

Water quality assessment in the Georgian Black Sea basin

Lali Tabatadze^{1*}, Giorgi Gigauri²

* Sokhumi State University, Faculty of Natural Sciences, Mathematics, Technologies and Pharmacy,
Tbilisi, Georgia

**P. Melikishvili Institute of Physical and Organic Chemistry, Ivane Javakhishvili Tbilisi State
University, Tbilisi, Georgia

***Georgian Technical University, Faculty of Agricultural Sciences and Chemical Technologies Tbilisi,
Georgia

Abstract

The Black Sea, with its unique hydrological regime and closed basin, requires special attention in terms of organic pollution, since an excess of organic substances leads to intensive oxygen consumption, which often becomes the cause of hypoxia and eutrophication. The paper discusses the assessment of the degree of pollution with organic compounds of the Black Sea water in Georgia, Port of Poti and adjacent industrial zones, using chemical and biochemical parameters in the context of ISO 6060 and ISO 5815 standards. Based on the results of the laboratory study, a high level of organic pollution COD (145 mg/l) and BOD₅(16 mg/l) and a low biodegradability index BOD₅/COD ratio (0.11) are noted. The results of the study determined the amount of oxygen required for aerobic microorganisms to decompose biodegradable organic substances in water. As well as the equivalent amount of oxygen required for complete chemical oxidation of organic substances in water.

Keywords: environmental protection, black sea, oxygen content, water quality, organic pollution.

Introduction

Pollution of sea and ocean waters is a global issue, which is associated with many factors: wastewater, industrial waste, soil leaching, tourist pressure, atmospheric deposition, etc. [Micella et al., 2024; Amelia et al., 2021]. Based on the conducted studies, the Black Sea is one of the most ecologically polluted seas. About 150 rivers (including small rivers) flow into the Black Sea from the territory of Georgia. Among them, the most abundant is the Rioni River, which brings 406 m³ of water and an average of 4.7 million tons of solid waste into the Black Sea annually. In addition

to untreated sewage from rivers and settlements, wastewater from factories flows into the Black Sea, which is contaminated with toxic chemicals and waste [Tabatadze et al., 2025]

The sea is also heavily polluted by oil products spilled from tankers and oil rigs. Organic polymer pollutants, toxic and others [Razuri-Esteves et. Al., 2022; Tabatadze et al., 2026; Mtchedlishvili et. al., 2024.; Tabatadze et. al., 2026]. Environmental pollutants of bioaccumulative nature enter the water through improper processing of agricultural and industrial waste, which poses a threat and ruthlessly destroys the aquatic flora and fauna of the Black Sea. To address these challenges and prevent threats, it is important to restore water resources. Signs of eutrophication are observed in the northwestern part of the Black Sea and along the Georgian coastline (especially at the mouths of rivers). Rivers (Rioni, Chorokhi, Danube) are receiving large amounts of nitrogen and phosphorus compounds, which leads to excessive growth of algae. After their death, a large amount of oxygen is consumed in the decomposition process [Lazar et. al., 2024]. Eutrophication has a negative impact on aquatic ecosystems. There are many techniques for the prevention of eutrophication, consequent on the need for the provision of portable water and the protection of water bodies and the aquatic ecosystem [Akinawo et. al. 2023].

Assessing seawater quality is important for human health and well-being. In water quality assessment, indirect methods are used to determine the total content of organic substances, which are based on measuring the amount of oxygen required for their oxidation. BOD and COD are the most common and informative parameters of this type [Bakan et al., 2007]. Understanding the levels of BOD and COD in water bodies is essential to determining the level of pollution and potential harm to aquatic organisms.

The aim of the research is to test the measurements of the oxygen demand parameter in the area surrounding the port of Poti. BOD (Fig.1.) measures the amount of oxygen required by aerobic microorganisms to break down biodegradable organic matter in water. COD (fig.2.) measures the equivalent amount of oxygen required for complete chemical oxidation of organic matter in water. Unlike BOD, COD (Fig.2.) includes both biodegradable and inert organic compounds (e.g., lignin, cellulose). Various methods have been developed to determine chemical oxygen demand (COD) and biochemical oxygen. Over the past two decades, the use of BOD and COD has been increasing to solve many problems, making it possible to perform analysis in polluted water, environmental and industrial facilities [Singh et. al. 2021].



Fig. 1. Biological Oxygen Demand

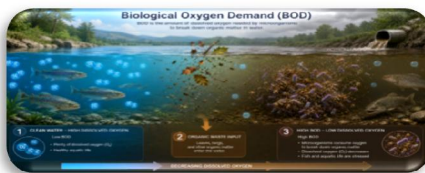


Fig. 2. Chemical Oxygen Demand

Materials and Methods

Equipment and instrumentation: Spectrophotometer HACH LANGE DR 3900, Spectrophotometer HACH LANGE DRB 200, Homogenizer (30 seconds at 20,000 rpm), thermostat, automatic pipette (1 ml), pipette heads; Required reagents - LCK 555 (4–1650 mg/l), LCK 400 (0–1000 mg/l), sulfuric acid, potassium dichromate solution, silver sulfatedistilled water.

Research methodology: Samples for Chemical Oxygen Demand (COD) analysis were taken according to ISO 6060 standard and for Biochemical Oxygen Demand (BOD) analysis - according to ISO 5815 standard. Seawater samples were taken in accordance with the Minister of Labour, Health, and Social Affairs of Georgia "Sanitary Rules for Water Sampling", Order N 15/N (22/01/2004), Sanitary Rules for Water Sampling 2.1.45. 005-04, Chapter 22 - Seawater Sampling Requirements and Standards.

Chemical and Biochemical analysis: The quality of the water in the Black Sea basin was assessed in a chemical laboratory using two critical parameters - Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The method of measuring dissolved oxygen (BOD) involves incubating water samples in a controlled environment with microorganisms and measuring the reduction in dissolved oxygen levels over a specified period of time. This analysis provides an accurate measure of the oxygen demand of organic matter and microorganisms in the water. COD is measured using chemical oxidation methods, such as the dichromate method or the mercury-free COD method. A strong oxidizing agent is added to the water sample and the amount of oxygen consumed during the reaction is measured. COD analysis is faster than BOD and provides a quantitative measurement of organic and inorganic pollutants in water.

Results and Discussion

The study was conducted in the Black Sea waters adjacent to the coastal strip of the port of Poti (Georgia.). (BOD) Determination of oxygen biochemical demand. BOD was used to determine the amount of oxygen needed by aerobic microorganisms to decompose biodegradable organic matter in sea water. The 5-day biochemical oxygen demand was determined by inhibiting nitrification with 5 mg/l allylthiourea. The dissolved oxygen in alkaline solution was analyzed with a pyrocatechol derivative in the presence of Fe^{2+} , resulting in the formation of a red dye. This reflects the initial phase of oxidation of carbonaceous compounds.

Samples were prepared for analysis on a HACH LANGE DR3900 spectrophotometer (table 1.). Homogenization was performed (20 °C) for 5 minutes at 700 to 900 rpm. Sample dilutions were performed stepwise as shown in table 2. The closed cuvette prepared for analysis is placed in a thermostat together with a control cuvette of distilled water for 5/[n] days in the dark at 20 °C (68 °F). The dilution factor is indicated during the analysis process. After 5 days, the full analysis response is recorded on the monitor of the spectrophotometer. The biochemical oxygen demand BOD5 in the Poti sea water is 16 mg O_2 /l.

Equipment and materials	BOD	COD
Tool/equipment	HACH LANGE DR3900	HACH LANGE DRB 200
Required reagents	LCK 555 (4–1650 mg/l)	LCI 400 (0-1000 mg/L), distilled water
Auxiliary tool	Automatic pipette (1 ml), pipette heads	Automatic pipette (1 ml), pipette heads

Table 1. Equipment and materials required for analysis

Measuring range (mg/l)	Sample reaction tube	reaction tube dilution water	Pipette in cuvette test	dilution factor
A => 4–58 *				
=> A1 => 4–19 mg/l *	4 ml	—	1.8 ml	3.5
=> A2 => 7–38 mg/l *	4 ml	—	1.8 ml	7/0
=> A3 => 11–58 mg/l *	4 ml	—	1.8 ml	10.5
B => 25–413 *				
=> B1 => 25–138 mg/l *	1 ml	1 ml	0.5 ml	25
=> B2 => 50–275 mg/l *	1 ml	3 ml	0.5 ml	50
=> B3 => 75–413 mg/l *	1 ml	5 ml	0.5 ml	75
C => 100–1650 *				
=> C1 => 100–550 mg/l *	0.4 ml	2.8 ml	0.5 ml	100
=> C2 => 200–1100 mg/l *	0.4 ml	6.0 ml	0.5 ml	200
=> C3 => 300–1650 mg/l *	0.4 ml	9.2 ml	0.5 ml	300

Table 2. Sample Analysis

(COD) Determination of chemical oxygen demand. Oxidizable substances react with sulfuric acid and potassium dichromate solution in the presence of silver sulfate as a catalyst. Chlorine is masked by mercuric sulfate. The green color of Cr^{3+} is determined spectrophotometrically. The homogenized seawater sample cuvettes are placed in a thermostat preheated to 148 °C for 2 hours together with the control samples. They are cooled to 60 °C and shaken again. After cooling to room temperature, they are measured with a spectrophotometer. The COD chemical oxygen demand in the seawater sample from the Poti coastline was determined to be 145 mg O_2/l . Table 3 shows the data obtained from the analysis of Poti seawater samples (COD and BOD₅) performed on a spectrophotometer.

Parameter	Value	Unit
COD	145	mg O_2/l
BOD ₅	16	mg O_2/l
BOD ₅ /COD	~ 0.11	-

Table 3. Analysis Results

The COD/BOD ratio - an indicator of water biodegradability - was determined:

- **COD/BOD < 2:** Water is easily amenable to biological purification.
- **COD/BOD > 3:** Indicates the presence of toxic substances or persistent organic compounds caused by industrial pollution.

Conclusion

Sed on the results of laboratory research conducted in the Port of Poti and the surrounding industrial zones in Georgia, using chemical and biochemical parameters according to ISO 6060 and ISO 5815 standards, the following conclusions were made:

1. High level of organic pollution: COD (145 mg/l) and BOD₅ (16 mg/l) indicators significantly exceed the typical values characteristic of clean sea water. This indicates a significant organic load of the water body.
2. Low biodegradability index: The BOD₅/COD ratio (0.11) is very low (as a rule, for readily biodegradable wastewater this indicator is more than 0.5). This means that only a small part of the organic substances in the water (approximately 11%) is subject to biological decomposition.
3. Nature of pollution: Such a low ratio indicates that the pollution is unlikely to be caused by fresh domestic wastewater. It is more likely to indicate industrial pollution or the presence of refractory organic compounds in the water.

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