CLXXXIII. THE DIURNAL VARIATION OF THE GASEOUS CONSTITUENTS OF RIVER WATERS. PART IV.

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THE work described in Parts I, II and III [Butcher, Pentelow and Woodley, 1927, 1928] has now been concluded and the present paper includes the following experiments over periods of 24 hours:

- R. Lark.* Series XI. January 25-27, 1928. Table XXII.
Series XII. February 16-17, 1928. Table XXIII. Fig. 19.
Series XIII. March 1-2, 1928. Table XXIV. Fig. 20.
Table XXV. Summary of R. Lark results. March 1927-March 1928.
- R. Itchen.* Series IX. January 17-18, 1928. Table XXVI. Fig. 21.
Series X. February 21-22, 1928. Table XXVII. Fig. 22.
Series XI. March 20-21, 1928. Table XXVIII. Fig. 23.
Series XII. May 3-4, 1928. Table XXIX.

Variation in dissolved oxygen.

River Lark. A few observations were made on January 25th-27th, 1928, when the effects of the pollution by the effluents from the beet-sugar factory were less marked than in November 1927, and it will be seen that the diurnal variation effect is still evident in this polluted water.

The experiment of February 16th-17th was made when the effects of the winter pollution were disappearing, sewage fungus was still abundant, and the diatoms were first beginning to appear. The range of variation of oxygen content was smaller than at any other time of the year, viz. 66-77 %, indicating the scarcity of actively assimilating plants, and this was confirmed by the absence of variation in p_H value. The figures obtained in March 1928 indicate the commencement of that rapid increase of diatoms which occurs every spring.

River Itchen. The oxygen curves of January, February, March and May show an increasing range of variation with the increase in the hours of daylight and with the increase in the number of diatoms.

Table XXII. *River Lark. January 25th-27th, 1928. Series XI.*

Time	Temp. ° C.	Dissolved oxygen		Ammoniacal nitrogen.	p _H value	Date
		Parts per 100,000	% satu- ration	Parts per 100,000		
10.45 a.m.	4.2	0.682	52	0.015	7.7	25. i. 1928
4.30 p.m.	4.9	0.690	54	0.01-0.015	7.6	25. i. 1928
9.30 a.m.	5.05	0.397	31	0.03	7.6	26. i. 1928
2.45 p.m.	6.0	0.463	37	0.015	7.6	26. i. 1928
3.45 p.m.	6.0	0.444	35	0.01-0.015	7.5-7.6	26. i. 1928
4.45 p.m.	5.9	0.428	34	0.01-0.015	7.5-7.6	26. i. 1928
8.45 p.m.	6.0	0.389	31	0.015	7.5-7.6	26. i. 1928
12.40 a.m.	4.7	0.355	27	0.02-0.025	7.5	27. i. 1928
1.40 a.m.	4.7	0.359	27	0.03	7.5-7.6	27. i. 1928
10.5 a.m.	4.5	0.352	27	0.025	7.5-7.6	27. i. 1928

Sunset January 25th, 4.36 p.m.

Sunrise " 26th, 7.48 a.m.

Sunset " 26th, 4.37 p.m.

Table XXIII. *River Lark. February 16th-17th, 1928. Series XII.*

Time	Temp. ° C.	Dissolved oxygen		Ammoniacal nitrogen.	p _H value	Remarks
		Parts per 100,000	% satu- ration	Parts per 100,000		
10 a.m.	10.0	0.766	67	0.09	7.8	Dull. Cloudy. High wind
11 "	9.9	0.804	70	0.08	7.8	River full. Turbid
Midday	10.1	0.815	71	0.08	7.8	Floating broken sewage fungus
1 p.m.	10.1	0.850	74	0.07	7.8	Dull
2 "	10.2	0.863	75	0.06	7.8	Dull. Drizzle
3 "	10.4	0.876	77	0.05-0.06	7.8	Dull
4 "	10.25	0.873	76	0.05	7.8	Brighter
5 "	10.1	0.877	76	0.04-0.05	7.8	Dusk
6 "	9.95	0.877	76	0.04	7.8	Almost dark
7 "	9.8	0.867	75	0.04	7.8	Dark. Fine
8 "	9.6	0.857	74	0.04	7.8	Stormy
9 "	9.3	0.846	73	0.05	7.8	
10 "	9.0	0.835	71	0.05-0.06	7.8	Fine
11 "	8.6	0.817	69	0.05-0.06	7.8	Clear. Starry
Midnight	8.1	0.793	66	0.08	7.8	Clear
1 a.m.	8.1	0.798	66.5	0.09	7.8	Cloudy. Windy
2 "	7.8	0.804	66	0.1	7.8	Clear. Windy
3 "	7.4	0.796	66	0.1	7.8	Clear. Windy
4 "	7.2	0.804	66	0.1	7.8	Heavy rainstorm
5 "	6.9	—	—	0.1	7.8	Fine
6 "	6.5	0.857	69	0.1	7.8	Dawn. Showery
7 "	6.3	0.856	69	0.09	7.8	Daylight
8 "	5.9	0.910	72	0.08	7.8	Bright sun
9 "	5.9	0.923	73	0.07	7.8	Bright sun. Windy
10 "	6.0	0.983	78	0.06-0.07	7.8	Bright sun

Sunset February 16th, 5.15 p.m.

Sunrise " 17th, 7.13 a.m.

Sunset " 17th, 5.17 p.m.

Fig. 19.

Table XXIV. River Lark. March 1st-2nd, 1928. Series XIII.

Time	Temp. ° C.	Dissolved oxygen		Ammoniacal nitrogen. Parts per 100,000	pH value	Remarks
		Parts per 100,000	% satu- ration			
10 a.m.	7.6	0.791	65	0.13	7.5	Cloudy. Drizzle
11 "	7.7	0.866	72	0.11	7.7	" "
Midday	7.9	0.979	82.5	0.05-0.06	7.7-7.8	" Fine
1 p.m.	8.2	1.031	87	0.05	7.8	" "
2 "	8.4	1.149	97	0.04	7.9	" "
3 "	8.6	1.189	100	0.04	7.9-8.0	" "
4 "	8.7	1.187	100	0.04	7.9-8.0	" "
5 "	8.8	1.161	99	0.03	7.9-8.0	" "
6 "	8.8	1.036	88	0.02-0.03	7.9	Dusk. Cloudy. Drizzle
7 "	9.0	0.978	84	0.02-0.03	7.8-7.9	Dark. Cloudy. Fine
8 "	9.0	0.927	79	0.05	7.8-7.9	Cloudy. Fine
9 "	8.9	0.876	75	0.05	7.7-7.8	" "
10 "	8.8	0.846	72	0.05-0.06	7.7-7.8	" "
11 "	8.7	0.777	66	0.10	7.7	Mill stopped. Cloudy. Fine
Midnight	8.7	0.743	63	0.11	7.7	Cloudy. Fine
1 a.m.	8.7	0.714	61	0.11	7.6	" "
2 "	8.7	0.698	59	0.11	7.6	" "
3 "	8.7	0.653	55	0.13	7.5-7.6	" "
4 "	8.7	0.600	51	0.13	7.5-7.6	" Raining
5 "	8.7	0.632	54	0.13	7.5-7.6	" "
6 "	8.7	0.653	55	0.13	7.5-7.6	Dawn. Cloudy. Raining
7 "	8.7	0.659	55	0.16	7.5-7.6	Cloudy. Raining
8 "	8.7	0.663	56	0.16	7.5-7.6	" "
9 "	8.8	0.688	59	0.13	7.5-7.6	Sun breaking
10 "	8.9	0.713	61	0.11	7.5-7.6	Dull
11 "	9.1	0.812	69	0.11	7.6	Fine
1 p.m.	9.7	1.151	103	—	—	"

Sunset March 1st, 5.39 p.m.
Sunrise " 2nd, 6.45 a.m.
Sunset " 2nd, 5.41 p.m.

Fig. 20.

FACTORS AFFECTING THE DISSOLVED OXYGEN CONTENT OF RIVER WATERS.

The main factors governing the dissolved oxygen content of a river water may be summarised as follows.

1. The time of day in its connection with the processes of photosynthesis and respiration.
2. The season of the year, with which varies:
 - (a) the quantity and class of plants and animals present,
 - (b) the length of the periods of light and darkness.
3. The prevailing actinic conditions.
4. The physical characters of the river.
5. Temperature variations.
6. The solution of oxygen from the atmosphere.
7. The degree and nature of any pollution.

Table XXV.

Date	% saturation of dissolved oxygen		p_H value		Ammoniacal nitrogen		Temperature (° C.)		Weather	Sunrise a.m.	Plants
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum			
1927											
Mar. 30-31	3 p.m. 157	1-7 a.m. 65	2-7 p.m. 7.9-8.0	2-9 a.m. 7.6-7.7	2-5 a.m. 0.16	3-6 p.m. 0.01	3-4 p.m. 10.0	5 a.m. 6.75	Bright	5.40	Diatoms abundant, submerged and littoral plants just appearing
Apr. 27-28	3-4 p.m. 178	3-6 a.m. 57	2-6 p.m. 8.0	4-7 a.m. 7.5-7.6	3-9 a.m. 0.16	4-11 p.m. 0.02	6 p.m. 11.5	5-7 a.m. 7.0	Sunny	4.40	Submerged and littoral plants 1 ft. high. Diatoms abundant. Green algae appearing
May 18-19	4-5 p.m. 181	5-7 a.m. 36	4-8 p.m. 8.0	3-7 a.m. 7.5	6 a.m.-mdy. 0.2	6-10 p.m. 0.01-0.015	5 p.m. 15.4	7-8 a.m. 10.8	Sunny	4.5	Submerged plants at height of growth. Diatoms on decrease. Green algae dominant
June 28-29	3-4 p.m. 111	6 a.m. 37	5-9 p.m. 7.9-8.0	5-8 a.m. 7.4-7.5	6-10 a.m. 0.18	6 p.m.-mdt. 0.01	3 p.m. 14.5	8-9 a.m. 12.7	Dull. Rain	3.40	Submerged plants at height of growth. Cut June 22. Few diatoms
June 30	5-7 p.m. 110	—	—	—	—	—	6 p.m. 16.2	—	Afternoon brighter than on June 29	—	—
Aug. 4-5	4-5 p.m. 124	7 a.m. 42	2-7 p.m. 8.0-8.2	5-8 a.m. 7.5	1-4 p.m. 0.015-0.02	7 p.m.-10 a.m. 0.01	5 p.m. 18.4	7 a.m. 15.7	Sunny	4.20	Submerged plants at height of growth. Some green algae
Sept. 7-8	4-5 p.m. 71	5-8 a.m. 39	4-6 p.m. 8.0	6-8 a.m. 7.4-7.5	2-5 p.m. 0.15	Mdt.-10 a.m. 0.01	2-5 p.m. 16.0	7 a.m. 13.1	Cloudy. Some sun	5.20	Weed-cutting
Sept. 22-23	5 p.m. 70	5-8 a.m. 26	5-7 p.m. 7.8	7-8 a.m. 7.5	9 a.m.-2 p.m. 0.05-0.06	7 p.m.-4 a.m. 0.01	1 p.m. 15.4	8 a.m. 11.95	Dull. Rain	5.50	—
Oct. 12-13	3-4 p.m. 49	7-9 a.m. 27	2-4 p.m. 7.8	5-7 a.m. 7.4-7.5	8 a.m.-1 p.m. 0.11	7 p.m.-5 a.m. 0.01	1-11 p.m. 10.6	8 a.m. 9.9	Dull	6.20	—
Nov. 17-18	2-3 p.m. 10	2 a.m.-mdy. 2	3 p.m. 7.6	5-7 a.m. 7.4-7.5	4 a.m.-mdy. 0.16	9-10 p.m. 0.025	1 p.m. 8.2	11 p.m. 7.2	Dull	7.20	Pollution
1928											
Feb. 16-17	3 p.m. 77	Mdt.-4 a.m. 66	10 a.m.-10 a.m. 7.8	7-8 a.m. 7.8	2-6 a.m. 0.1	6-8 p.m. 0.04	3 p.m. 10.4	8-9 a.m. 5.9	Dull	7.15	Sewage fungus abundant. Plants few
Mar. 1-2	3-4 p.m. 100	4 a.m. 51	3-5 p.m. 7.9-8.0	3-10 a.m. 7.5-7.6	7-8 a.m. 0.16	6-7 p.m. 0.02-0.03	1 p.m. 9.7	11 p.m.-8 a.m. 8.7	Cloudy	6.45	Diatoms becoming abundant

Table XXVI. *River Itchen. January 17th-18th, 1928. Series IX.*

Time	Temp. ° C.	Dissolved oxygen		Am- moniacal nitrogen. Parts per 100,000	pH value	Remarks
		Parts per 100,000	% satura- tion			
9 a.m.	5.4	1.051	82	0.005	7.7	Misty. River high and clear
10 "	5.3	1.095	86	0.005	7.7	Misty
11 "	5.1	1.140	88	0.005	7.8	"
Midday	5.3	1.174	90	0.005	7.8	Sunshine. Mist clearing
1 p.m.	6.0	1.184	94	0.005	7.8	"
2 "	6.7	1.201	97	0.005	7.8	"
3 "	7.0	1.172	95	0.005	7.8	"
4 "	7.1	1.138	92	0.005	7.7	Sun setting
5 "	6.8	1.100	89	0.005	7.7	Dusk. Clear
6 "	6.2	1.063	85	0.005	7.6	Dark. "
7 "	5.8	1.053	83	0.005	7.6	Ground mist
8 "	5.6	1.049	83	0.005	7.6	"
9 "	5.3	1.041	81	0.005	7.6	"
10 "	5.1	1.054	82	0.005	7.6	Clear "
11 "	4.9	1.046	81	0.005	7.6	"
Midnight	4.7	1.065	82	0.005	7.6	"
1 a.m.	4.5	1.058	81	0.005	7.6	"
2 "	4.3	1.061	81	0.005	7.6	"
3 "	4.3	1.054	80	0.005	7.5-7.6	Becoming cloudy
4 "	4.3	1.071	82	0.005	7.5-7.6	Cloudy
5 "	4.4	1.060	81	0.005	7.5-7.6	Very overcast
6 "	4.5	1.054	81	0.005	7.5-7.6	Drizzle
7 "	4.9	1.054	82	0.005	7.5-7.6	Raining. Dawn
8 "	5.0	1.047	81	0.005	7.5-7.6	Dull. Fine. Daylight
9 "	5.0	1.043	81	0.005	7.5-7.6	" "

Sunrise January 17th, 7.59 a.m.
 Sunset " 17th, 4.21 p.m.
 Sunrise " 18th, 7.58 a.m.

Fig. 21.

1. Diurnal variation.

The oxygen content varies diurnally, reaching its maximum value just after midday and having a period of minimum value during the night. The photosynthetic production of oxygen during the day and its continuous absorption by respiration and by chemical oxidation of organic matter throughout day and night result in a maximum concentration of dissolved oxygen a few hours after midday and a minimum content during the night, when photosynthesis has ceased.

Table XXVII. *River Itchen. February 21st-22nd, 1928. Series X.*

Time	Temp. ° C.	Dissolved oxygen		Am- moniacal nitrogen. Parts per 100,000	pH value	Remarks
		Parts per 100,000	% satura- tion			
8 a.m.	5.3	1.006	79	0.005	7.7-7.8	Sunshine. Ground mist
9 "	5.5	1.084	85	0.005	7.7-7.8	"
10 "	5.9	1.137	90	0.005	7.8	"
11 "	6.5	1.173	94	0.005	7.8-7.9	"
Midday	7.1	1.222	99	0.005	7.9	"
1 p.m.	8.0	1.220	102	0.005	7.9	"
2 "	8.5	1.220	103	0.005	7.9	"
3 "	9.0	1.209	103	0.005	7.9	"
4 "	9.1	1.182	101	0.005	7.9	"
5 "	9.0	1.118	95	0.005	7.9	" Sun low
6 "	8.4	1.067	90	0.005	7.8	Dusk
7 "	7.8	1.033	85	0.005	7.6	Dark. Clear
8 "	7.2	0.990	81	0.005	7.6	Ground mist
9 "	6.8	0.991	80	0.005	7.6	"
10 "	6.2	0.981	78	0.005	7.6	"
11 "	6.0	0.978	78	0.005	7.6	"
Midnight	5.7	0.988	78	0.005	7.6	"
1 a.m.	5.4	0.978	77	0.005	7.5-7.6	"
2 "	5.1	0.990	77	0.005	7.5-7.6	"
3 "	5.0	0.990	77	0.005	7.5-7.6	"
4 "	5.0	1.003	78	0.005	7.5-7.6	"
5 "	4.9	0.994	77	0.005	7.5-7.6	"
6 "	4.9	1.011	78	0.005	7.5-7.6	Sky just lightening
7 "	4.8	1.002	77	0.005	7.5-7.6	Daylight
8 "	4.6	1.024	79	0.005	7.5-7.6	Sunshine

Sunrise February 21st, 7.5 a.m.

Sunset " 21st, 5.24 p.m.

Sunrise " 22nd, 7.3 a.m.

Fig. 22.

2. Season of the year.

(a) Quantity and class of plants present.

1. *Diatoms*. A study of the maxima clearly shows that from March to May the water becomes supersaturated to a far greater extent than at any other time of the year. This period exactly coincides with the period of greatest growth and development of the diatoms (Part II), and there seems no doubt that it is these micro-organisms that are capable of production of oxygen so

Table XXVIII. *River Itchen. March 20th-21st, 1928. Series XI.*

Time	Temp. ° C.	Dissolved oxygen		Am- moniacal nitrogen. Parts per 100,000	p_H value	Remarks
		Parts per 100,000	% satura- tion			
8 a.m.	7.9	1.040	87	0.005	7.8-7.9	Sunshine. Some clouds. Windy
9 "	8.0	1.160	97	0.01-0.015	7.8-7.9	" "
10 "	8.5	1.231	104	0.005	7.9	" "
11 "	9.4	1.237	107	0.005	7.9-8.0	Cloudy. " Windy "
Midday	9.6	1.255	108	0.005	7.9-8.0	" "
1 p.m.	9.7	1.226	106	0.005	7.9-8.0	" "
2 "	9.5	1.201	104	0.005	7.9-8.0	" "
3 "	9.2	1.151	99	0.005	7.9-8.0	" "
4 "	9.1	1.143	98	0.005	7.9-8.0	" "
5 "	9.1	1.078	92	0.005	7.9-8.0	" "
6 "	9.0	1.050	90	0.005	7.9	" Less wind
7 "	8.9	0.985	84	0.005	7.8-7.9	Raining slightly
8 "	8.8	0.955	81	0.005	7.8	" Dusk
9 "	8.5	0.925	78	0.005	7.8	Cloudy. " Fine. Dark
10 "	8.3	0.931	78	0.005	7.7-7.8	Raining slightly. Windy
11 "	8.2	0.936	78	0.005	7.7-7.8	Raining. Windy
Midnight	8.1	0.914	76	0.005	7.7-7.8	" "
1 a.m.	8.0	0.930	77.5	0.005	7.7	" "
2 "	7.9	0.925	77	0.005	7.6	" "
3 "	7.6	0.923	76	0.005	7.6	" "
4 "	7.3	0.931	76	0.005	7.6	" "
5 "	7.2	0.938	77	0.005	7.6	" Sky just lightening
6 "	7.1	0.923	75	0.005	7.6	" Daylight
7 "	7.0	0.931	76	0.005	7.6-7.7	" Less wind
8 "	7.0	0.945	77	0.005	7.7	" "

Sunset March 20th, 6.11 p.m.

Sunrise " 21st, 6.3 a.m.

Sunset " 21st, 6.13 p.m.

Fig. 23.

as to supersaturate the water to a very high figure. It is not that they necessarily produce more oxygen than any other plants, but, because of their small size, the size of the oxygen bubbles or particles must also be so small as to remain in solution in the water if not subject to violent agitation. Bubbles of oxygen evolved from flowering plants collect in the stomata and intercellular

spaces, where they enlarge and can be seen rising into the air, especially when the stem of a water-plant is broken.

The volume of diatoms produced in the Lark is considerably greater than in the Itchen and it is not the free floating organisms that are important but those growing on the river bed, for the latter are in numbers 10,000 times greater than the former.

Table XXIX. *River Itchen. May 3rd-4th, 1928. Series XII.*

Time	Temp. ° C.	Dissolved oxygen		Remarks
		Parts per 100,000	% saturation	
4 p.m.	14.1	1.119	107	Slightly overcast
9 "	12.5	0.590	54	
4 a.m.	10.8	0.556	49	Dawn
9 "	10.9	1.119	100	Bright and sunny
11 "	13.4	1.293	122	"
2 p.m.	15.4	1.362	129	"
4 "	15.9	1.261	125	"

Sunset May 3rd, 7.25 p.m.

Sunrise May 4th, 4.27 a.m.

What applies to diatoms should apply with equal force to other micro-organisms, *e.g.* *Protococcales* and *Schizophyceae*, but the volume of these is very small in the rivers under observation, and therefore insufficient to make any marked change in the oxygenation of the water. The best illustration of the work of the diatoms is shown in the results of February 16th and March 1st. It was not until the diatoms were present in quantity in March that the dissolved oxygen reached a high maximum.

2. *The flowering plants.* After the diatoms have decreased in volume almost to disappearance there remain the larger plants to oxygenate the water. Their importance is best shown by a comparison of the ecology of the two streams. In the River Lark the plants die down in the autumn and it is not till June that they are present in appreciable quantity, after which their volume increases very rapidly. It will be seen that when the flowering plants are present in greatest quantities the diurnal maximum of oxygen saturation is only 124 %, while in September after extensive weed-cutting had taken place the maximum oxygen figure is still lower at 70 %.

On the Itchen the flowering plants are in much smaller volume and the decrease from summer to winter is also small, the effect of which is shown in the constancy of the maximum oxygen values throughout the year with the exception of the "diatom" period.

The following summary of the results obtained on the River Lark indicates the influence of this seasonal variation in plant life upon the diurnal variation of dissolved oxygen in river water.

Date	Plant life	% saturation of dissolved oxygen	
		Maximum	Minimum
March 1927	Diatoms abundant. Submerged plants just appearing	160	65
April 1927	Diatoms abundant. Green algae appearing. Submerged plants 1 foot in height	180	60
May 1927	Diatoms decreasing. Green algae dominant. Large green plants growing vigorously	180	40
June 1927	Few diatoms. Submerged plants at height of growth. (Some weed-cutting had taken place)	110	40
August 1927	Submerged plants at height of growth. Some green algae	120	40
September 1927	After heavy weed-cutting	70	30
October 1927	Pollution by effluents from beet-sugar factory	(50)	(30)
November 1927	Pollution by effluents from beet-sugar factory	(10)	(2)
February 1928	Plants few. Sewage fungus abundant. Diatoms just beginning to appear, after cessation of pollution	77	66
March 1928	Diatoms becoming abundant	103	51

(b) *The effect of the seasonal variation of the duration of the periods of light and dark.*

This effect is seen in the differences in the lengths of the periods of minimum of oxygenation during the nights. During the summer, when the nights are short, the period of minimum of oxygen is correspondingly short, while in winter, when the nights are long, the period of minimum is extended over several hours.

3. *Prevailing actinic conditions.*

The effect of the variations in prevailing actinic conditions upon the periods and values of maximum and minimum oxygenation is small compared with that of the seasonal variation in plant life, and has been fully discussed in Part III.

4. *Type of stream.*

The depth of the stream, its speed of flow, and the nature of the bed, whether muddy or stony, have a considerable bearing upon the extent of the diurnal variation of dissolved oxygen. In general, the normal equilibrium between the oxygen of the atmosphere and that in solution in the river water is displaced by the effects of photosynthesis and respiration, and this displacement is more marked in the slower moving and deeper Lark than in the more turbulent and shallow Itchen, with the result that the range of diurnal variation of dissolved oxygen in the Lark is much greater than in the Itchen.

5. *Temperature variations.*

A study of the oxygen figures for June to October on the River Itchen (Series III to VI) shows that, whereas the maximum oxygen content of the river water expressed in parts per 100,000 remains constant, some variation is shown in the values expressed as percentage saturation of dissolved oxygen;

it will also be seen that the curve of the maximum values in percentage saturation follows the mean water temperature curve. This would indicate that the equilibrium between the oxygen of the atmosphere and that in solution is not maintained during a rise or fall in temperature; *e.g.* after a fall in temperature, oxygen is not immediately taken up from the air to maintain the original degree of saturation.

Example. River Itchen. November 10th–11th, 1927.

	Temp. ° C.	Dissolved oxygen	
		Pts/100,000	% saturation
10 p.m.	5.1	1.056	82
Midnight	4.7	1.056	81
6 a.m.	4.2	1.056	80

The ease with which this equilibrium may be established by solution of oxygen from the air is dependent to a certain extent upon the original oxygen saturation of the water, since the rate of solution of a gas in a liquid varies directly as the degree of unsaturation of the liquid, and consequently the temperature lag discussed in the previous paragraph is more evident in the region of saturation than in very subsaturated solutions. In general, this temperature effect is hidden by the larger and more rapid changes due to photosynthesis, respiration and pollution.

6. *Oxygen absorption from the atmosphere.*

Throughout these experiments Fox's tables [1907] have been used for the conversion of parts per 100,000 to percentage saturation of dissolved oxygen, but it is questionable as to whether these theoretical values may be strictly applied to river waters, in view of the temperature lag discussed above, and since their use assumes that the solubility of oxygen in these river waters is the same as in distilled water.

7. *The degree and nature of any pollution.*

A striking example of the overshadowing of nature's processes of river water aeration by the effects of industrial pollution is afforded by a study of the oxygen curves on the River Lark for October, November and January, 1927, when the river was practically deoxygenated throughout the day by the effluents from the beet-sugar factory 7 miles above the point of sampling.

p_H VALUE OF RIVER WATERS.

Throughout the year the p_H curves were very similar in structure to those of saturation of oxygen, and showed the same effects of diurnal variation, seasonal variation of plant life and of the duration of night and day, indicating that the concentration of carbon dioxide is roughly inversely proportional to that of oxygen.

Time of day. The p_H value of the river water varied diurnally, having a maximum value during the afternoon due to the removal of carbon dioxide

during the photosynthetic production of oxygen, and having a period of minimum during the night, when photosynthesis ceases and carbon dioxide is still being liberated by the respiration of plants and animals.

Season of year. The values and periods of the diurnal variations in p_H value are affected considerably by the quantity and type of plant life present, depending upon the season of the year. The greatest range in p_H variation was obtained during the summer months when the large green plants were at the height of their growth, while on the River Lark in February 1928, when the plants were very few, no diurnal variation in p_H value was observed.

The periods of the maxima and minima are dependent upon the duration of the periods of light and dark, according to the season of the year, in a manner corresponding to the oxygen curves.

DIURNAL AND SEASONAL VARIATION IN AMMONIACAL NITROGEN.

The diurnal variation of ammoniacal nitrogen has been discussed in Part III, with the general conclusion that the nitrogen content varies in a sense opposite to that of oxygen.

On the Itchen no diurnal or seasonal variation was observed, while on the polluted River Lark considerable variations were observed throughout the year, although the data obtained were not sufficient to establish definite relationships between the nitrogen variation and the factors affecting it.

In conclusion the authors wish again to thank Sir R. Robertson and the Ministry of Agriculture and Fisheries for permission to publish these results, and Mr Stokes of the Fisheries Laboratory, Lowestoft, who is responsible for the graphs in all four parts.

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