THE IMPORTANCE OF DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND IN THE SELF-PURIFICATION PROCESS OF RIVER WATER

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ABSTRACT

River self-purification is a natural process through which physical, chemical, and biological mechanisms reduce pollutant concentrations and transform certain harmful substances. Dissolved oxygen (DO) and biochemical oxygen demand (BOD) are key indicators for evaluating this process. DO supports aquatic organisms and aerobic microbial activity, whereas BOD indicates the oxygen required by microorganisms to decompose biodegradable organic matter under specified test conditions. When oxygen consumption exceeds oxygen replenishment, river water may experience oxygen depletion, with adverse consequences for aquatic communities and overall water quality. This review examines the relationship between DO and BOD, the main mechanisms governing oxygen balance, and the influence of temperature, river flow, turbulence, microbial activity, and organic pollution. The analysis emphasizes that these indicators should be interpreted together and monitored across different locations and seasons. Understanding their relationship provides a scientific basis for evaluating river self-purification capacity and developing sustainable water-quality management measures.

Keywords: river water, self-purification, dissolved oxygen, biochemical oxygen demand, BOD_5, organic pollution, water quality, aquatic ecosystems.

INTRODUCTION

Rivers support domestic water supply, agriculture, industry, energy production, and aquatic biodiversity. At the same time, the discharge of municipal wastewater, industrial effluents, and agricultural runoff can introduce biodegradable organic matter and nutrients into river systems. These inputs may alter oxygen conditions, disturb nutrient cycling, and reduce the ecological quality of water.

River self-purification refers to the combined physical, chemical, and biological processes through which pollutants are diluted, transported, transformed, deposited, or biologically degraded. The term does not necessarily mean that all pollutants are destroyed: some may accumulate in bottom sediments or be transported downstream, and may later re-enter the water column.

Dissolved oxygen is essential for aerobic aquatic life and the microbial decomposition of organic matter. Biochemical oxygen demand provides an estimate of the oxygen consumed during the biological breakdown of biodegradable substances. Consequently, the relationship between DO and BOD is central to understanding whether a river can process organic pollution while maintaining suitable oxygen conditions. The objective of this article is to analyze the role of these indicators in river self-purification and identify the main environmental factors affecting their interaction.

METHODS

This article was prepared as a narrative review of scientific literature on river self-purification, dissolved oxygen dynamics, and biochemical oxygen demand. The approach involved the conceptual analysis and systematization of information from textbooks, research articles, and technical materials concerning aquatic ecology and water-quality assessment.

The review focused on: (1) physical processes such as dilution, mixing, sedimentation, and reaeration; (2) chemical transformations and oxidation processes; (3) biological decomposition of organic matter; and (4) the influence of

temperature, river discharge, turbulence, nutrients, and anthropogenic pollutant loads. DO and BOD were examined as complementary indicators rather than as independent measures of water quality.

For interpretation, BOD_5 is understood as the oxygen consumed by a water sample during a standardized five-day incubation, commonly at 20°C. The specific analytical procedure should follow the applicable standard method, including any required dilution and seed corrections. No original field measurements or laboratory experiments were conducted for this review.

RESULTS

The literature analysis indicates that river self-purification is governed by interacting physical, chemical, and biological processes. Dilution and mixing reduce local pollutant concentrations, while sedimentation removes suspended particles from the water column. However, sedimentation may transfer pollutants to the riverbed rather than eliminate them permanently. Changes in flow, flooding, or water chemistry can remobilize previously deposited substances.

Biological decomposition is particularly important for biodegradable organic pollution. Microorganisms use dissolved oxygen to oxidize organic compounds, producing carbon dioxide, water, and microbial biomass. This activity increases oxygen consumption and can cause a decline in DO when the oxygen demand exceeds the rate of replenishment. BOD is therefore useful for estimating the potential oxygen demand associated with biodegradable material.

Atmospheric reaeration and photosynthesis replenish oxygen, while respiration, microbial decomposition, nitrification, and sediment oxygen demand consume it. Water temperature influences both oxygen solubility and biological reaction rates. Warm water generally holds less oxygen than cold water at the same pressure and salinity, and elevated temperatures may intensify the risk of oxygen depletion in polluted rivers.

The main indicators and their interpretation are summarized in Table 1.

Indicator	What it represents	Relevance to self-purification
Dissolved oxygen (DO)	Oxygen currently dissolved in water	Shows oxygen available to aquatic organisms and aerobic processes
BOD_5	Oxygen consumed during a standardized five-day biological test	Indicates potential oxygen demand from biodegradable organic matter
Chemical oxygen demand (COD)	Oxygen equivalent associated with chemically oxidizable substances	Complements BOD by covering a broader range of oxidizable material
Water temperature	Thermal condition of the river	Affects oxygen solubility and biological reaction rates
pH and nutrients	Acid–base condition and nutrient availability	Influence microbial activity, biological production, and pollutant mobility

Table 1. Principal water-quality indicators used to interpret river self-purification.

The general relationship between oxygen deficit and organic-matter decomposition can be represented by a simplified oxygen-balance equation:

$$\mathbf{dD/dt = k^dL - k_rD}$$

where D is the dissolved oxygen deficit relative to saturation, L is the remaining ultimate carbonaceous biochemical oxygen demand, k^d is the deoxygenation coefficient, k_r is the reaeration coefficient, and t is time. The equation illustrates the balance between oxygen consumption during decomposition and oxygen

replenishment through reaeration. Actual rivers may also require terms for photosynthesis, respiration, nitrification, sediment oxygen demand, and inflows.

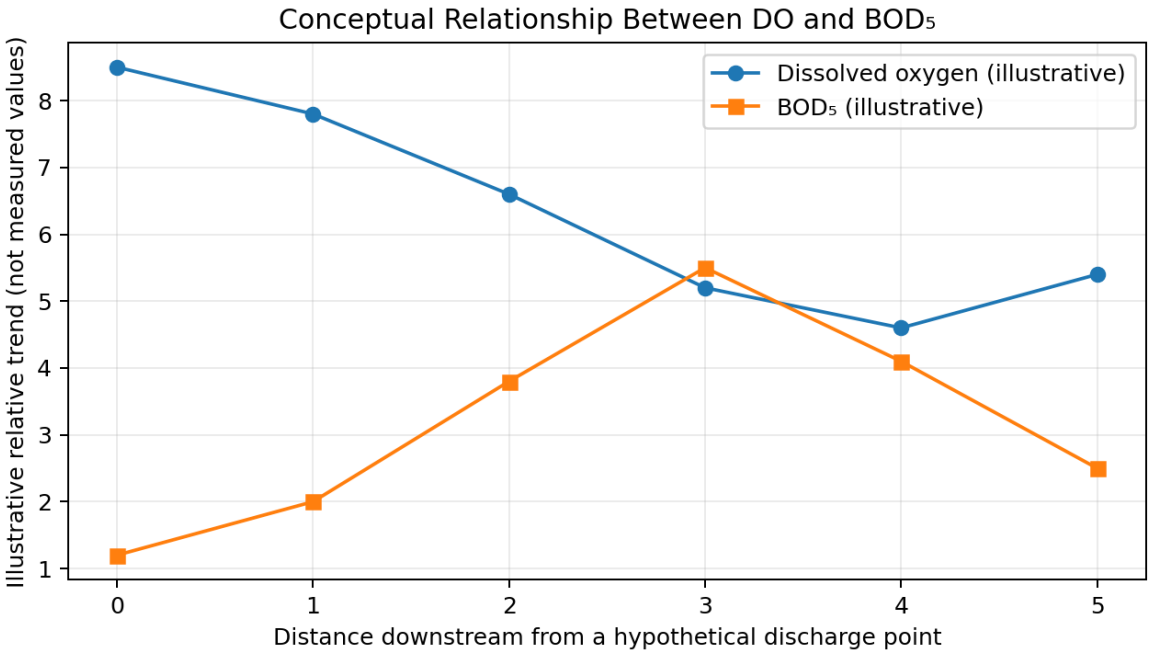

Figure 1. Conceptual illustration of DO and BOD₅ trends downstream from a hypothetical pollution source. The curves are illustrative and do not represent measured river data.

DISCUSSION

DO and BOD provide complementary information. A high BOD value indicates that biodegradable organic matter may consume substantial oxygen, but it does not prove that the river is already oxygen-depleted at every point. Similarly, a single high DO measurement does not demonstrate that the river is free from organic pollution. Oxygen concentrations vary with time of day, season, flow conditions, and the location of sampling.

The location of the oxygen minimum may occur downstream from a discharge point because microorganisms require time to decompose organic matter. The resulting pattern depends on pollutant load, river velocity, turbulence, temperature, and the rate of oxygen transfer from the atmosphere. In low-flow conditions, dilution

and reaeration may be limited; during warm periods, the lower oxygen-holding capacity of water can further increase ecological risk.

Nutrient enrichment can also complicate oxygen dynamics. Nitrogen and phosphorus may stimulate algal and plant growth, raising DO during daylight through photosynthesis. At night, respiration continues without photosynthetic oxygen production, and the decomposition of dead biomass can increase oxygen demand. Therefore, monitoring at different times of day and across seasons is important.

The results support several practical implications. Wastewater treatment should reduce biodegradable organic loads before discharge. Agricultural practices should limit the movement of manure, fertilizers, and organic residues into streams. River monitoring should combine DO, BOD_5, COD, temperature, pH, nutrients, and hydrological measurements. Sampling upstream and at multiple downstream locations can help distinguish dilution and transport from actual pollutant degradation.

The main limitation of this article is its review-based design. It does not provide original measurements or quantify the contribution of individual mechanisms for a particular river. Further work should include field sampling, laboratory BOD_5 tests, seasonal comparison, and, where appropriate, oxygen-balance modeling.

CONCLUSION

Dissolved oxygen and biochemical oxygen demand are fundamental indicators for evaluating river self-purification. DO represents the oxygen available in water, while BOD_5 estimates the oxygen required for the biological decomposition of biodegradable organic matter. When oxygen consumption exceeds replenishment, dissolved oxygen can decline and create stress for aquatic organisms. Temperature, river flow, turbulence, microbial activity, nutrients, and sediment processes all influence this balance.

Reliable assessment therefore requires combined DO and BOD_5 measurements, supported by other physicochemical and hydrological indicators and repeated across locations and seasons. Reducing untreated wastewater discharges, protecting natural river flow, and maintaining effective monitoring are essential for preserving the self-purification capacity and ecological stability of river systems.

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