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# WATER QUALITY EVALUATION IN SHKODRA LAKE

**Përmbledhje:** Cilësia e ujit në Liqenin e Shkodrës është vlerësuar duke u bazuar në parametrat si Oksigjeni i Tretur (DO), Kërkesa Biokimike për Oksigjen (BOD), pH dhe temperature, duke realizuar monitorimin gjatë dy viteve te ndryshëm (2007 dhe 2009). Mostrat janë mbledhur në katër stacione. Vlerat e paraqitura të DO të ujërave të liqenit renditen nga 6.8 mg/l në 10 mg/l gjatë vitit 2007 dhe 6.6 mg/l deri në 11.3 mg/l për vitin 2009. Vlerat e DO të stacionit të zgjedhur në bregun pranë zonave urbane duke treguar nivel më të ulët demostruan efektin e ndotjes së zones urbane, veçanërisht gjatë periudhave të verës. Vlerat e BOD në Liqenin e Shkodrës, si masë e sasisë së oksigjenit të përdorur në oksidimin aerobik të lëndës organike, janë brenda niveleve të përshtatshme dhe normale

**Fjalë kyçe:** *uji, Oksigjeni i Tretur, Kërkesa Biologjike për Oksigjen, Liqeni i Shkodrës*

**Abstract:** The quality of water in Shkodra Lake is evaluated based on parameters as Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH and temperature, monitoring during two different years (2007 and 2009). Samples are collected in four stations. Represented DO values of the lake waters ranged from 6.8 mg/l to 10 mg/l during 2007 and 6.6 mg/l to 11.3 mg/l for 2009. The DO values of selected station on the shore near urban areas shown lower level demonstrated the effect of urban area pollution, especially during summer periods. The BOD values in Shkodra Lake, as measure of the quantity of oxygen used by microorganisms in aerobic oxidation of organic matter, are inside the adequate and normal levels.

**Key words:** *Water, Dissolved Oxygen, Biochemical Oxygen Demand, Shkodra Lake*

## INTRODUCTION

The main factor contributing to changes in dissolved oxygen levels is the build-up of organic wastes. A significant ingredient in urban and agricultural runoff is fertilizers that stimulate the growth of algae and other aquatic plants. As plants die, aerobic bacteria consume oxygen in the process of decomposition. Depletions in DO

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can cause major shifts in the kinds of aquatic organisms found in water bodies (Table 1). Nuisance algae and anaerobic organisms may also become abundant in waters with low levels of dissolved oxygen. DO levels provide information about the biological, biochemical, and inorganic chemical reactions occurring in aquatic environment. Most aquatic organisms are highly dependent upon dissolved oxygen and will experience stress, or perhaps even be eliminated from a system, when dissolved oxygen levels fall below about 3.0 ppm.

Table. 1. Guideline for Interpretation of Dissolved Oxygen Readings

| | |
|---|---|
| 0–2 mg/l | Not enough oxygen to support life |
| 2–4 mg/l | Only a few kinds of fish and insects can survive |
| 4–7 mg/l | Acceptable for warm water fish |
| 7–11 mg/l | Very good for most stream fish including cold water fish |

Dissolved oxygen (DO) levels indicate how well aerated the water is. The ability of water to hold oxygen is dependent on temperature, time of day, season, turbidity, and salinity. DO is a commonly measured parameter because it is an immediate indicator – inadequate oxygen levels will quickly affect aquatic life. DO is essential for the maintenance of healthy lakes and rivers. The presence of oxygen in water is a good sign, while the lack of oxygen is a signal of severe pollution. Waters of consistently high DO are usually considered healthy and stable ecosystems capable of supporting many different kinds of aquatic organisms (Jarvie, 2003).

The two main sources of oxygen in the water are the atmosphere (aided by wind and turbulence created by flow over channel substrate) and through aquatic plant photosynthesis. Oxygen is essential for aquatic life and also for decomposition of organic matter, that consumes oxygen. DO levels vary greatly during a daily (diurnal) cycle. DO levels rise from morning through the afternoon as a result of photosynthesis, reaching a peak in late afternoon. Photosynthesis stops at night, but plants and animals continue to respire and consume oxygen. As a result, DO levels fall to a low point just before dawn. DO levels may dip below 4 mg/liter in such waters – the minimum amount needed to sustain warm-water fish (Mellergaard & Nielson, 1987).

## MATERIAL AND METHODS

A standard chemical method to determine the amount of oxygen dissolved in a water sample is a type of titration, the Azide Modification of the Winkler Method. Precisely measured amounts of chemicals are added to a water sample until a color change is achieved. A color change marks the endpoint of the test. Units for measuring dissolved oxygen are parts per million (ppm) or milligrams per liter (mg $l^{-1}$) (Annonymus, 2005).

The BOD measure is the amount of oxygen consumed by organic matter and associated microorganisms in the water over a five-day period (Annonymus, 2005; Stavroulakis *et al*. 2007). BOD is determined by measuring the dissolved oxygen lev-

el in a freshly collected sample and comparing it to the dissolved oxygen level in a sample that was collected at the same time but incubated under specific conditions (20 °C in the dark to prevent photosynthesis) for five days. The difference in the oxygen readings between the two samples, the final DO and initial DO is the BOD. BOD is recorded in units of mg $l^{-1}$.

Because physical and chemical indicator levels vary so much according to time, weather and temperature, these tests have been run during the same period (time of day), when monthly comparisons are made. In very large, deep waters there may be little mixing of the water and this could cause differences in the measurements from the surface to the water's bottom. The samples were taken in the shore, away from the shore and below the water surface.

## RESULTS AND DISCUSSION

The monitoring is carried out three times during 2007 (August – October). The monitored stations were four: St. 1- N 42° 04' 73.2", E 019 ° 26' 62.8"; St. 2- N 42 ° 05' 09.9", E 19° 27' 30.3"; St. 3- N 42 ° 04' 10.3", E 019 ° 26' 59.2"; St. 4- N 42 ° 03' 98.0", E 019 ° 27' 58.0".

The monitoring is carried out times during 2009 (April – October). St. 1- N–42 ° 03' 31.6"; E–019 ° 28' 40.4" St. 2- N–42 ° 03' 53.8"; E–019 ° 27' 49.8" St. 3- N–42 ° 04' 07.8"; E–019 ° 25' 48.2", St. 4- N–42 ° 04' 32.7"; E–019 ° 23' 87.8".

The temperature of the lake is constant and normal according to the months of monitoring in the four stations (Table 2, 4). Based to the previous studies, the stratification and water circulation are important for the chemistry and biology of this lake. Quantities of in-/outflow, water temperature, wind and lake morphology/bathymetry are determining factors. Water circulation and mixing in Shkodra Lake is high, as in-/ outflow is high. Water residence time is about 120 days: the lake is shallow, and groundwater wells up from the deeper parts and mixes with the water originating from surface inflow. Stratification does not occur. This means that the habitats of many water species present in the lake cover wide areas. Due to its low elevation, southern position and shallow water, the water temperature of the Shkodra Lake is high. The temperature on October is diminished about 4–5$^0$ C and this phenomenon should to affect on the dissolved oxygen (DO) content. Temperature and dissolved oxygen are related in that cooler water holds more oxygen than warmer water.

Table 2, 3. Water temperature and pH of Shkodra Lake during the monitoring period 2007.

| Months | Temperature (0 C) | | | |
|---|---|---|---|---|
| 2007 | St. 1 | St. 2 | St. 3 | St. 4 |
| August | 20.5 | 20.5 | 20 | 21 |
| Septemb. | 20 | 21 | 20.5 | 20 |
| October | 15.5 | 16 | 16 | 16 |

| Months | pH | | | |
|---|---|---|---|---|
| 2007 | St. 1 | St. 2 | St. 3 | St. 4 |
| August | 7 | 7 | 7 | 7 |
| Sept. | 7 | 6.5 | 7 | 7 |
| October | 6.5 | 6.5 | 6.5 | 6.5 |

Water pH of the Shkodra Lake monitored during the time August – September is neutral, but on October is observed a low decrease (6.5), a moderate acidic pH (Table 3, 5). However, this change can be a natural one in pH occurred with variations in levels of carbon dioxide. Carbon dioxide is very soluble in water. It enters the water from the atmosphere and is also generated from animal and plant respiration and decomposition. Dissolved carbon dioxide can combine with water to yield carbonic acid. Plants reduce amounts of carbon dioxide through photosynthesis making surface waters more basic. The moderate acidic pH of the water of Shkodra Lake can relate with the decrease of the photosynthesis of water plants and phytoplankton due to the decrease of the water temperature.

Water quality standards generally call for a pH from 6.0 to 9.0. A pH between 6.7 and 8.6 will support a well-balanced fish population. The water pH of the Shkodra Lake during the monitoring period considers optimal for the life of the lake organisms.

Table 4, 5. Water temperature and pH of Shkodra Lake during the monitoring period 2009.

| Months | Temperature ($^0$C) | | | |
|---|---|---|---|---|
| 2009 | St. 1 | St. 2 | St. 3 | St. 4 |
| April | 17 | 17 | 17 | 17 |
| May | 24.5 | 24.5 | 26 | 25 |
| June | 28 | 29 | 28 | 29 |
| July | 28 | 29 | 29 | 30 |
| August | 26 | 27 | 28 | 27 |
| Sept. | 24 | 23 | 24 | 22 |
| October | 20 | 20.5 | 21 | 20 |

| Months | pH | | | |
|---|---|---|---|---|
| 2009 | St. 1 | St. 2 | St. 3 | St. 4 |
| April | 7 | 7 | 7 | 7 |
| May | 6.5 | 6.5 | 6.5 | 6.5 |
| June | 7.5 | 7.5 | 8 | 8 |
| July | 7 | 8 | 7.5 | 7 |
| August | 7 | 7 | 7 | 7.5 |
| Sept. | 7.5 | 7.5 | 7.5 | 7.5 |
| October | 7 | 7 | 7 | 7 |

The dissolved oxygen content in the Lake Shkodra water has remained mostly above 7 mg $l^{-1}$ {average lake water quality for the period 1995–2005, according to the previous studies (Babani *et al*., 2007)}. This implies that the water is abundant with oxygen, which is important for the biota in the lake.

From our data during the monitoring period (August – October), the dissolved oxygen (DO) content on the water of the Shkodra Lake is calculated inside the interval from 6.75 mg $l^{-1}$ to 9.93 mg $l^{-1}$, the mean 8.5 mg $l^{-1}$ (Table 6, 7; Fig. 1). The lower value is found in the Station 1, in the shore of the Lake, where is indicated a higher trophic level characterized as mesotrophic state. However, the values above 6 mg $l^{-1}$ indicate that the levels of the oxygen in the water are adequate for the maintenance of healthy lake. DO levels provide information about the biological, biochemical, and inorganic chemical reactions occurring in aquatic environment.

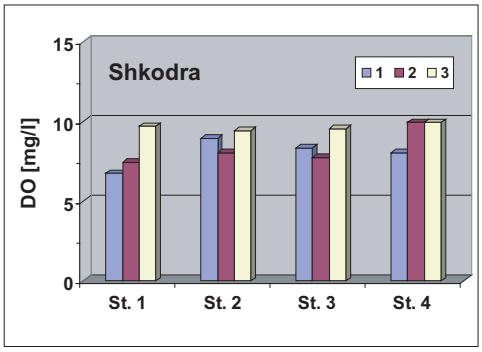
This presence of oxygen in water is a good sign, while the lack of oxygen is a signal of severe pollution. Waters of consistently high DO are usually considered healthy and stable ecosystems capable of supporting many different kinds of aquatic organisms. Most aquatic organisms experience stress, or perhaps even be eliminated from a system, when dissolved oxygen levels fall below 3.0 mg $l^{-1}$ approximately.

Table 6. Dissolved oxygen (DO) content on the water of the Shkodra Lake 2007.

| Months | Dissolved oxygen (DO) content (mg l–1) | | | | |
|---|---|---|---|---|---|
| 2007 | St. 1 | St. 2 | St. 3 | St. 4 | Mean |
| August | 6.75 | 8.94 | 8.34 | 8.04 | 8.65 |
| September | 7.45 | 8.05 | 7.75 | 9.93 | |
| October | 9.69 | 9.44 | 9.54 | 9.93 | |

Table 7. Dissolved oxygen (DO) content on the water of the Shkodra Lake 2009.

| 2009 | St. 1 | St. 2 | St. 3 | St. 4 | Mean |
|---|---|---|---|---|---|
| April | 9.74 | 9.41 | 11.13 | 10.93 | 8.76 |
| May | 10.46 | 9.61 | 9.91 | 10.56 | |
| June | 8.79 | 8.61 | 9.44 | 9.54 | |
| July | 7.04 | 7.43 | 8.67 | 8.56 | |
| August | 7.55 | 7.94 | 8.77 | 9.14 | |
| September | 8.64 | 8.44 | 7.15 | 6.16 | |
| October | 7.67 | 7.29 | 8.23 | 8.60 | |



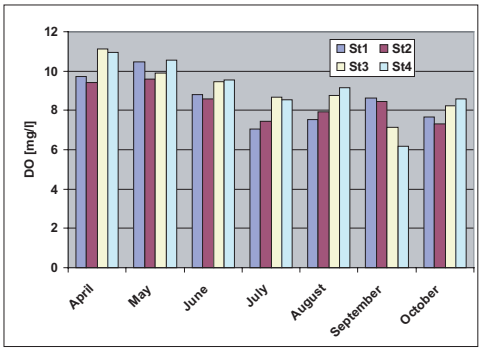




Figure 1, 2. Dissolved oxygen (DO) content on the water of the Shkodra Lake (1 – August, 2 – September, 3 – October) and (April to October)

The dissolved oxygen is lower in the summer period, while on the third monitoring period (October), when the temperature decreased, dissolved oxygen content is increased. Temperature and dissolved oxygen are related in that warmer water holds less oxygen than cooler water.

The values of the dissolved oxygen in the water samples incubated at 20°C, in the dark for five days ($DO_5$) were lower then DO represented values inside the interval from 5.76 mg $l^{-1}$ to 8.76 mg $l^{-1}$, the mean 7.62 mg $l^{-1}$ (Fig. 1, 2, 3). The values of the dissolved oxygen in the water samples the interval 7–11 mg $l^{-1}$ is very good for most stream fish including cold water fish. The values of dissolved oxygen $DO_5$ were higher on October, when the water temperature decreased. These differences (DO

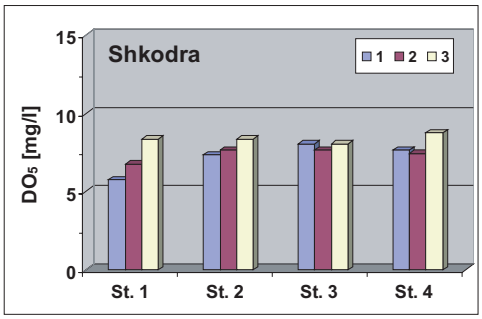



Figure 3. Dissolved oxygen DO5 content on the water of the Shkodra Lake

– $DO_5$) indicating the Biochemical Oxygen Demand (BOD), demonstrate the variation during the monitoring period on the amount of oxygen consumed by bacteria in the decomposition of organic material and the oxygen required for the oxidation of various chemical in the water. While a dissolved oxygen value tells how much oxygen is available, a BOD test tells how much oxygen is being consumed.

Table. 8. Biochemical oxygen demand (BOD) on the water of the Shkodra Lake.

| Months | Biochemical oxygen demand (BOD) (mg l–1) | | | |
|---|---|---|---|---|
| 2007 | St. 1 | St. 2 | St. 3 | St. 4 |
| August | 0.99 | 1.6 | 0.29 | 0.39 |
| September | 0.7 | 0.4 | 0.5 | 0.58 |
| October | 1.35 | 1.1 | 1.49 | 1.17 |

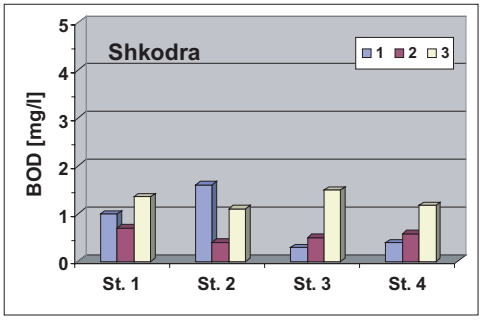



Figure 4. Biochemical oxygen demand (BOD) on the water of the Shkodra Lake

The BOD values were inside the interval from 0.39 mg $l^{-1}$ to 1.35 mg $l^{-1}$ (Table 8). The higher BOD values were measured during October on all monitored station; and on Stations 1 and 2 especially on August. The values of the Biochemical Oxygen Demand (BOD), as a measure of the quantity of oxygen used by the microorganisms in the aerobic oxidation of organic matter, are inside the adequate and normal interval representing a mean of 0.88 mg $l^{-1}$ (Table 8, Fig. 4).

The BOD is a common indicator of the degree of contamination of natural water by organic pollutants. The BOD values lower than 1 mg $l^{-1}$ characterizes the clean water whereas BOD values within the range 1–5 mg $l^{-1}$ demonstrate moderate water quality (Stavroulakis *et al.* 2007).

In general, the quality of the water of Shkodra Lake appears to be within the acceptable limits as specified in the classification and can be categorized as clean water to moderate one.

## CONCLUSIONS

1. Water pH of the Shkodra Lake monitored during the month of August – September is neutral, but on October is observed a low decrease (6.5), a moderate acidic pH.

2. Dissolved oxygen (DO) content on the water of the Shkodra Lake ecosystem is inside the interval from 6.75 mg $l^{-1}$ to 10.93 mg $l^{-1}$, being adequate to support healthy lake.

3. DO content represented the lowest values on the water of Shkodra Lake (mean 8.5 mg $l^{-1)}$

4. The values of the Biochemical Oxygen Demand (BOD) are inside the adequate and normal interval values 0.88 mg $l^{-1}$ on Shkodra Lakes,

5. The quality of the water of the Shkodra Lakes appears to be within the acceptable limits as specified in the classification and categorization.

6. The degree of contamination of natural water by organic pollutants as classify by BOD indicator is higher.

## REFERENCES

[1] Annonymus. 2005. Annis Water Resources Institute. Instructor' Manual Index, 1995–2005, 1–44.

[2] Babani, F., Kongjika, E., Ylli, A. & Stamo, I. 2007. *Trophic state and water quality of some Albanian Lagoons of Adriatic Coast,* In: *Environmental features and sustainable development of the Albanian and Apulian Wetlands,* Universita degli Studi di Bari, Atti, Edizione dal Sud, 19–25.

[3] Jarvie, H. P., Love, A. J., Williams, R. J. & Neal, C. 2003. *Measuring in-stream productivity: the potential of continuous chlorophyll and dissolved oxygen monitoring for assessing the ecological status of surface waters*. Water Science Technology, 48 (10): 191–198.

[4] Mellergaard, S. & Nielson, E. 1987. *The influence of oxygen deficiency on the population in the eastern North Sea and the southern Kattegat.* International Council for the Exploration of the Sea-Collected Papers 1987/E, 6: 1–7.

[5] Stavroulakis, G.,Kirikou, St., Barbouni, M. & Panagiotakis, G. 2007. *Seasonal water quality variation of the lake Kournas, Greece*. Proceedings of the International Conference on Environmental Management, engineering, Planning and Economics, 985–990.