneath that of the lower until the maximum difference is attained in January and February, coincident with the minimum absolute temperature.

Relations of temperature in the upper and lower layers of soil.

(4.)—Water-Level.—(Diagram II.)

Water-level in Calcuttta dependent on local rain-fall.

The only point calling for special notice here is the demonstration afforded by the diagram, that the water-level in Calcutta is really essentially dependent on the local rain-fall. In so far as weekly averages are concerned, the influence exerted by the tides is so slight as to be almost inappreciable, and the same holds in regard to drainage into the delta from the melting of the snows on the Himalaya, and other non-local supplies of water, which might have been expected to produce very evident effects in a soil such as that in and around Calcutta. The three years' Table (No. VII) demonstrates the same fact for a longer period.



THE RELATION OF THE VELOCITY OF THE WIND TO THE AMOUNT OF CARBONIC ACID IN SOIL-AIR.

(5.)—Relations which the different conditions of Soil bear to one another.—(II, III, IV Diagrams.)

Relations of various conditions of soil to one another.

The most important point to be noted in regard to this subject is the apparent dependence of the amount of carbonic acid in the soil on the degree of soil-moisture. When the latter is high, the carbonic acid is at its maximum, and the minimum periods of both also coincide generally. The facts already pointed out in regard to the behaviour of the carbonic acid-contents of the individual layers in reference to the rain-fall and water-level, very clearly indicate such a dependence; for, whilst the carbonic acid of the upper layer coincides more closely with the rain-fall than with the water-level, the reverse relation appears in the case of the lower layer of soil.

(6.)—Comparison of the prevalence of Disease with the occurrence of various conditions of Soil in regard to Carbonic Acid, Temperature and Water-Level.—(Diagrams II—III.)

Prevalence of cholera.

On comparing the figures and diagrams on this point in reference to cholera, the only remarkable coincidence appears to lie in the converse relation which water-level, and in a less marked degree rain-fall, bear to the prevalence of the disease. When the latter is at a maximum, the water-level is at a minimum, and when the water-level is at a maximum, the prevalence of cholera is at a minimum. There is no such close coincidence either in regard to conditions of soil-temperature or amount of carbonic acid, although, in so far as soil-moisture appears to determine the amount of carbonic acid in the soil, there is a general coincidence in regard to the latter also. The relations between rain-fall and prevalence of cholera are not so strongly marked as those between the latter and the water-level; and it even appears as though the converse relation between conditions of water-level and prevalence of cholera were in some degree more distinct than the direct one between the water-level and the rain-fall.

Prevalence of fevers.

The greatest prevalence of fevers during the period of observation occurred coincidently with the period of maximum carbonic acid and highest water-level.

Prevalence of dysentery.

There were two maximum periods of dysentery, one occurring during the rise in the water-level, and the other at a corresponding point in the course of its fall. No coincidence can be traced in regard to the other conditions of soil, save the carbonic acid of the upper layer which in this part of its course very closely corresponds with the water level.

General mortality.

No very clear connection can be traced between the statistics of total mortality and the prevalence of any special conditions of soil. There were two periods of maximum mortality during the period of observation—one in November and December, coincident with marked prevalence of fever and dysentery; the other in April and May with maximum cholera.

Data regarding certain soil-conditions for three years. Reasons for the absence of Mortuary statistics.

The comparison of the prevalence of disease with the existence of special physical conditions is, of course, very imperfect when confined, as in the present instance, to the phenomena of one year. We had hoped to have been able to furnish data regarding the prevalence of disease and the existence of conditions of soil-temperature, water-level, &c., for a longer period, and had indeed drawn up a table showing the monthly figures on these points from February 1872 to August 1874. On coming to examine the statistics of disease in the Returns of the Calcutta Municipality, however, we found such inexplicable discrepancies in the figures contained in two sets of tables prepared in the same office, that we had to abandon the idea. In the meantime, we insert the figures in this table with the exception of those regarding disease. With regard to our other tables and diagrams, it is, of course, necessary that the condition of the mortuary statistics of Calcutta should be taken into consideration in comparing the total mortality and the prevalence of cholera with the data regarding physical facts.

Monthly Means of Soil-Temperature, Water-level, &c., from February 1872 *to August* 1874—*Table VII.*

Month.	Mean Maximum Temperature of Soil in Calcutta.		Rain-fall in Calcutta.	Average Temperature [open air].	Distance of water-level from surface in feet. [At Allpore.]
	3 feet from surface.	6 feet from surface.			
1872.					
February	70°7′Fahr.	74°0′Fahr.	2·82 inches.	72°9′Fahr.	13′8″
March	75°2′	75°6′	0·21 „	83°1′	14′2″
April	82°1′	79°1′	1·83 „	85°9′	14′4″
May	84°3′	81°2′	1·99 „	87°0′	14′7″
June	85°3′	83°3′	9·45 „	85°4′	14′7″
July	82°2′	83°0′	5·55 „	83°3′	13′9″
August	82°0′	82°5′	11·52 „	83°1′	12′7″
September	82°0′	82°0′	8·42 „	83°2′	10′7″
October	88°8′	81°5′	8·93 „	81°6′	10′7″
November	75°7′	77°8′	0·02 „	76°6′	11′2″
December	72°3′	75°4′	0·09 „	70°3′	13′0″
1873.					
January	68°0′	72°4′	…	68°3′	13′7″
February	70°5′	72°5′	…	74°5′	14′4″
March	75°8′	76°1′	1·18 „	80°3′	14′7″
April	81°8′	79°4′	1·84 „	84°4′	14′9″
May	83°4′	80°5′	3·78 „	87°0′	15′0″
June	84°8′	82°1′	4·30 „	88°2′	15′0″
July	83°3′	82°3′	14·76 „	83°5′	14′7″
August	82°0′	81°2′	10·23 „	83°5′	11′9″
September	82°3′	81°4′	5·82 „	84°5′	10′2″
October	80°1′	80°7′	2·40 „	82°1′	11′5″
November	76°2′	78°4′	0·14 „	76°0′	12′9″
December	72°6′	75°5′	0·82 „	70°2′	14′0″
1874.					
January	68°8′	72°8′	0·94 „	66°9′	14′7″
February	70°4′	73°0′	3·77 „	72°5′	14′10″
March	74°3′	74°6′	1·94 „	78°6′	15′0″
April	80°7′	78°1′	1·20 „	85°4′	15′0″
May	83°4′	81°0′	1·16 „	87°4′	15′2″
June	82°4′	81°7′	6·89 „	83°9′	15′2″
July	81°5′	81°7′	8·89 „	84°2′	15′2″
August	81°0′	81°6′	10·19 „	83°1′	15′1″

(7.)—General Conclusions regarding the Observations.

It may appear to many that the result of all these observatins on conditions of soil is not commensurate with the time and labour expended in obtaining it. In so far as arriving at any definite determination of the influence of soil-conditions on health is concerned, the results as they stand at present are, no doubt, not so conclusive as might be desired. It is only on prolonged and continuous observations in various localities that definite conclusions can be based.

Definite results regarding the relation of conditions of soil and disease only attainable by means of prolonged observation.

Even as it is, however, the determination of the coincidence of prevalence of cholera in Calcutta with the existence of certain marked characteristics in the conditions of the soil is of great importance. It has, no doubt, been known for a long time that the ordinary course of cholera in Calcutta was similar to that shown in this Report, and that the prevalence of the disease was related to local conditions of season; but in regard to this phenomenon, attention has hitherto been almost entirely directed to the conditions of atmospheric meteorology, and this is almost the first attempt which has been made to ascertain whether any definite relations exist between the prevalence of the disease and special telluric phenomena.

The observations in Calcutta may serve as a standard for comparison, and may serve to attract attention to the subject.

We believe that the present observations, although confined to a very limited period, may serve a good purpose in attracting attention in this country to the importance of the subject and to the desirability of obtaining data regarding it. We have, in so far as our own work is concerned, by their means obtained standards of comparison which will be of very great value in examining the conditions of soil present in other localities during the pre-

valence of special diseases; but it is greatly to be desired that systematic observations of a similar nature should be carried out in various localities throughout the country. Observations from a large number of places are not necessary, and they might readily be conducted at any good meteorological station.

CALCUTTA,
September 1875.

O. S. G. P.—No. 7 S. C.—10-12-75.—30.

PLAN OF UPPINGHAM

to accompany Mr Haviland's Medical Report on the outbreak of Enteric Fever in Archdeacon Johnson's School, Uppingham, June – November, 1877.