SOME PHYSICAL AND CHEMICAL CONDITIONS OF THE WATER OF LAKE BALATON, INVESTIGATED FROM SEPTEMBER 1948, TO APRIL 1949. (TEMPERATURE, TRANSPARENCY, DISSOLVED OXYGEN, pH AND ORGANIC SUBSTANCES)

BY

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In modern limnological research the study of the physical and chemical conditions of the water plays a constantly growing part, as these conditions and their variations influence decisively the formation, continuity and changes in the living world of the water. Among these decisive factors are the movement of the water, its temperature, light conditions, total salt concentration, oxygen content, pH, organic substances, the maximum or minimum presence of numerous dissolved inorganic ions etc.

Much research has been devoted to the study of these factors in Lake Balaton (ENTZ, G. and SEBESTYÉN, 1946:219—255) but this work was not carried out throughout all the seasons, most of it being done in summer, and furthermore most of it took only one of the factors into consideration. As the different factors and their changes do not act singly on the different organisms but together and even reciprocally*) (ÖSTERLIND, 1947, L. D. TOWNSEND and H. CHEYNE, 1944, WELCH, 1935), it seemed desirable to undertake systematic investigations along these lines in Lake Balaton. The first part of my investigations, from the end of September, 1948, to April 1949, were principally devoted to the temperature, transparence, pH, dissolved oxygen and dissolved organic substances, their seasonal changes, and the possible relations existing among these factors.

Samples were collected in two places: 1.) In the open water in front of the Hungarian Biological Research Institute at about 250 m from the shore, in water 3 m deep; 2.) In the „K u t", the deepest part of Lake Balaton, near the Tihany ferry, in water 10 m deep. We took the water samples at distances of 1 m, advancing from the surface to the bottom, with a Ruttner vessel. The collected material was brought to the laboratory in vessels with polished glass stoppers and worked up in the shortest possible time.

* THIENEMANN 1939 p. 271—272: „18. Alle Einzelfaktoren eines Biotops wie auch des gesamten Lebensraumes stehen in engster Wechselwirkung miteinander; daher wirkt ihre Gesamtheit wiederum als übergeordneter Faktor — „lokaler Einheitsfaktor" FRIEDERICHS) für Einzelbiotop als „Holocoen" (FRIEDERICHS) für den gesamten Lebensraum (Weltzusammenhang) . . . "

TEMPERATURE

A thermometer with a scale marked at 0.1° C intervals, installed in the Ruttner vessel, indicated the temperature. As appears from Table I. and Figure 1, the temperature of the water dropped gradually from 16—18° C in September, to 1—2° C at the end of November and oscillated thereabout until it froze. There was no appreciable difference in the temperature at any distance from the surface to the bottom, so that we cannot speak of temperature stratification in either of the collecting places, in front of the Institute or in the Kút. Slight temporary differences in temperature occurred between surface and bottom in the former spot (e. g. September 28th 1.5° C and October 19th 0.6° C) whereas during the same time, under the same circumstances, the greatest difference observed in the Kút was 0,3° C. This is probably closely connected with the almost constant strong current existing in the Kút, amounting at the time of our collections to 10—20 m/min. With the formation of ice a reversed temperature stratification* occurred, which gradually became more pronounced with the warming of the water which, as we know, takes place under the ice (ENTZ, G. and SEBESTYÉN, 1946:239). Whereas at Collecting place I. on December 14th, the day it froze, the difference between surface and bottom water was 0.0° C, on December 29th it was 1.0° C, and by January 10th had risen to 3.0° C. At the same time, a similar stratification occurred in the Kút (on January 4th 1.5° C). On the breaking up of the ice the stratification diminished again, and ceased on its disappearance, in booth places (January 22nd 0,1° C). In the meantime the water cooled to a uniform 1—2° C. After this, no similar prolonged temperature stratification was observed. At one time, when the lake froze in again there was, on March 12th, a difference in temperature between surface and bottom water (1.2° C) but it ceased after a few days, when the ice melted.** The conditions of temperature on March 23rd were interesting. At that time, after several days of blustering storm, the morning temperature was uniformly 2,7° C. In the afternoon, with quiet sunny weather, a great warmth set in. It began to heat the surface of the very troubled water, which reached 3.1° C, while at the bottom the temperature remained at 2.7° C. This paradoxical condition ceased on the following day, and from then on, the water became gradually warmer and was at the beginning of April 10—12° C, at the end of April 18—20° C. This very decided and rapid heating, means that raising the temperature of the whole water volume of the lake requires 36.10^{12} calories, which represents the consumption of 4,500,000 tons of the best coal.

* By stratification here and in the following I do not mean stratification as generally used in the limnology, occurring in deep lakes, but merely the „microstratification" evidenced in small differences occurring from time to time in the shoal water of Lake Balaton.

** It is to be noted that the ice does not often break up and then form again in Lake Balaton (see ENTZ and SEBESTYÉN, 1946 239).

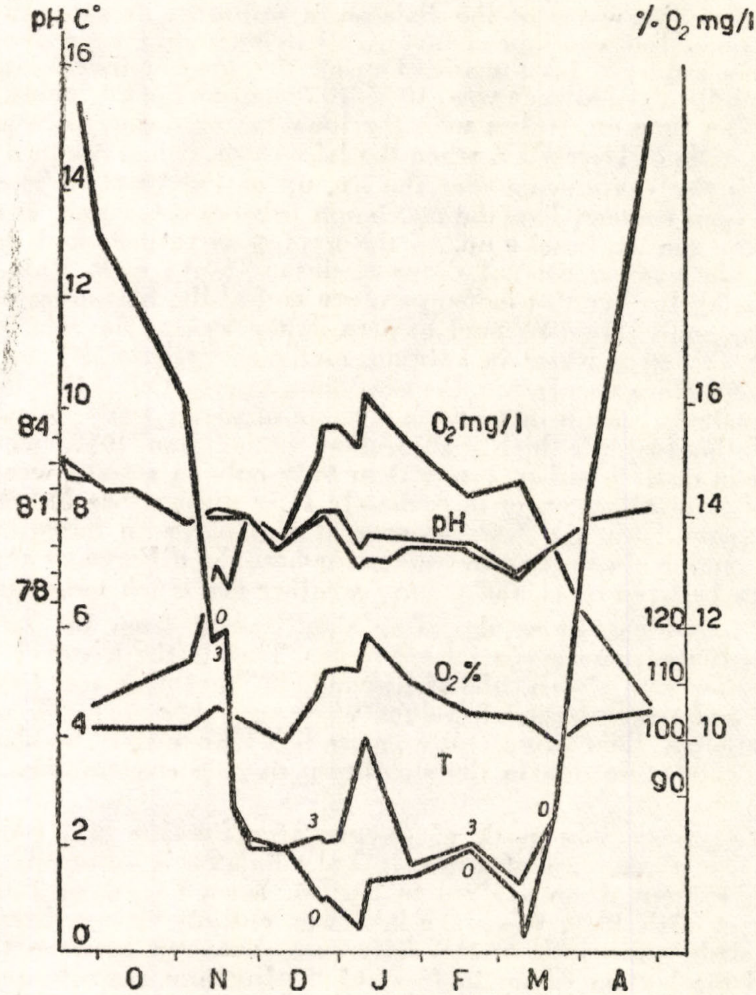

Fig. 1. Changes in temperature, pH and dissolved oxygen content of the water of Lake Balaton from October 1948, to April 1949, at Tihany in front of the Biological Research Institute at 250 m from the shore. The pH graph (7.8—8.4) here and there consists of a double line, when there was an appreciable difference in the values measured at the same time and place between surface and bottom. The double line represents the outside values. The double line of the temperature graph T (16—0° C) expresses the difference on November 19, but especially from December 14 to March 13, again between surface (0 m) and bottom (3 m). Where there is a single line no difference in temperature could be observed between surface and bottom. The O_2 content is expressed in mg/l (10—16) and in %ual saturation.

DISSOLVED OXYGEN CONTENT

Determination of the oxygen content of the water was made by MAUCHA's method (1945). As MÜLLER (1929), MALDURA (1931), CSEGEZY (1938), DOBY and JACZÓ (1939), SZABÓ (1930), and other investigators have shown, the water of the Balaton is saturated or super-saturated with oxygen. But continuous investigations extending over the whole year have not yet been made. During the present investigation the amount of dissolved oxygen was 10.5—10.7 mg/l at the beginning of October. From then on, it rose with the lowering of the temperature, and by the middle of December, when the lake froze, it had attained 13—14 mg/l. This rise continued under the ice, up to 15—16 mg/l. The maximum oxygen content, like the maximum relative saturation, is reached just before the ice breaks up. As the ice begins to melt and then disappears, the oxygen content drops again to 13—14 mg/l. This continues with the further rise in temperature and at the beginning of April there was only 11—12 mg/l oxygen in the water. The relative saturation in the open water in autumn, oscillated between 93 and 107%. When the surface was frozen, the saturation rose to 120—125% but after the ice melted it again dropped to a value of about 100%. Generally in front of the Institute higher saturation values than 103% were only obtained in quiet weather, lower than 99% only in stormy weather, in violently agitated water, or immediately after storms. (See SZABÓ l. c. p. 492). Apparently in the Kút the current also plays an important part in the formation of oxygen saturation, for here the differences appearing elsewhere between quiet and stormy weather are much more indistinct.

I found conditions deviating significantly from the saturation values, only under quite special conditions. Thus in the Kis-öböl — near the shore — large shoals of fish assemble in November and December. In their midst the saturation values were very low (85—50, or even 30%). But here there were really „more fish than water", so that these extreme values are due to the significant oxygen consumption of the fish.

We can scarcely speak of oxygen stratification in the different depths. The whole mass of water in Lake Balaton is uniformly saturated with oxygen, from surface to bottom. From December 14th 1948, to January 13th 1949, when the lake was entirely frozen there developed a slight stratification; the difference, however, between the surface and the bottom values in front of the Institute, scarcely amounted to 0.1—0.8 mg/l of oxygen. After the ice began to break up here and there, but in water samples taken from under the ice, more oxygen occurred near the bottom than on the surface. After the final melting of the ice, the oxygen distribution became again completely uniform. On two occasions less oxygen was found in the Kút near the bottom than on the surface. This, however may be considered a merely transitory state of affairs, because while, for example, the oxygen distribution observed on November 11 was on the surface: 11.52 mg/1=100%, and on the bottom 10.84 mg/1=93.6%, the following day there was again a completely uniform distribution. But all these divergent values in respect to depth differ so little from one another, that they can have only the very slightest effect or none at all on the depth distribution of the living organisms.

Measurement of diurnal variations were made twice, on March 12—13th, in a lively storm in cloudy weather and on April 6—7th, in quiet sunny weather. On both occasions the collections were made every 4 hours and the water samples were taken from the surface. The diurnal variation was less in stormy weather than in the quiet, sunny weather (See F i g u r e 4). In both cases the oxygen content decreased from 10 to 14 hrs. and mounted in the afternoon from 14 to 18 hrs. From 18 hrs until morning in quiet weather there was a gradual decrease, whereas in stormy weather after 22 hrs at night a slow increase set in. In quiet weather in the open water with less diurnal change there was on an average less oxygen present than in the Kis-öböl at the same time. There, at a distance of 4—5 m from the shore, with greater changes, the values fall between those obtained in the open water and in the reed. The most extreme values were obtained among the broken stubble of last year's reed, thickly overgrown with the organism which live in its coating. Peak values in all three collection places were obtained at 18 hrs. in quiet weather. The daily variation values reached, and even exceeded the differences existing between the different depths at the same times and places.

LIGHT CONDITIONS

We have at our disposition a number of literary data on the light-transmitting capacity of Balaton water, from different periods. A good part of these are no more than measurements with a Secchi disc. The other more accurate measurements were all made in July and August (GÄRTNER, 1929, LUDÁNY-PÁTER, 1929, ULLYOTT and KNIGHT, 1938). All the investigations showed, that the water of Lake Balaton is very turbid and its transparency can change radically in a very short time — primarily on account of the wind — so that the light conditions in the lake are exeptionally variable. This circumstance and the further one that light is an essential factor in water habitats, makes a detailed study of the problem desirable (BIRGE and JUDAY, 1933, SAUBERER, 1941, UTTERBACK, 1941. BURR, 1941). I myself approached the question in several ways. I measured the transparency with a Secchi disc, I also determined the turbidity indirectly with a Pulfrich photometer, and recently began investigations with the photoelectric method.

The transparency values as measured with the Secchi disc, from the end of September to the end of November varied between 70—170 cm in a wind of less than 4 m/sec. Between November 19 and 22 there were three completely windless days. The transparency then reached almost 200 cm. A violent storm which followed, on November 24, again reduced the transparency to 20—30 cm. The values measured at other similar times of severe storms likewise moved around 20—30 cm. In the winter under the ice there was a constant, gradual sedimentation of the floating particles. The transparency thus gradually increased and on January 13 in front of the Institute extended to the bottom, (275 cm) and in the Kút at the same period, was 354 cm. After the ice broke up, the transparency again diminished. This decrease was especially striking at the beginning of April, when during 5—6 days of almost completely windless weather the water kept a milky turbidity and the transparency never rose above 40—60 cm.

Parallel with this I began measurements similar to GÄRTNER's (1929) with a Pulfrich photometer. In this investigation I worked up the samples within one or at the most two hours, and to avoid as far as possible the settling of the sediment, reversed the bottles several times every 15—20 minutes. Contrary to GÄRTNER (1929:187) I guarded against a „thorough shaking“, as it is my experience that, especially in very turbid water, where there are large floating particles, the particles themselves are thus shaken to bits and we get a significantly greater turbidity than the actually existing one (e. g. a 5% transparency instead of 20%). I used a 5 cm long cuvette for the measurements and distilled water as comparative fluid. I also used a yellowish-green filter for the measurements. (No S. 57 Zeiss). The results are percentage values, which express what quantity of light progresses through the water under investigation, as compared with distilled water. The values obtained are approximately identical with the Secchi disc data (Figure 2).

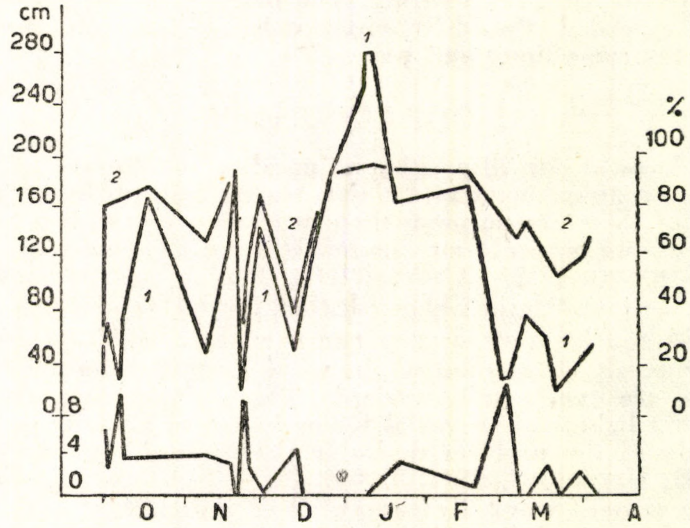

Fig. 2. In Graph 1 appear, in cm, the transparency values as measured with a Secchi disc. In Graph 2 are given the transparency values as measured with a Pulfrich Stepphotometer. The curve at the bottom shows the wind force measured at collecting time, in m/sec. On windless days and, naturally, under the ice the wind force was O, so the curve falls within the abscissa axis.

In quiet autumn weather the surface transparency varied between 80—88%, in winter under the ice in consequence of the constant settling, it rose to 96% decreased again in spring, so that at the beginning of April, even in quiet weather, it was only 60—80%. From the surface to the bottom in quiet autumn and winter weather the transparency normally decreased by 1—3%, more rarely by 7—8%, but in spring, during the greater turbidity, 20 and even 30% differences in transparency were obtained between surface and bottom. That floating particles subside in spring much more slowly is probably due — aside from chemical conditions — to the strong vertical current arising in consequence of the difference in density of the various layers, caused by the vigorous warming up in the daytime and extreme cooling at night, which constantly stirs the water up. In storms, during the whole period of the investigation, the transparency was 15—20%.

A good deal of the particles which cause the turbidity dissolves in diluted hydrochloric acid. (MÜLLER 1929 p. 151). As second measurement in this investigation, I dropped 0.5 ml 10% hyrochloric acid into the samples. The values thus obtained were higher than the results obtained with the original samples by 5—15% in quiet antumn weather, 1—5% higher than in winter under the ice, 20—30% higher in quiet spring weather, and in general during storms 30—50% higher. In the samples treated with hydrochloric acid the transparency decreases from surface to bottom by 1—4% in the autumn and by about 10% in the spring.

I will not digress here to the photoelectric measurements begun in the spring, but will discuss them in a later publication.

I carried out several sedimentation experiments during storms (Figure 3). From these it appears that the settling of floating particles, given identical turbidity, is the same in November, March and May. Thus, with an initial transparency of about 20%, it increased to 52—65% in 2 hours, 64—73% in 4 hours, 74—82% in 8 hours, 70—86% in 12 hours, and after 24 hours' settling was 86—90%. Hence the distribution as to size of the floating particles agrees, largely speaking in all these samples.

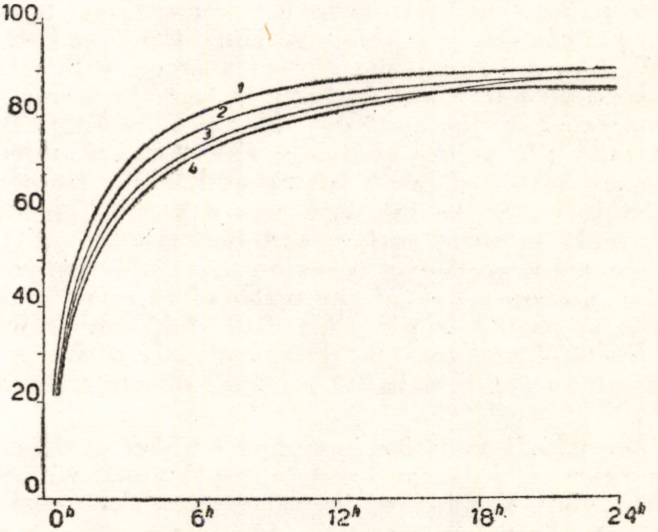

Fig. 3. Results of the sedimentation experiments. The curves show the %al values at the different times, measured with a Stepphotometer. Date of samples: 1. 10—5—1949; 2. 25—11—1948; 3. 5—3—1949; 4. 24—11—1948.

pH CONDITIONS

pH determinations were made by the MAUCHA method (MAUCHA, 1940, 1945). I myself modified this method slightly. I made two measurements, during which I changed the eprouvettes used for comparison. I took the mean value of the two measurements as final result. This was necessary because the diameters of the different eprouvettes, the thickness of their walls, differences in shade, etc., affect comparisons of colour differently. Thus there were differences amounting to as much as 0.1 pH units in the same samples. On the other hand, by twice measuring the water sample, using several different eprouvettes, the mean value obtained showed at most a difference of 0.01—0.02 pH unit. Besides this I measured the pH with a Pulfrich photometer and a Sonntagh electric pH measurer. But in the present investigations the MAUCHA method proved the most suitable, for speed and accuracy, and is also best for field investigations.

Several particulars as to the pH of Balaton water are given in the literature. MÜLLER got a pH of 8.62 in the open water (1929:151) DOBY and JACZÓ found pH values between 7.8 and 8.9 in the littoral during investigations made only in the favourable season (1939:33). According to later measurements (MAUCHA, SEBESTYÉN, verbal communications) the pH value varies to some extent throughout the year. It likewise varies throughout the day (MALDURA, 1931).

From the present investigations it was found that the pH of the water of the Balaton continuously decreases from autumn until the beginning of March, till the disappearance of the last ice covering, with some relapses (September 27th pH=8.37, March 12th pH=7.88) and from then on again gradually rises (April 6 pH=8.13). (See Figure 1). The close parallel which appears between seasonal temperature variations and pH changes is interesting. Thus, until the first half of November both decrease decidedly. From then on, with relatively small variations, we find low values in both, in fact the lowest temperature and pH data occur on the same day, March 12th. From then on, both temperature and pH values gradually rise. Another interesting relationship, when there was a fairly strong and lasting temperature stratification forming under the ice there was a parallel, fairly significant difference in pH between surface and bottom (0.05—0.11 pH units). This is all the more worthy of mention as under experimental conditions a rise in temperature of the water of 10 or even 30° C never caused a greater change in pH than 0.01—0.02 units, which is still within the limits of experimental error, and only a rise in temperature of 40° C caused an appreciable (0.1 pH unit) difference (using MAUCHA's method).

The diurnal pH variation in stormy weather at the end of March was almost completely insignificant (0.03 pH unit), whereas on April 6th, in quiet, sunny weather, at the same place there was a difference of 0.11 units, in the values measured. On this occasion a close connection was shown between the amount of dissolved oxygen and the pH (See Figure 4), a phenomenon similar to which was also observed by CZERNY (1948:48).

It is possible that the seasonal changes in the transparency of the water of the Balaton are also connected with the seasonal pH variations. (MESCHKAT, 1934 p. 442). Sedimentation tests showed, that if I reduced the pH of settling turbid water from 8.1 to 7.8 by adding diluted hydrochloric acid to it, there was no significant change in the speed of sedimentation. But on further acidification to pH 7.4, the sedimentation was definitely accelerated. More detailed investigation is necessary however, to clear up this question.

I also determined the dissolved organic contents by MAUCHA's method (1945). They showed that the oxygen consumption of the organic material gave values between 1.575—3.23 O_2 mg per liter, the mean value being about 2.5 mg. The values changed constantly, now dimin-

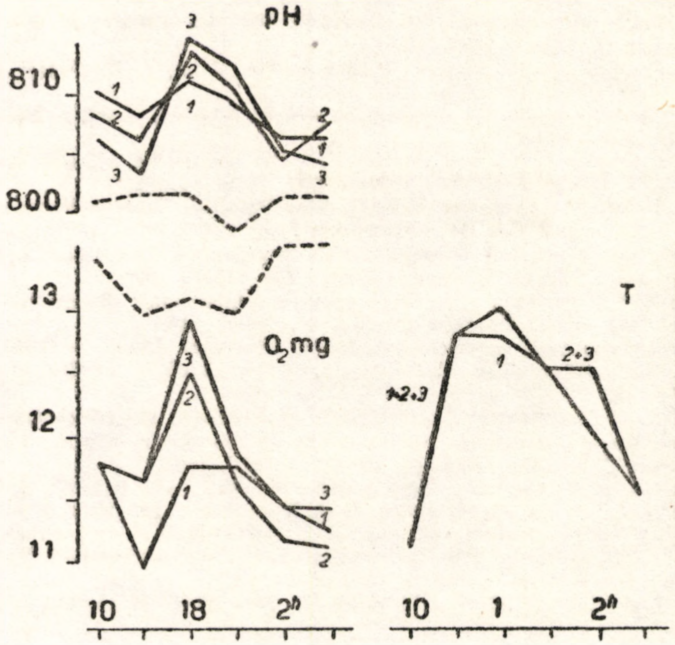

Fig. 4. Graphs showing the pH, O_2 (mg/1), and temperature (° C) data obtained in diurnal investigations on April 6—7, 1949 and March 12—13. 1. Open water. 2. Interior of Kis-öböl. 3. Last year's reed.

ishing, now increasing according to depth and it was impossible to show a possible relationship with other factors (see Table I.).

Continuation of the investigations and their extension to other important factors, as well as knowledge of their closer relationship to the biology of living organisms, is a task for the future.

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НЕКОТОРЫЕ ФИЗИЧЕСКИЕ И ХИМИЧЕСКИЕ УСЛОВИЯ ВОДЫ ОЗЕРА БАЛАТОНА; ИССЛЕДОВАННЫЕ С СЕНТЯБРЯ 1948 г-а ДО АПРЕЛЯ 1949 г-а

(Температура; прозрачность; содержание кислорода; pH и органические вещества)

Автор: БЕЛА ЭНЦ

РЕЗЮМЕ

С осени 1948 года до весны 1949 года я исследовал температуру прозрачность, pH, содержание кислорода и органических веществ воды в глубине 3 м., около восточного берега полуострова Тихань и в глубине 10 м у „Кут"-а. Я ставил себе задачу, установить определенные сезонные изменения или-же изменения соответствующие разным глубинам, а также установить связь между различными факторами.

Вода озера от поверхности до дна являлась насыщенной или перенасыщенной кислородом. Минимум был 93% максимум 126%. Насыщение достигло наименьшую степень во время бури а большую степень в тихую погоду. Самая высокая степень насыщения встречалась зимой, под льдом.

Прозрачность, начиная с осени (70—170 см. Secchi-диск, 80—88% на фотометре Pulfrich-а) постепенно увеличивалась и достигла наивысшую степень под льдом (354 см., 96%). Весной, когда вода стала более теплой, прозрачность резко уменьшилась (40—60 см., 60—80%). Большая часть пловучих частиц, являющихся причиной мутности растворяются в разбавленной соляной кислоте.

Путем небольшой модификации метода определения pH пригодного и в полевых условиях мы могли определить pH с точностью ± 0.015.

pH постепенно уменьшился с 8,38 (сентябрь) до 7,88 к концу зимы. В начале апреля, когда вода стала более теплой pH опять поднялся до 8,10—8,15.

В общем pH изменился в прямой пропорции с температурой, а прозрачность и содержание кислорода изменились в обратной пропорции с температурой.

TABLE I.

Changes in transparency, pH, and organic matter content of Balaton water from Sept. 27, 1948 to April 2, 1949.

Date	Wind m/sec.	Transparency Secchi disc.	Transparancy with % in natural cond				Stufen photometer % with HCl				pH					Organic substance			
			0	1	2	2.75	0	1	2	2.75	0	1	2	2.75	3	0	1	2	2.75*
27. 9	4·5	72	80	79	76·5	75	93	91	90	90	8·37	8.38	8.37	8·34					
28. 9	2·1	97.5	87	85	82	79	95	94	92	93	8·27	8·28	8·26	8·25					
29. 9	1	130	86·5	85	85	81	95	94	94	93									
1.10	6·4	30	24	23	23	19	57	56	56	57									
2.10	2·0	72	81	77	75	73	86·5	86	85·5	85									
8.10	9·0	20					56				8·22								
9.10	3·3	74	84	85	84	84	91	92	91	91	8·20	8·20	8·20	8.20					
19.10	2·2	170	88	88	88	82	93	92	91	92	8·20	8·20	8·20	8·20					
10.11	3·7	45	64	64	63	60	87	87	87	86	8·08	8·08	8·08	8·08					
19.11	3 0	125	87	85	83·5	81·5	92·5	92	92	93	8 13	8·13	8·10	8·10					
22.11	2·0	192	88·5	87·5	88	86	94·5	92	92	93	8 13	8·12	8.10	8 10					
25.11	8·0	20	19	19	19	19	59	59	59	59	8·10	8·10	8· 0	8·10					
26.11	2·2	50	56	56	55	53	86	85	84	80	8·10	8·10	8 10	8·10					
1.12	0·0	145	86·5	86	84.5	84·5	94·5	94	92	90	8·10	8·10	8·10	8·10					
14.12	4 5	50									7·98	7·98	7·98	7·98	8·04				
27.12	—	185	91	91	90	90	96	95	94	94	8·10	8·11	8·10	8·10					
29.12	—	195	91·5	91	90	90	96	96	96	94	8·10	8·10	8·11	8·11					
3. 1	—	215	95	92	91	90	99·5	97	96	95 5	8.03	8·10	8·11	8·09	8·10				
10. 1	—	250	96·5	94·5	90·5	90·5	97	96	96	94	7·91	7·97	7·98	7·98	8·02				
13. 1	—	275	96·5	96·5	94·5	94	99	98	97	95·5	7·95	8·01	8·03	8·02	8·06	3·12	2·74	2·74	2·74
22. 1	3 0	160	94	91·5	92	89·5	95	95	96	94	8·00	7·95	7·97	8·03		2·76	2·49	2·29	
19. 2	1·0	140	92	92	89 5	89	96·5	95	94	93·5	7·99	7 98	8·01	7·99	7·96	1·58	1·58	1·58	1·66
5. 3	11·0	20	20				68 5												
9. 3	--		66	55	38·5		87	81·5	71·5		7.90	7·88	7·88		7·68				
12. 3	—	75	73	71	72	71	89	88	88	87	7·91	7·93	7·92	7·92	7·96	2·69	2·84	3·00	3·07
23. 3	0 0	40	50	46	42		81	79	80	71	8·01	8·00	8·00	8·00		2·71	2·33	2·33	3·08
2. 4	2·0	43	58	56	56	56	82	81	81	81·5	8·07	8·07	8·07	8·06	8·04	2·24	2·31	2·54	2·61

* depths of water in m

TABLE II.

Changes in temperature and oxygen saturation of Balaton water, September 27, 1948 to April 2, 1949.

Date	Wind m/sec.	Temperature °C					O_2 mg/l					O_2 % saturation.				
		m 0	1	2	2·75	3	0	1	2	2·75	3	0	1	2	2·75	3*
27. 9	4·5	16·5	16·4	16·4	16·4	16·4										
28. 9	2·1	16·9	16·9	16·8	16·7	16·7										
1.10	6·4	15·7	15·7	15·7	15·7	15·7										
2.10	2·0	15·6	15·5	15·4	15·2											
9.10	3·3	13·2	13·2	13·2	13·2		10·54	10·60	10·70	10 60		101·1	101·4	102·3	101·4	
19.10	2·2	13·2	13·0	12·8	12·6											
10.11	3·7	10·2	10·2	10·1	10·0		11·36	11·36	11·36	11·36		101·3	101·3	101·3	101·3	
19.11	3·0	5·9	5·9	5·8	5·8		13·22	13·10	13·16	12·99		106·3	105·3	105·5	104·3	
22.11	2·0	6·0	5·9	5·9	5·9											
24.11	9·0	6·0	6·0	6 0	6.0		12·70	12·70	12·70	12·70		102·8	102·8	102 8	102·8	
26.11	2·2	2·6	2·7	2·7	2·7		13·47	13·47	13·47	13·47		99·4	99·4	99·4	99·4	
1.12	0·0	2·0	2·0	2 0	2·1	2·8	13·67	14·42	13·98	14·17		99·3	104·7	101·5	103·1	
14.12	4·5	2 0	2·0	2·0	2·0		13·63	13·57	13·57		13·45	99·0	98·6	98·6		97·7
27.12	—	1·0	1·4	1·4	2 2		15·26	15·14	15·02		15·08	107·8	108·1	106·7		111·4
29.12	—	1·1	1·2	1·5	2·1	2·1	15·94	15·94	15 44	15·24	13·76	112·7	113·2	110 6	111·0	100·2
3. 1	—	0·9	1·4	1·5	2·0	2·1	16·13	15·79	15·60	15·30	15·34	113·6	112·8	110·9	111·9	116·0
10. 1	—	0·5	2·2	2·8	3·3	3·5	14·60	15·42	15·50	15·71		101·7	112·6	115·0	118·1	
13. 1	—	1·4	1 5	2·0	3·6	4·0	14·79	16·78	16·40	16·70	16·09	105·5	120 0	119·1	126·5	123 2
22. 1	3·0	1·7	1·6	1·6	1·6	1·6										
29. 1	—	1·5	1·6	1.6	1·6		15·69	15·35	15·00	15·38		112·3	110·0	107·7	110·4	
19. 2	1·0	2·0	2·1	2·1	2·1		14·15	14·52	14·52	14·15		102·8	105·7	105·7	103·0	
9. 3	—	1·1	1·2	1·2			14·39	14·84	14·58			101·9	105·1	103·8		
12. 3	—	0 4	0·5	1·0	1·4	1·6	14·43	14·73	14·47	14·62	14 62	100·2	102·6	102 2	104·4	104 9
23. 3	0·0	3·1	2·9	2·9	2·8	2·7	13·35	13·42	13·27	13·35	12·65	99·8	99·8	98·7	99 0	93·6
2. 4	2·0	8·2	8·2	8·2	8·1	7·9	12·15	12·19	12·14	12·12	11·74	103·6	104·0	103·5	102·9	99·3

* depths in m.

TABLE III.
Measurements of diurnal variations, April 6—7, 1949.

Time of collection	Place of collection	Direction and velocity of wind	Transparency Secchi disc	Temperature	O_2 mg/1	O_2 ml/1	O_2 0/0 saturation	pH	Transparency Pulfrich natural cond	Transparency Pulfrich + HCl
10hr	O.W.			11·1	11·73	8·21	106·9	8·10	67	88·5
	Reed	N	55	11·1	11·81	8·27	107·9	8·06	81·2	93
	Bay	1m/sec		11·1	11·81	8·27	107·9	8·08	82	93
14hr	O.W.			12·8	10·90	7·63	103·2	8·08	78	89
	Reed	—	60	12·8	11·68	8·18	110·7	8·03	76·7	90·8
	Bay			12·8	11·65	8·15	110·4	8·06	82·7	93
18hr	O.W.			12·8	11·73	8·21	111·2	8·11	78·7	92·1
	Reed	—	55	13·0	12·89	9·02	122·8	8·14	84·2	93·1
	Bay			13·0	12·56	8·79	119·6	8·13	84	94·75
22hr	O.W.			12·5	11·73	8·21	110·4	8·09	72	92
	Reed	SW	—	12·5	11·81	8·27	111·2	8·12	83·2	93
	Bay	4m/sec		12·5	11·64	8·15	109·6	8·10	89	98
2hr	O.W.	S		12·0	11·43	8·01	106·5	8·06	73	91
	Reed	1m/sec	—	12·5	11·43	8·01	109·1	8·05	83	95
	Bay			12·5	11·15	7·80	106·4	8·04	89	96·5
6hr	O.W.	S		11·5	11·40	8·04	105·6	8·06	65·1	88
	Reed	3·5m/sec	50	11·5	11·23	7·86	103·3	8·04	74·2	88·7
	Bay			11·5	11·10	7·69	101·1	8·07	85·5	95·5