

Environmental Chemistry

Dissolved Oxygen

A Conventional Perspective

DO

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Presentation Menu

- Introduction
- Environmental significance
- Collection of samples for DO test
- Oxidation-reduction



Introduction

All living organisms are dependent upon oxygen in one form or another to maintain the metabolic processes that produce **energy** for:

Growth

Reproduction (regeneration of new cells)

Introduction

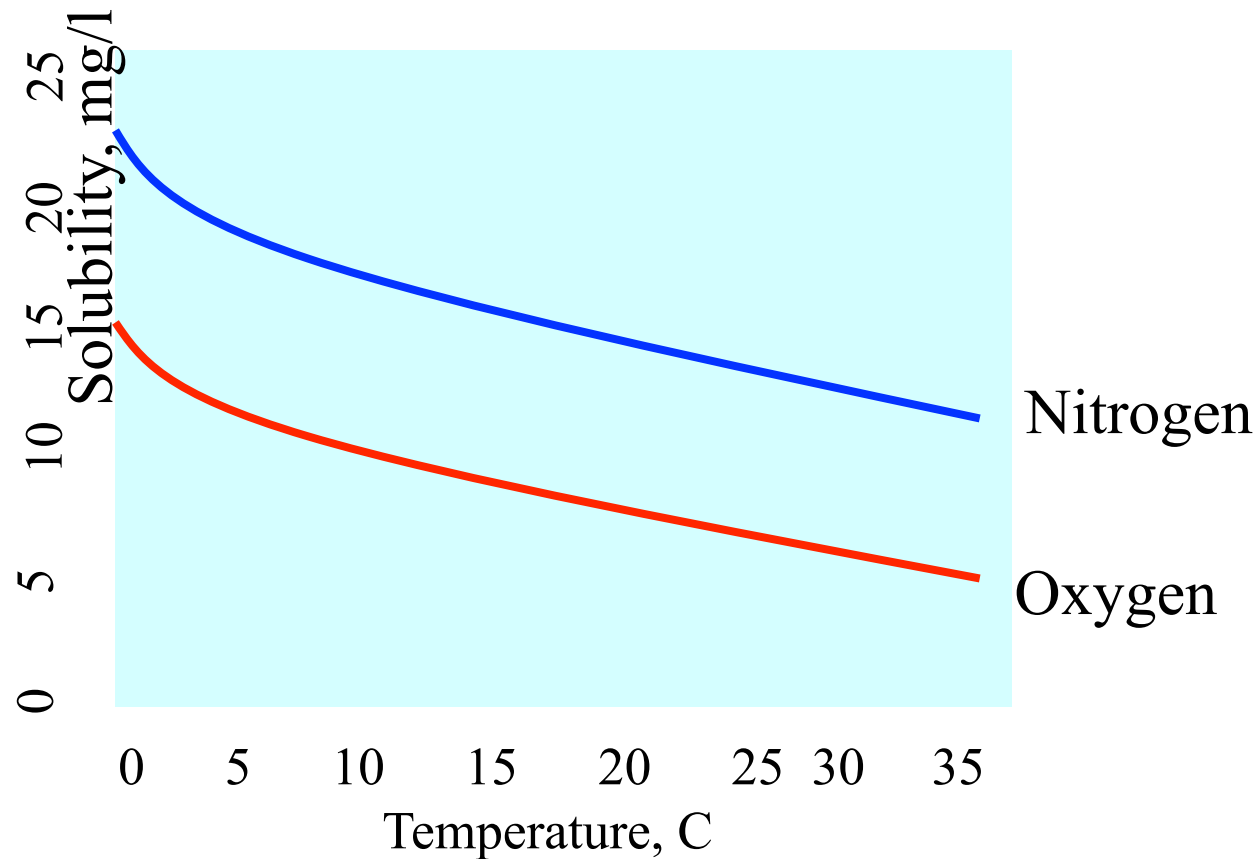
Aerobic process – need for free oxygen

All gases in atmosphere are soluble in water to some degree

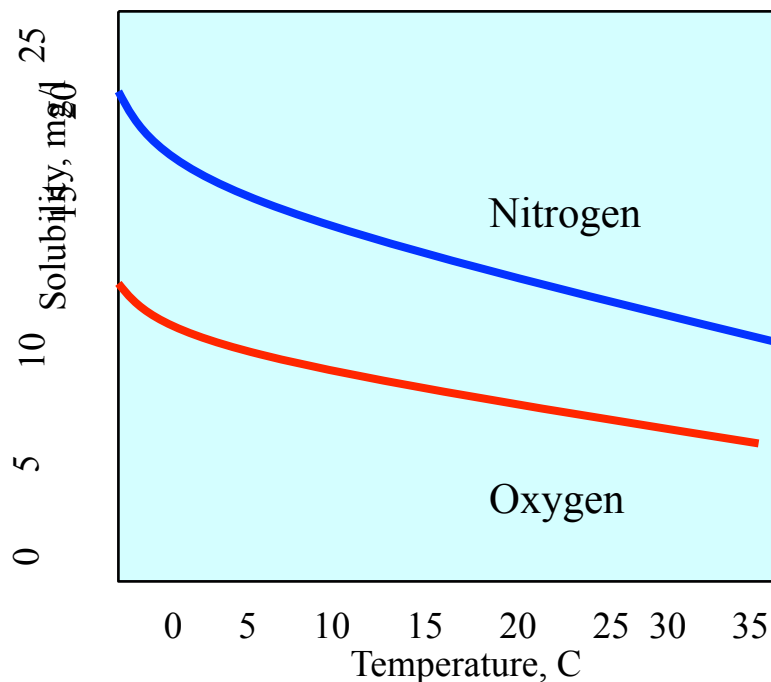
Oxygen and nitrogen are **poorly soluble**, since they do not react with water chemically, their solubility is directly proportional to their **partial pressures**

Henry's law is used to calculate the amounts present at saturation at any given temperatures

Solubility of oxygen and nitrogen in distilled water saturated with air at 760 mm Hg



Solubility of oxygen and nitrogen in distilled water saturated with air at 760 mm Hg



Under partial-pressure conditions, more nitrogen than O_2 dissolves in water

At saturation, dissolved gases contain 38% O_2 on molar basis, or twice O_2 in normal atmosphere

Solubility of atmospheric O_2 in fresh waters ranges from 14.6 mg/l at 0°C to to about 7 mg/l at 35°C under 1 atm.

Poorly soluble gas

Significant for high altitude

Rates of biological oxidation with tempt, and O_2 demand

... Solubility of oxygen and nitrogen in water

Most problems related to O₂ deficiency occur during high temperature (summer in temperate climate) when solubility of oxygen is low

Solubility of oxygen in freshwater: **Maximum of 8 mg/l**
under critical conditions

Solubility of oxygen is less in salt-containing water
(compared to clean water)

Solubility of O₂ decreases from estuary to sea

... Solubility of dissolved oxygen in water in equilibrium with dry air at 760 mm Hg containing 20.9% oxygen

Temp, °C	Cl=0 mg/l	Cl=5000 mg/l	Cl=10,000 mg/l	Cl=15,000 mg/l	Cl=20,000 mg/l
0	14.6	13.8	13.0	12.1	11.3
5	12.8	12.1	11.4	10.7	10.0
10	11.3	10.7	10.1	9.6	9.0
20	9.2	8.7	8.3	7.9	7.4
30	7.6	7.3	6.9	6.5	6.1

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Chloride in seawater = 19,000 mg/l

... Solubility of dissolved oxygen in water in equilibrium with dry air at 760 mm Hg containing 20.9% oxygen

- In polluted waters the saturation values is less than clean water
- Ratio of the value in polluted water to clean water = β value
- Rate of solution of oxygen in polluted waters is less than clean water, and the ratio = α value
- Polluted waters: $\beta > 0.8$; $\alpha > 0.4$
- Values of β and α are important for selection of aeration equipment

Environmental significance of DO

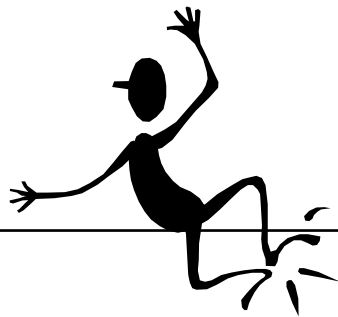
- The most **important** single tests for environmental engineering
- DO determine biological processes in water: aerobic or anaerobic
- **Aerobic**: use free oxygen for oxidation of organic and inorganic matters produce innocuous end products
- **Anaerobic**: oxidation occurs through reduction of certain inorganic salts e.g. sulfates produce innocuous end products

Environmental significance of DO

- DO must be monitored to maintain the biological process or environmental conditions
- DO related to BOD test DO foundation

Electron Transfer in Bioprocesses

Processes	Terminal electron acceptor
Aerobic	Oxygen
Anoxic	Nitrates
Anaerobic	Sulfate Organic matters Water Halogenated organic compounds Fe^{3+}



Environmental significance of DO

- DO is significant in **corrosion** of iron and steel, particularly in water distribution systems and boilers.
- Removal of DO from boiler-feed water by physical and chemical means is common practice in power industry

Determination of DO

- In most cases, DO level is below saturation exposure to atmosphere will lead to error
- DO measurement is in-situ basis
- Since oxygen values may change rapidly with time because of biological activity, samples is treated using conventional reagent, then perform titration when samples are brought to laboratory
- Two procedures for measuring DO:
 - Oxidation-reduction titration using iodometry
 - Specialised adaptation of polarography using membrane-covered electrode

Oxidation-Reduction

- Based on **atomic structure** and **electron transfer**
- Atom, molecule or ion is said to undergo oxidation when it **loses an electron**
- Reduction when **gains an electron**
- When sodium reacts with chlorine to form sodium chloride, the sodium atom loses an electron and becomes oxidized to sodium ion, Na^+ . Chloride gains an electron and is reduced to the anion, Cl^-

Process Theory

(ii) Plug-flow reactor

