

SEASONAL AND VERTICAL VARIATIONS OF WATER TEMPERATURE AND OXYGEN CONTENT IN THE DOSPAT RESERVOIR, BULGARIA

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SEZONSKA I VERTIKALNA VARIJACIJA TEMPERATURE VODE I SADRŽAJA KISEONIKA U AKUMULACIJI DOSPAT, BUGARSKA

Abstract

The changes in water oxygen content depending on the water temperature and depth of Dospat dam lake for the period May 2009 –April 2010 were investigated. The dam lake is situated in the Western Rhodopi Mountain. With it's altitude of 1200 m above sea level it is the highest dam lake in Bulgaria, with a total of 22 000 dka of flooded area. The average surface layer temperature values vary from 9.6°C (April) to 22.74°C (July). In the summer months these values are within the limits of 17.26°C – 22.74°C (0.5 m dept) – 5.26°C -5.47°C (30 m dept). Lower temperature values were reported during the spring (April-May) and autumn (November). The horizontal differentiation indicates that the average surface layer values of the oxygen content in the water vary from 4.22 mg.l⁻¹ to 11.48 mg.l⁻¹. In the summer months sampling points the values were within the limits of 4.22 mg.l⁻¹–7.47 mg.l⁻¹ (0.5 m depth) and respectively of 1.12 mg.l⁻¹ - 1.60 mg.l⁻¹ (30 m depth). These investigations gave the possibility to determine the periods and the depth zones with optimum values of temperature and oxygen content for trout rearing, which can be used for optimization of the technological process of the net cage aquaculture in Dospat dam lake.

Key words: monitoring, water, temperature, oxygen content, Dospat reservoir

INTRODUCTION

Dospat Reservoir is an artificial dam lake with considerable depressions in the bottom terrain, great depths and characteristic temperature stratification. It is situated upon a total area of 22 000 dka (22 km²) in the Western Rhodopi Mountain, with an altitude of 1200 m above sea level and it is the highest dam lake in Bulgaria. This also determines the prolonged period of time, during which the ice cover of the dam is preserved (2-4 months) (Naumova and Zivkov, 1988).

Dospat Reservoir is a part of the hydro-energetic complex, the cascade of Dospat - Vatcha. The complex utilization for the needs of energy production, hydro-meliorations and aquaculture has motivated a number of investigations on the ecosystem and water quality of Dospat Reservoir during different periods of time after it was put in operation in 1967 (Naidenov & Sais, 1977; Zivkov, 1987; Naumova & Zivkov, 1988; Ivancheva & Sirakov, 2003).

Naumova & Zivkov (1988) have outlined two periods in the fisheries utilization of Dospat Reservoir. The first one – up to 1978-1980, which is characterized by a successful introduction and acclimatization of carp (*Cyprinus carpio*) and peled (*Coregonus peled Gmelin*) as well as with the relatively low production catches (5-10 t annually), in which the fish species of little value were dominant. The second period – after 1978-1980 is distinguished by its high production catches of a rainbow trout and by the powerful development of the intensive trout-fisheries in net cages.

The aim of this investigation was to determine the seasonal and vertical dynamics of water temperature and the quantity of the oxygen dissolved in it as limiting ecological factors affecting the processes in the aquatic environment. -

MATERIALS AND METHODS

The investigation was carried out in Dospat Reservoir, with geographic co-ordinates at 41° 41' 54^{II} Northern latitude and at 24° 05' 10^{II} Eastern longitude, for the period May 2009 – April 2010. The water samples were collected from 6 stations located along the wall (1 station), around the net cages (3 stations) and on the tail (2 stations) of the Reservoir. The water temperature and the oxygen content (mg.l⁻¹) were determined *in-situ* per each meter from the surface layer (0.5 m) to the bottom layer, which depending on the dam lake bottom and the level of waters in the dam lake reaches up to 30-40 m. The measurements were done by a submerged oximeter WTW Oxi 1970i.

The data were statistically analyzed using the Microsoft Office 2007.

RESULTS AND DISCUSSION

The average surface layer temperature (Table 1) values vary from 9.6 °C (April) to 22.74°C (July). In the summer months these values are within the limits of 17.26 °C – 22.74°C (0.5 m dept) – 5.26 °C -5.47°C (30 m dept). Lower temperature values were reported during the spring (April - May) and autumn (November). The differences between the average seasonal temperature values in the separate stations are insignificant.

The vertical temperature differentiation depending on the depth (0.5-40 m), season (spring, summer, autumn) and stations position for taking samplings are shown in Table 2. There was a larger variation of the temperature in the surface layer (up to 0.5 m) with

recorded values between 9.2°C – April 2010, 16.5 °C - 17.4 °C – September and 10.0 °C - 10.3 °C November 2009, and from the 5th to the 10th meter, the values vary between 8.8 °C to 9.6 °C – May, 16.2 °C -16.5 °C – September and 9.9 °C -10.0 °C – November. The lowest temperatures were measured just above the bottom.

The highest absolute value, of 23°C, for this index, was reported on 23/24.07.2009 at Station 2 with variations of 22.1 °C to 22.9°C in the remaining stations of the epilimnion layer. These values are close to the values reported for the same month (22°C) by Naumova & Zivkov (1988).

The temperature stratification for the separate stations varies from 4.5 °C to 10.3°C (May) to 0.9 °C -1.9°C (0.5 - 5 m) – 11.1 °C - 12°C (0.5-30 m) (July - September). The zone of the temperature cline (thermocline) of the stratification lake is particularly clear during the months of July-September – (8 - 15 m).

Table 1. Average values of temperature (T⁰C) and oxygen content (mg.l⁻¹) in Dospat reservoir in period 2009-2010

Depth 0.5 m	2009	Average values of temperature				Average of year
Months	May	July	September	November	April	
X	13.94	22.74	17.26	10.18	9.26	14.67
Sx	0.2387	0.1833	0.321	0.1194	0.0758	2.759
Cv	3.23	1.60	3.72	2.35	1.63	37.59
n	5	5	5	5	5	25
Depth 30 m						
X	4.52	5.26	5.47	6.15	4.70	5.22
Sx	0.055	0.0837	0.0553	0.1374	0.0354	0.3249
Cv	2.42	3.18	1.74	3.87	1.5	12.45
n	5	5	4	4	5	23
Depth 0.5 m	2009	Average values of oxygen content				Average of year
Months	May	July	September	November	April	
X	10.26	4.22	7.47	8.42	11.48	8.37
Sx	0.1016	0.2076	0.3757	0.1752	0.0503	1.3982
Cv	1.98	9.84	10.06	4.16	0.87	33.41
n	5	5	5	5	5	25
Depth 30 m						
X	8.05	1.60	1.12	1.24	9.08	4.22
Sx	0.3786	0.1772	0.2763	1.1137	0.1741	1.9944
Cv	9.40	22.15	42.53	155.25	3.83	94.57
n	5	5	4	4	5	23

In November the autumn homothermy was reported for stations 1-3, at water temperature of 8.9 °C - 10.2°C and depth up to 20 m. For the bottom layer (20-30 m) colder waters were reported of 6.1 °C - 6.2°C and 5.7 °C on the depth 40 m.

In the region of the net cages the surface layer temperature varies within the limits of 9.1 °C - 9.2 °C (April), 13.4 °C - 14.7°C (May), 22.8 °C - 23.0 °C (July), 16.7 °C - 17.7°C (September) and 9.90 °C - 10.3°C (November). At the 5th meter the values vary within the limits of 8.7 °C - 9.1°C (April), 8.8 °C – 10.0°C (May), 21.0 °C -21.6 °C (July), 16.4

°C -16.5°C (September) and 9.9°C -10.0°C (November). In general, the dam lake offers favorable conditions for trout rearing.

Table 2. Values of water temperature in Dospat reservoir (T°C)

Date	depth	sampling points (station)					
	m	1	2	3	4	5	6
14/15.05.09	0.5	14,0	13,8	13,4	14,7	13,8	
23/24.07.09		22,1	23	22,8	22,9	22,9	
24/25.09.09		16,5	16,7	17,7	17,4	18,0	
11/12.11.09		10,2	10,0	9,9	10,3	10,5	
26/28.04.10		9,5	9,2	9,2	9,1	9,3	9,3
14/15.05.09	5	9,5	8,8	10	9,6	9,4	
23/24.07.09		21,2	21,1	21	21,6	21,1	
24/25.09.09		16,2	16,5	16,4	16,4	16,4	
11/12.11.09		10,0	9,9	9,9	10,0	10,1	
26/28.04.10		9,1	9,1	8,7	8,7	9,1	7,3
14/15.05.09	10	6,2	6,4	6,5	8,6	6,2	
23/24.07.09		12,7	13,1	13,6	13,8	12,8	
24/25.09.09		16,2	16,3	16,0	16,2	15,7	
11/12.11.09		10,0	9,9	9,8	9,8	10,1	
26/28.04.10		8,7	8,5	8,4	6,6	7,6	6,8
14/15.05.09	20	5,2	4,8	5,3	5	4,7	
23/24.07.09		6,6	6,2	6,2	6,2	6,6	
24/25.09.09		6,4	6,1	6,1	6,3	6,4	
11/12.11.09		9,5	8,9	9,4	7,4	6,7	
26/28.04.10		5,9	5,1	5,0	5,2	4,7	4,7
14/15.05.09	30	4,5	4,5	4,7	4,5	4,4	
23/24.07.09		5,4	5,2	5,4	5	5,3	
24/25.09.09			5,5	5,4	5,4		
11/12.11.09			6,1	6,2	6,1		
26/28.04.10		4,8	4,7	4,8	4,7		4,6
14/15.05.09	40	4,5	4,3		4,3	4,4	
23/24.07.09		4,9	4,9		4,9	4,9	5,1
24/25.09.09		5,2	5,2		5,2		
11/12.11.09			5,7		5,7		
26/28.04.10			4,5		4,5	4,6	

The vertical distribution of the oxygen content depending on the depth, season and position of stations in which samples were taken (parallel with temperature records) are shown in Table 3.

Table 3. Values of oxygen content in Dospat resevoir (mg.l⁻¹)

Date	depth	sampling points (station)					
	m	1	2	3	4	5	6
14/15.05.09	0.5	10,16	10,25	10,07	10,2	10,6	
23/24.07.09		4,44	4,50	4,43	4,24	3,5	
24/25.09.09		7,42	6,34	8,41	7,77	7,40	
11/12.11.09		8,34	8,31	7,94	8,64	8,86	
26/28.04.10		11,58	11,45	11,53	11,55	11,33	11,11
14/15.05.09	5	11,06	10,1	12,13	10,76	11,53	
23/24.07.09		4,08	3,95	3,90	3,95	2,67	
24/25.09.09		5,23	7,86	8,70	7,86	6,38	
11/12.11.09		8,20	7,95	7,53	8,28	8,43	
26/28.04.10		11,34	11,3	11,41	11,24	11,22	10,86
14/15.05.09	10	9,80	9,26	9,95	10,76	9,76	
23/24.07.09		4,33	4,25	3,86	4,06	2,46	
24/25.09.09		4,53	6,98	3,24	7,24	3,91	
11/12.11.09		8,12	7,75	7,12	7,75	8,30	
26/28.04.10		10,99	11,15	11,29	10,6	10,95	10,53
14/15.05.09	20	8,82	9,09	11,46	9,29	8,67	
23/24.07.09		3,43	2,50	2,46	2,59	1,57	
24/25.09.09		3,40	3,40	2,02	4,07	3,62	
11/12.11.09		6,68	4,37	5,75	1,03	0,76	
26/28.04.10		10,56	9,99	10,03	9,80	8,76	8,59
14/15.05.09	30	7,88	7,06	7,88	8,82	7,69	
23/24.07.09		1,98	1,62	1,98	1,59	1,03	
24/25.09.09		1,38	1,49	1,38	0,43		
11/12.11.09		4,08	0,06	4,08	0		
26/28.04.10		9,30	9,20	9,30	9,37	8,50	
14/15.05.09	40	8,02	7,03		3,42	6,83	
23/24.07.09		0,99	0,21		1,10	1,00	1,02
24/25.09.09		0,30	0,24		0,06		
11/12.11.09			0,04		0,02		
26/28.04.10				6,45		6,10	8,36

The oxygen content within the region of net cages, as well as outside them, is comparatively high during the spring (IV-V) and autumn (XI) samples, in all sampling points at depth of 0.5 m to 10 m ($7.12 \text{ mg.l}^{-1} - 12.13 \text{ mg.l}^{-1}$) and it is within the optimal limits for trout rearing. In the epilimnion layer, in July, the oxygen content in the region of net cages (stations 2, 3, 4) was in range of ($3.90 \text{ mg.l}^{-1} - 4.5 \text{ mg.l}^{-1}$). These values are lower in comparison to those reported for September ($4.53 \text{ mg.l}^{-1} - 7.86 \text{ mg.l}^{-1}$), as well as compared to the spring and autumn levels. At a greater depth, in the region of thermocline and hypolimnion, oxygen deficiencies were registered and the oxygen level decreases sharply up to values below 1 mg.l^{-1} . A similar tendency is also reported by other authors (Borovec et al., 1998). In such situations the processes of biological oxidation of organic substances in the water are disturbed and conditions for accumulation of organic matter in the bottom layer of water and on the bottom are created.

The horizontal differentiation (**Table 1**) indicates that the average surface layer values of the oxygen content in the water vary from 4.22 mg.l^{-1} to 11.48 mg.l^{-1} . In the summer months sampling points the values were within the limits of $4.22 \text{ mg.l}^{-1} - 7.47 \text{ mg.l}^{-1}$ (0.5 m depth) and respectively of $1.12 \text{ mg.l}^{-1} - 1.60 \text{ mg.l}^{-1}$ (30 m depth). The level of oxygen during the spring and autumn varies from $8.42 \text{ mg.l}^{-1} - 11.48 \text{ mg.l}^{-1}$ (0.5 m depth) to $1.24 \text{ mg.l}^{-1} - 9.08 \text{ mg.l}^{-1}$ (30 m depth). In the spring samples the average values are significantly higher ($P < 0.001$) than those registered for summer and autumn up to depth of 30 m.

Taking into account the fact that the optimal values of temperature and oxygen content for trout fish rearing (Zaikov, 2009) are respectively in the range of $12-16^\circ\text{C}$, and above 8.0 mg.l^{-1} , and according to Directive 2006/44/EC above 9.0 mg.l^{-1} and 50% of saturation (Petrescu-Mag, 2008), then the results obtained from the research give the possibility to determine the periods and the depth zones with optimal temperature and oxygen content within the area of the net cages (stations 2, 3, 4) in 2010.

In regard to temperature these are the months of May and September, at water layer depth of 0.5-5.0 m, and respectively in July-September, at water layer depth of 10 m. The oxygen levels were optimal in the spring and autumn for all sampling points at water layer depth up to 10 m.

The water temperature at 20th meter during the seasons investigated and for all stations was below the optimum for trout fish rearing. At this depth, only during the spring (April and May) the oxygen content was within the optimal levels. Having in mind that the net cages are located at a depth of up to 20 m, then the results from the present investigation can be used for technological process optimization of the net cage aquaculture in Dospat dam lake.

CONCLUSIONS

The dependencies between water temperature, oxygen content of the water and depth in seasonal aspect were determined.

For the summer period (July to September) there are clearly defined thermocline and areas of temperature stratification for the separate sampling points. The heterograde profile of the oxygen content describes its specific alteration in the epilimnion.

The investigation gives the possibility to determine the periods and the depth zones with optimal values of the temperature and oxygen content of the water for trout rearing, which can be used for optimization of the technological process of the net cage aquaculture in Dospat dam lake.

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