More nutrients can mean less oxygen

Eutrophication is nutrient enrichment of a water body. Excess nitrogen and phosphorus can increase algal and plant growth, setting off changes that reduce oxygen available to aquatic animals.

1. FOLLOW THE CAUSAL CHAIN

1 **NUTRIENTS ENTER**

Fertilizer runoff or wastewater adds nitrogen and phosphorus.

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2 **ALGAE INCREASE**

Nutrient enrichment can stimulate a bloom; dense growth also shades submerged plants.

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3 **ORGANIC MATTER DIES**

Dead algae and plants supply material for decomposers.

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4 **RESPIRATION USES OXYGEN**

Microbes break down organic matter, consuming dissolved oxygen through aerobic respiration.

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5 **LOW OXYGEN HARMS LIFE**

If demand exceeds replacement, oxygen falls; animals may leave, become stressed or die.

2. NAME THE OXYGEN-CONSUMING PROCESS

Fertilizer does not simply "absorb all the oxygen." The key link is increased organic matter followed by oxygen-consuming respiration during decomposition. Shading can add dead submerged plants to the material being decomposed.

3. GROWTH IS NOT THE SAME AS A HEALTHY ECOSYSTEM

A large bloom can reduce habitat quality and water clarity even before a fish kill is visible. More algal biomass does not automatically mean greater biodiversity or a more stable aquatic food web.

Nutrient enrichment, shading and decomposition: NOAA, What Is Eutrophication?
Oxygen loss and aquatic animals: NOAA, What Is a Dead Zone?

Scope: College Board AP Environmental Science CED, Topic 8.5, p. 162.

Compare nutrient status and oxygen

Oligotrophic and eutrophic describe nutrient conditions and associated productivity. They are not labels for whether all organisms are present or absent, and they do not describe salinity.

1. OLIGOTROPHIC VERSUS EUTROPHIC

FEATURE	OLIGOTROPHIC	EUTROPHIC
Nutrients	Very low nutrient availability.	High nutrient availability.
Algal growth	Lower productivity; relatively stable algae populations.	Higher productivity; blooms can occur.
Water clarity	Often clearer, with less algal material.	Often lower during dense algal growth.
Oxygen pattern	Generally high oxygen compared with eutrophic waters.	Greater risk of low oxygen as organic matter decomposes.

2. HYPOXIA IS LOW OXYGEN, NOT ZERO LIFE

Hypoxia: low dissolved oxygen. Anoxia: no dissolved oxygen.
A "dead zone" is a common name for a hypoxic area. Mobile animals may escape; organisms unable to move can die. Oxygen needs differ among species. Nutrient enrichment can contribute to these conditions in lakes, estuaries and coastal waters, not just in the ocean.

3. A SINGLE OXYGEN READING IS NOT THE WHOLE STORY

Dissolved oxygen varies with depth, mixing and time of day. Algae can produce oxygen during daylight photosynthesis while algae and other organisms also respire. A nutrient-rich water body can therefore have oxygenated surface water while deeper water is oxygen-poor. Compare nutrient levels, algal growth and oxygen patterns together.

Oligotrophic comparison: College Board, STB-3.F.4.
Hypoxic areas and their biological effects: NOAA, What Is a Dead Zone?
Variation with depth, mixing and time: US EPA, Dissolved Oxygen.

Scope: College Board AP Environmental Science CED, Topic 8.5, p. 162.

Reduce the inputs that feed the bloom

Human-driven nutrient enrichment is often called cultural eutrophication. The central sources in this topic are agricultural runoff and wastewater release, including nutrients from excessive fertilizer use and some detergents.

1. AGRICULTURE: KEEP NUTRIENTS ON THE FIELD

Apply fertilizer and manure in appropriate amounts, at suitable times and with suitable placement. Cover crops and vegetated buffers can reduce erosion and nutrient transport. Manage livestock access to streams and keep waste out of waterways. These practices target the nutrient source or its route into the water, rather than just the resulting algae.

2. WASTEWATER: REMOVE NITROGEN AND PHOSPHORUS

Human waste, food waste and certain detergents contribute nutrients to wastewater. Treatment effectiveness varies; treated discharge is not necessarily nutrient-free. Improve nutrient removal, maintain septic systems and reduce avoidable nutrient inputs. Some plants can improve performance through operational changes; others need additional treatment equipment.

3. MATCH THE RESPONSE TO THE CAUSE

Agricultural runoff is typically diffuse, so many land managers may need to act together. A wastewater outfall can be targeted at a specific facility. Do not assume all detergents contain phosphate or that every bloom has one identical source. Trace the inputs and evaluate whether nitrogen and phosphorus loads actually decrease.

4. EXTENSION: CHECK THE DAILY NUTRIENT LOAD

Illustrative discharge: 1,000,000 L/day containing 2 mg/L phosphorus.
Load = 1,000,000 × 2 = 2,000,000 mg/day = 2 kg/day
At the same flow, reducing concentration to 0.5 mg/L gives 0.5 kg/day.
Load reduction = (2 - 0.5) / 2 × 100 = 75%
A lower concentration does not guarantee a lower load if flow also changes.

Fertilizer, buffers and livestock management: US EPA, Sources and Solutions: Agriculture.
Treatment and septic systems: US EPA, Sources and Solutions: Wastewater.
Nutrient sources, including some detergents: US EPA, Sources and Solutions.

Scope: College Board AP Environmental Science CED, Topic 8.5, p. 162.