Environment Protection Engineering

Vol. 28 2002 No. 1

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TEMPERATURE AND OXYGEN PROFILES IN THE SOLINA RESERVOIR

This paper describes shaping of the temperature and oxygen profiles in the Solina reservoir in the 2000 year. Based on six characteristic stations located in the reservoir the results obtained in the period being analysed and in the previous year were compared. Serious oxygen deficiencies were observed in almost every measuring point during the period of research. This can be a sign of proceeding eutrophication in the Solina reservoir, but the load of nutrients is still acceptable and does not lead to an accelerated eutrophication.

1. INTRODUCTION

The specificity of a reservoir, i.e. the complex of factors that distinguish this type of ecosystem from the others, makes it difficult to manage it and to test the changes and processes which take place there [13], [14].

The process of eutrophication, whose nature at the present time is mainly of an anthropogenic character [1], [7], is an important economic problem, especially in planning the exploitation of water resources. Estimation of environmental changes observed in a reservoir due to this process is extremely difficult and requires repeated tests based on hydrotermic, hydrochemical and biological factors [8], [15]. The temperature and oxygen profile are considered to be among the most important factors, which enable estimation of a reservoir trophic level.

This paper describes shaping of the temperature and oxygen profiles in the Solina reservoir in the year 2000 and presents a comparison of the results obtained in the period being analyzed with the results collected in previous years [2]–[5], [9].

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2. THE SITE BEING STUDIED

The Solina reservoir (figure 1) is situated in the San River in the Bieszczady Mountains, south-eastern Poland. It is the biggest man-made lake in Poland.

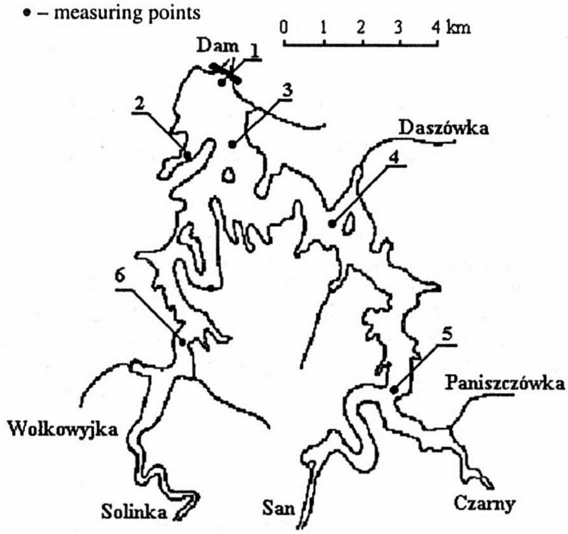

Fig. 1. Measuring points

The drainage basin of the reservoir is of a highland nature. It is dominated by forests, meadows and pastures. The share of arable land does not exceed a few per cent of the area. Apart from that, this region is sparsely populated. There are no industrial plants. The agricultural utilization of the area is poor, few small towns earn their living mainly from tourism [11].

The Solina reservoir is a typical highland reservoir. Generally its water is exchanged twice a year. According to STARMACH [12], the Solina reservoir is a limnic one.

Satisfactory morphometrical parameters (i.e. a great average depth of 22.4 meters, a high ratio of the reservoir volume to shore-line length approaching 157 kilometers) and a large surface of drainage basin make the reservoir relatively resistant to degradation [11].

As a result of the Solina reservoir's narrow and meandric shape, many tributaries and constant operation of the Solina hydro-electric power station, the reservoir's hydraulics of flow is complicated and exerts a considerable influence on the temperature and oxygen profiles [9].

3. METHODS

Water temperature and dissolved oxygen content were measured between July and November, 2000, in six stations located in the reservoir (figure 1). The measurements were carried out using WTW-CELLOX 325 oxygen probe with a temperature sensor. In September, bad weather made it impossible to conduct measurements in the first measuring position (near the dam).

4. RESULTS AND DISCUSSION

The results of the tests proved that from July to September only in the first, third and fourth measuring points a distinct thermal and oxygen stratification, characteristic of stagnant water, was observed (the depth of water in these three places was the greatest).

The first measuring point was located 200 meters from the dam. The temperature curves (figure 2) and the analysis of the water temperature in this point showed that in July the temperature of the surface water was much higher than that of the bottom water. In a clearly shaped epilimnion, reaching the depth of 7 meters, the temperature ranged between 18.4 °C and 18.9 °C. The thermocline reached a depth of 20 meters. In August, the temperature of the surface water was much higher than in July and at a depth of 0.2 meters below the water surface it amounted to 24.7 °C, while at a depth of 1–5 meters it ranged from 22.2 °C to 23.2 °C. A distinctly shaped thermocline was observed at a depth from 5 to 17 meters.

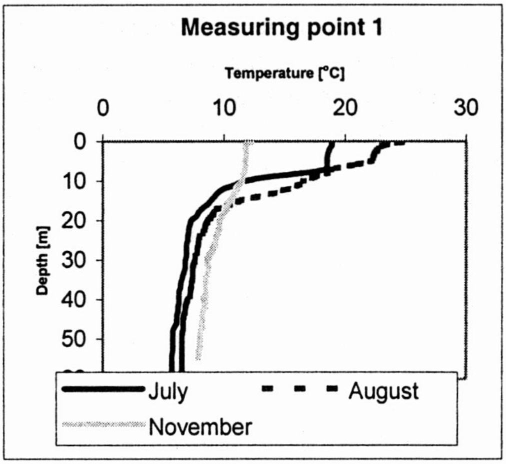

Fig. 2. Temperature profiles near dam in the Solina reservoir

In November, the temperature of the surface water was 12.3 °C, and the temperature of the bottom water was 7.9 °C. A disappearance of the thermocline was observed. The highest temperature of the surface water layer, i.e. 24.7 °C, was measured in August, and the lowest, 18.9 °C, in July. In the bottom water layer, the lowest temperature, i.e. 5.7 °C, was also measured in July, and the highest temperature, 8 °C, in August.

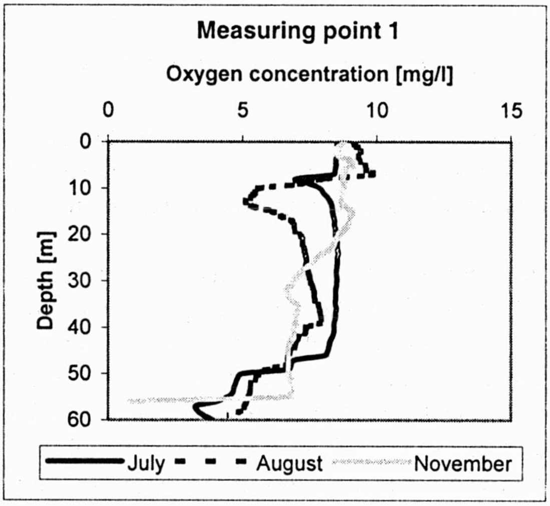

Fig. 3. Oxygen profiles near dam in the Solina reservoir

The oxygen concentration in the surface water layers (figure 3) was sufficient and amounted to 8.53 mg O_2/dm^3 in July, 9.1 mg O_2/dm^3 in August and 8.6 mg O_2/dm^3 in November. In July and August, oxygen stratification was observed. An oxycline occurred in July at a depth of 7–10 meters. The minimum oxygen concentration of 6.96 mg O_2/dm^3 was measured at a depth of 6 meters. Oxygenation of the bottom water decreased to approx. 30% and reached a value of 3.88 mg O_2/dm^3. In August, the oxycline was deepened to a depth of 16 meters. A considerable drop in oxygenation was observed in comparison with the oxygenation in July. In August, water oxygenation reached its minimum value of 5.09 mg O_2/dm^3 at a depth of 13 meters. The oxygen concentration in the bottom water layers was higher than that in July.

In November, no oxygen stratification was observed. In the bottom water layers, the concentration of oxygen decreased to 0.8 mg O_2/dm^3.

The third measuring point was located in the central part of the reservoir. Temperature and oxygen profiles in this position were virtually the same as these in the first measuring point. At the beginning of the research, in July, a distinct thermal stratification was observed (figure 4). The temperature of the surface water layers amounted to 19.1 °C. The epilimnion layer reached a depth of 7 meters. The metalimnion layer was in July at a depth of 7 to 16 meters and the maximum thermocline gradient amounted to 1 °C at a depth of 10 to 11 meters. In August, the temperature of the surface water reached 23.3 °C. The range of the metalimnion layer increased (from 5 to 15 meters in depth) and the temperature was between 19.8 °C and 10.5 °C. The maximum gradient of 2.1 °C was measured at a depth of 13 and 14 meters. A thermocline disappeared in November.

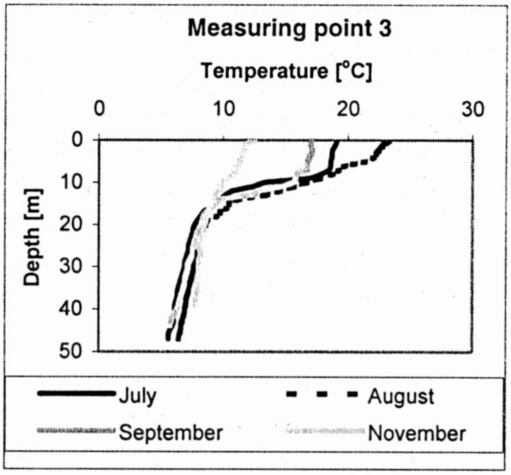

Fig. 4. Temperature profiles in the central part of the Solina reservoir

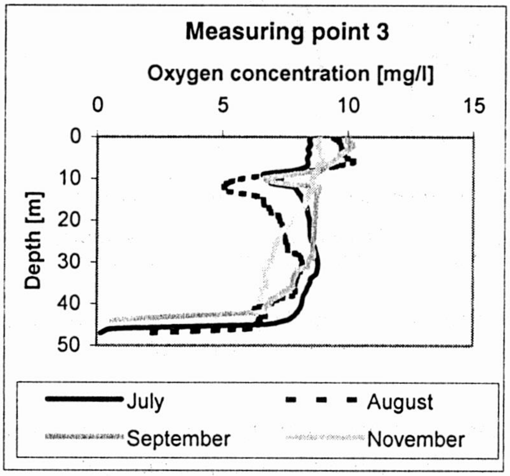

Fig. 5. Oxygen profiles in the central part of the Solina reservoir

In summer, the temperature of the bottom water was similar, i.e. between 5.6 °C and 6.4 °C. In November, the temperature increased by 1.4 °C and amounted to 7.8 °C.

In July, oxygen stratification in a water column was observed (figure 5). In the epilimnion layer (to a depth of 7 meters), the concentration of oxygen approached 8.42 mg O_2/dm^3, which means an almost 90% saturation. The maximum vertical gradient of dissolved oxygen was observed at a depth of 7 to 11 meters, and at a depth of 9 meters it reached its minimum – 6.61 mg O_2/dm^3. In August, the oxycline reached a depth ranging from 6 to 14 meters. The lowest concentration of oxygen – 5.05 mg O_2/dm^3, was measured at a depth of 12 meters. Oxygen stratification was also observed in September. In the metalimnion layer, the concentration of oxygen was similar to that in July. Oxygen stratification disappeared in November. The oxygenation in the surface water amounted to 8.9 mg O_2/dm^3 which means 83% saturation, and at the bottom the saturation of water with oxygen reached 55%.

In the hypolimnion, a strong oxygen deficiency was observed. In July and in September, the concentrations of oxygen were 0.17 mg O_2/dm^3 (1.35% saturation) and 0.64 mg O_2/dm^3 (5.1% saturation), respectively.

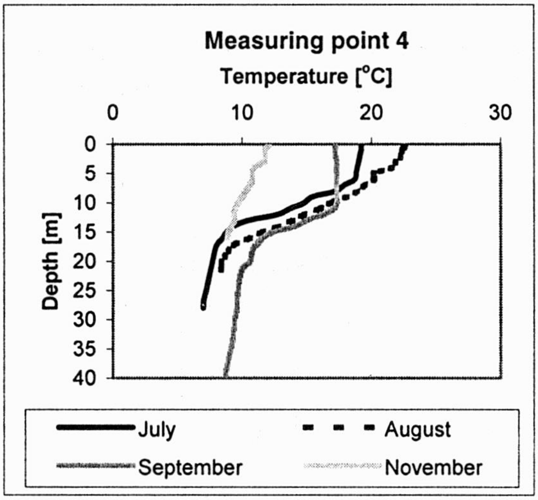

Fig. 6. Temperature profiles near the place where the River Daszówka flows into the Solina reservoir

The fourth measuring point was near the place where the River Daszówka flows into the Solina reservoir. Thermal and oxygen stratifications were observed in July (figures 6 and 7). The temperature in the epilimnion layer, which reached a depth of 6 meters, ranged from 18.7 °C to 19.2 °C. The saturation of water with oxygen in this layer was sufficient (approximately 8.3 mg O_2/dm^3, i.e. 89% saturation). A thermocline was observed at a depth of 6 to 15 meters. In this range of the depth, the temperature fell from 18.7 °C to 8.8 °C. In the hypolimnion layer, it dropped gradually with a gradient of 0.1 °C. The difference between the temperature of the surface water and the temperature of the bottom water was relatively big and amounted to 12.2 °C. Oxycline was observed in the metalimnion layer and a minimal amount of oxygen (5.08 mg O_2/dm^3) was measured at a depth of 11 meters. In the bottom water, the concentration of oxygen reached 0.09 mg O_2/dm^3 (less than 1% saturation).

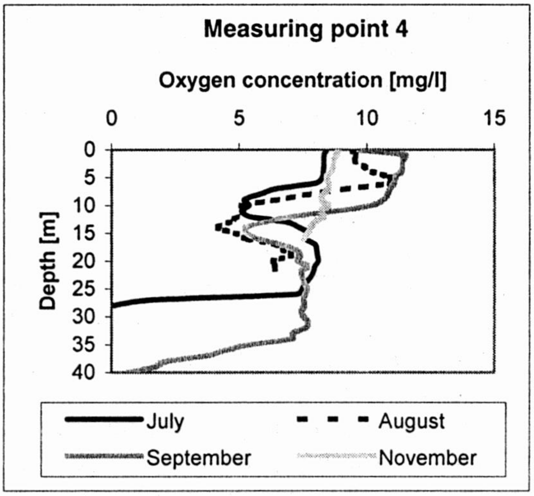

Fig. 7. Oxygen profiles near the place where the River Daszówka flows into the Solina reservoir

In August, a temperature of the surface water rose to 22.7 °C. The temperature of the bottom water in August was higher than in July (it rose by 1.03 °C). The metalimnion layer had deepened and reached the depth of 5–19 meters. The temperature difference in this layer was enormous and ranged from 8.7 °C to 20.2 °C. The concentration of oxygen in the surface water in August was higher than that in the previous month and amounted to 9.4 mg O_2/dm^3 (over 100% saturation) and a deep oxycline at a depth of 7 meters extended to lower layers. The lowest concentration of oxygen, i.e. 4.16 mg O_2/dm^3, was measured at a depth of 14 meters. The hypolimnion was very shallow and was sufficiently saturated with oxygen.

In September, both thermal and oxygen stratifications were kept. The epilimnion layer had deepened and reached the depth of 10 meters. The temperature of this layer was quite equalized and ranged from 17.1 °C to 17.3 °C. At a depth of 10–20 meters a thermocline appeared and the temperature of the water fell to 10.1 °C. A further slow and gradual drop in the temperature was observed in the hypolimnion layer (to a value of 8.7 °C).

In September, the concentration of oxygen in the epilimnion layer was as high as in July and August. A sharp decrease in the concentrations of oxygen, by 2.11 mg O_2/dm^3, was observed at a depth of 10–11 meters. Simultaneously, an oxycline reaching a depth of 17 meters appeared. The lowest concentration of oxygen, 5.25 mg O_2/dm^3, was measured at a depth of 14 meters. As in July, the oxygen deficiency (equal to 0.65 mg O_2/dm^3) was observed in the bottom water. Combined with a temperature of 8.7 °C it gave 5.6% oxygenation of water.

Neither thermal nor oxygen stratification was observed in November. The concentration of oxygen in the surface water reached 8.9 mg O_2/dm^3 (about 81% saturation) and in the bottom water it was 6.5 mg O_2/dm^3 (about 55% saturation).

In all measuring points, the bottom water layers suffered from a serious oxygen deficiency. Similar phenomenon was observed in previous years [2]–[5].

Measuring points 5 and 6 reflected the condition of water near the estuaries of rivers flowing into the reservoir (the San, the Czarny, the Solinka and the Wołkowyjka). Measuring position 2 was located near the place where the wastes from the sewage-treatment plant in Polańczyk were discharged into the reservoir. During our research nor distinct thermal neither distinct oxygen stratification was observed. In the previous years, this phenomenon was not recorded [2]–[5]. A relatively small depth at the measuring points as well as the water motion caused by tributaries (position 5 and 6) or wastes (position 2) were undoubtedly responsible for such a state. The concentration of oxygen in these positions was unequal during the time of the research.

A substantial decrease in the oxygen concentration was observed in the bottom water (as in previous years). This was probably caused by the decomposition of detritus, which sedimented in the bottom water, as the inflow of organic substances from other (outside) sources was strictly limited. In November, a total intermixing of water was observed. The changes in a water temperature as well as in the concentration of oxygen were slight at all depths.

5. CONCLUSIONS

In almost each measuring point, serious oxygen deficiencies were observed. This could be a sign of proceeding eutrophication of the water in the Solina reservoir. One of the factors accelerating this process could be drying of the reservoir litoral zone, which occurs quite frequently.

Based on the comparison of our results with the results concerning the eutrophication of the water in the Solina reservoir from previous years [6], [10], [16], one can arrive at conclusion that the load of nutrients is still acceptable and does not lead to an accelerated eutrophication.

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UKŁADY TERMICZNO-TLENOWE W ZBIORNIKU SOLIŃSKIM W 2000 R.

Omówiono kształtowanie się stosunków termiczno-tlenowych w zbiorniku Solińskim w 2000 r. Na podstawie badań przeprowadzonych w 6 charakterystycznych punktach zbiornika dokonano oceny stratyfikacji i porównania ze stanem w latach ubiegłych. Stwierdzono znaczne niedotlenienie wód warstw przydennych, będące prawdopodobnie wynikiem wzrostu stężenia czynników biogennych w hypolimionie. Nie stwierdzono jednak przyspieszonej eutrofizacji.

Reviewed by Jerzy Chmielowski