Water Pollution
(تلوث المياه)

Water Pollution

- Physical, chemical, biological changes in water quality that adversely affect living organisms

Water Pollution

- Physical tests
  - Temperature
  - Turbidity
  - Taste and smell
  - Color
- Chemical tests
  - pH
  - Total dissolved solids (TDS)
  - Radioactivity
  - Hard water
- Biological tests
  - Bacteria
  - Viruses

General Principles

- The fresh groundwater and surface water on the continents constitutes <1% of the water in the hydrosphere
- Any natural water contains dissolved chemicals
- Some are unhealthy and some are produced by a variety of human activity (agriculture, industry, and as people live)

General Principles:

- Geochemical Cycles
- Residence Time
- Residence Time and Pollution
- Point and Non-point Pollution Sources

TABLE 10.1

The Water in the Hydrosphere

Reservoir	Percentage of Total Water*	Percentage of Fresh Water†	Percentage of Unfrozen Fresh Water
oceans	97.54	—	—
ice	1.81	73.9	—
ground water	0.63	25.7	98.4
lakes and streams			
salt	0.007	—	—
fresh	0.009	0.36	1.4
atmosphere	0.001	0.04	0.2

Source: Data from J. R. Mather, *Water Resources,* 1984, John Wiley & Sons, Inc., New York.

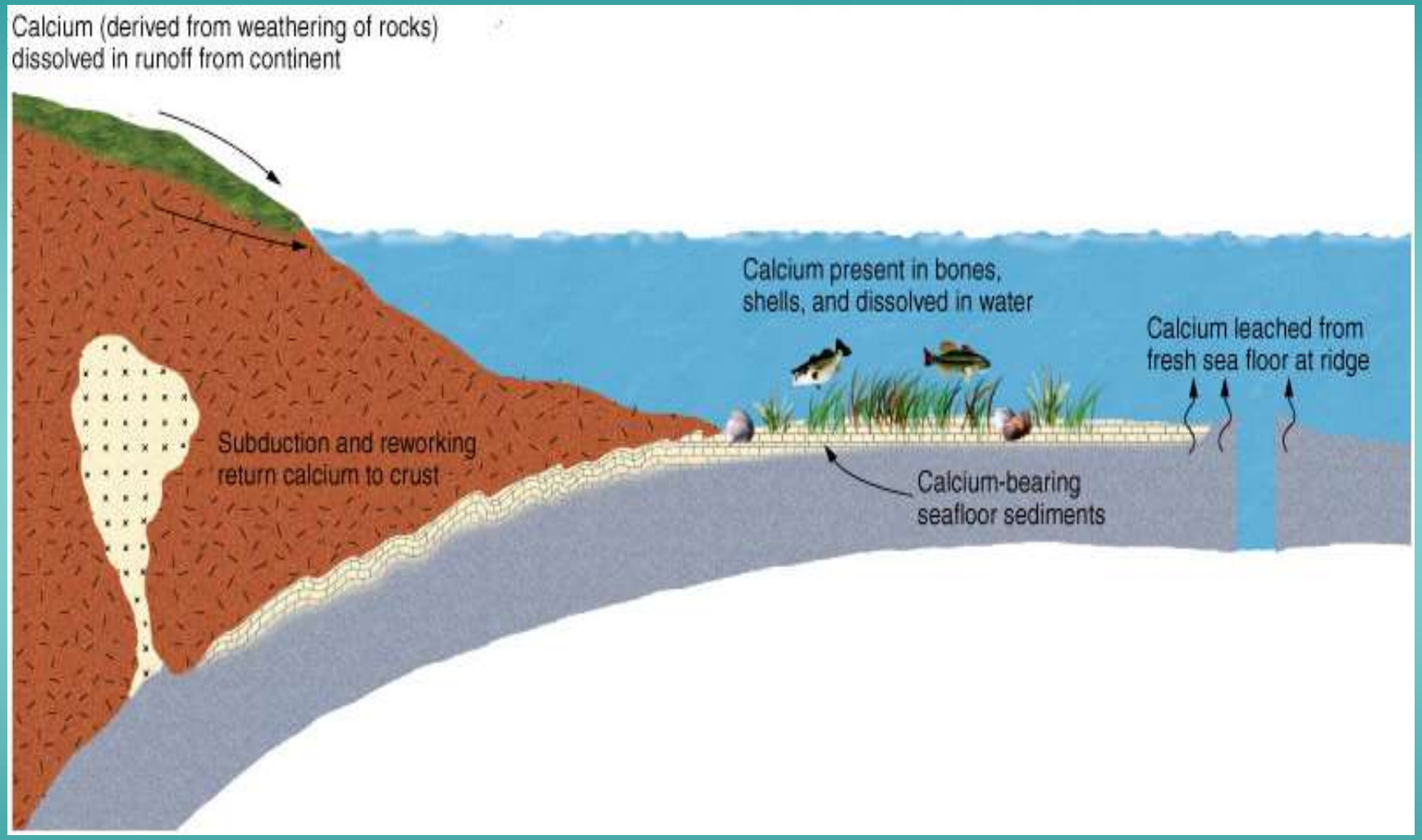
*These figures account for over 99.9% of the water. Some water is also held in organisms (the biosphere).

†This assumes that all ground water is more or less fresh, since it is not all readily accessible to be tested and classified.

Geochemical Cycles

- All of the chemicals in the environment participate in geochemical cycles of some kind, similar to the rock cycle
- Simplified cycle
  - Precipitation
  - Weathering
  - Ions transported as dissolved load in stream or ground water
  - Minerals precipitate out and cycle continues
  - Many systems become more complex because of subcycles

Simplified calcium cycle



Calcium weathered out of rocks into bodies of water. Some remains in solution, some is taken up by organism, and some is deposited in sediments. The deposited calcium is, in time, reworked through the cycle into new rock.

Residence Time
(زمن المكوث)

- Residence Time = Capacity/Rate of Influx
  - **Residence Time** – The average length of time a substance remains in a system (متوسط فترة بقاء الماده في خزان ما)
  - **Capacity** – maximum concentration of a substance a reservoir can reach before saturation occurs. For most substances in seawater, capacity is controlled by solubility.
  - **Rate of Influx** – how much of a substance a stream or ground water system brings into the reservoir
- Oceanic residence times for different elements vary widely
- The residence time varies from an average of 4,000 years for the water in the oceans to an average of 9 days in the atmosphere

Residence Time

- **Most often, human activities increase the rate-of-influx term, either by dumping of concentrated wastes or through accelerated weathering, as of mine tailings.**

TABLE 16.1

Residence Times of Selected Major and Minor Elements in Seawater with Respect to Modern Influx Through Surface Runoff

Element	Concentration (ppm)	Residence Time (years)
chlorine	18,980 (1.9%)	68,000,000
sodium	10,540 (1.0%)	100,000,000
magnesium	1270	12,000,000
calcium	400	1,000,000
potassium	380	7,000,000
bromine	60	100,000,000
silicon	3.0	18,000
phosphorus	0.07	180,000
aluminum	0.01	100
iron	0.01	200
cadmium	0.00011	500,000
mercury	0.00003	80,000
lead	0.00003	400

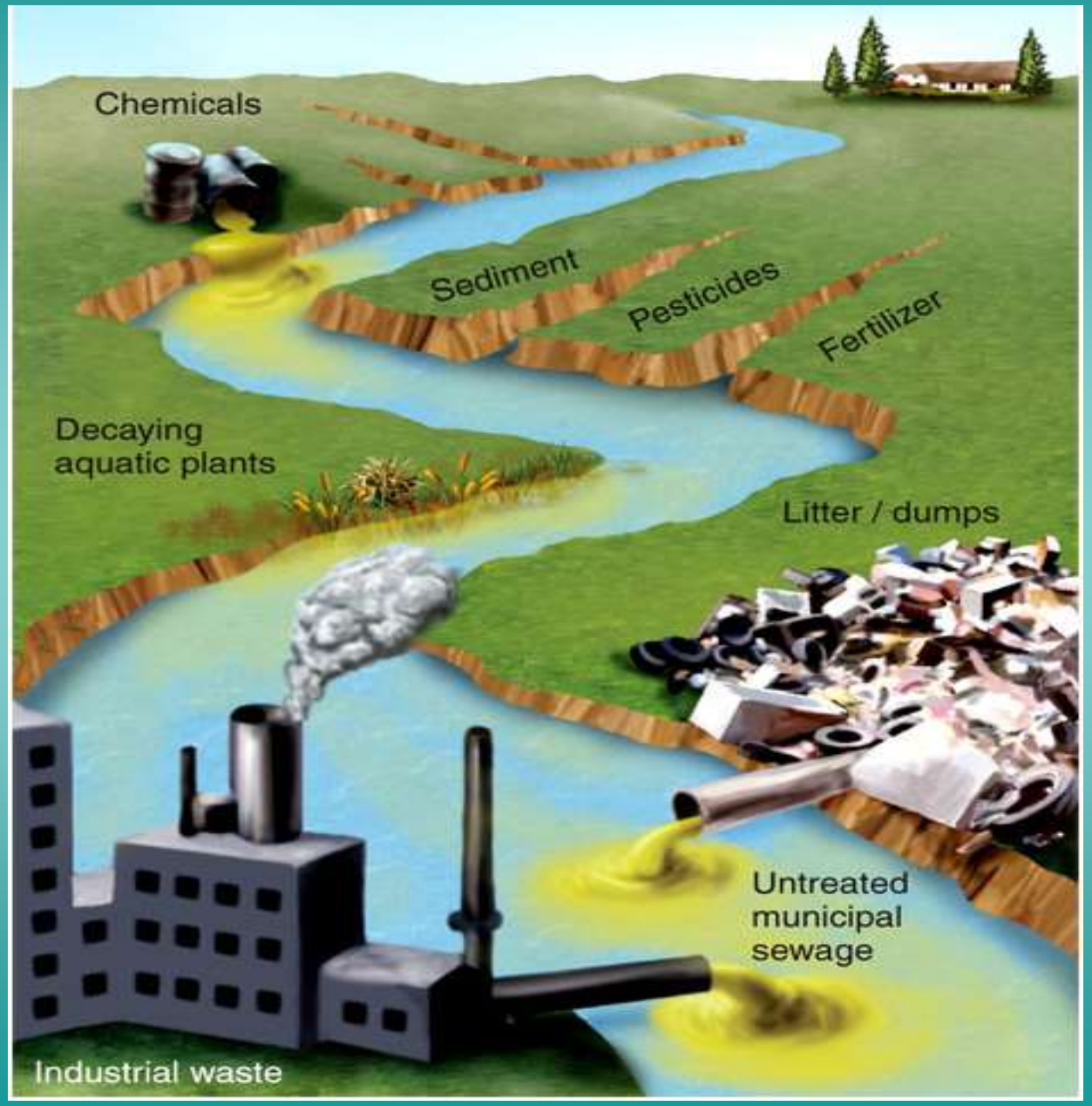
Source: Data from J. E. Fergusson, *Inorganic Chemistry and the Earth*. Copyright © 1982 Pergamon Press, Oxford, England.

Sodium has the longest oceanic residence time

Point and Nonpoint Pollution Sources
(مصادر الملوثات المختلفة)

- **Point source** (مصادر نقطية)– pollution enters a system from one, identifiable spot. The point sources are often easier to identify as potential pollution problems
  - Example: A sewage water stastions, mines, a septic tank, factories
- **Nonpoint source** (مصادر غير نقطية)– pollution enters a system from multiple and more diffuse sources, not having a specific location where they discharge pollution into a body of water.
  - Example: Gardens, Fertilizer runoff from farmland, acid drainage from an abandoned strip mine, roads, cities

Point sources of water pollution



Acid mine drainage

Organic Matter

- **Nature and Impacts**
- **Biochemical Oxygen Demand**
- **Eutrophication**

Organic Matter

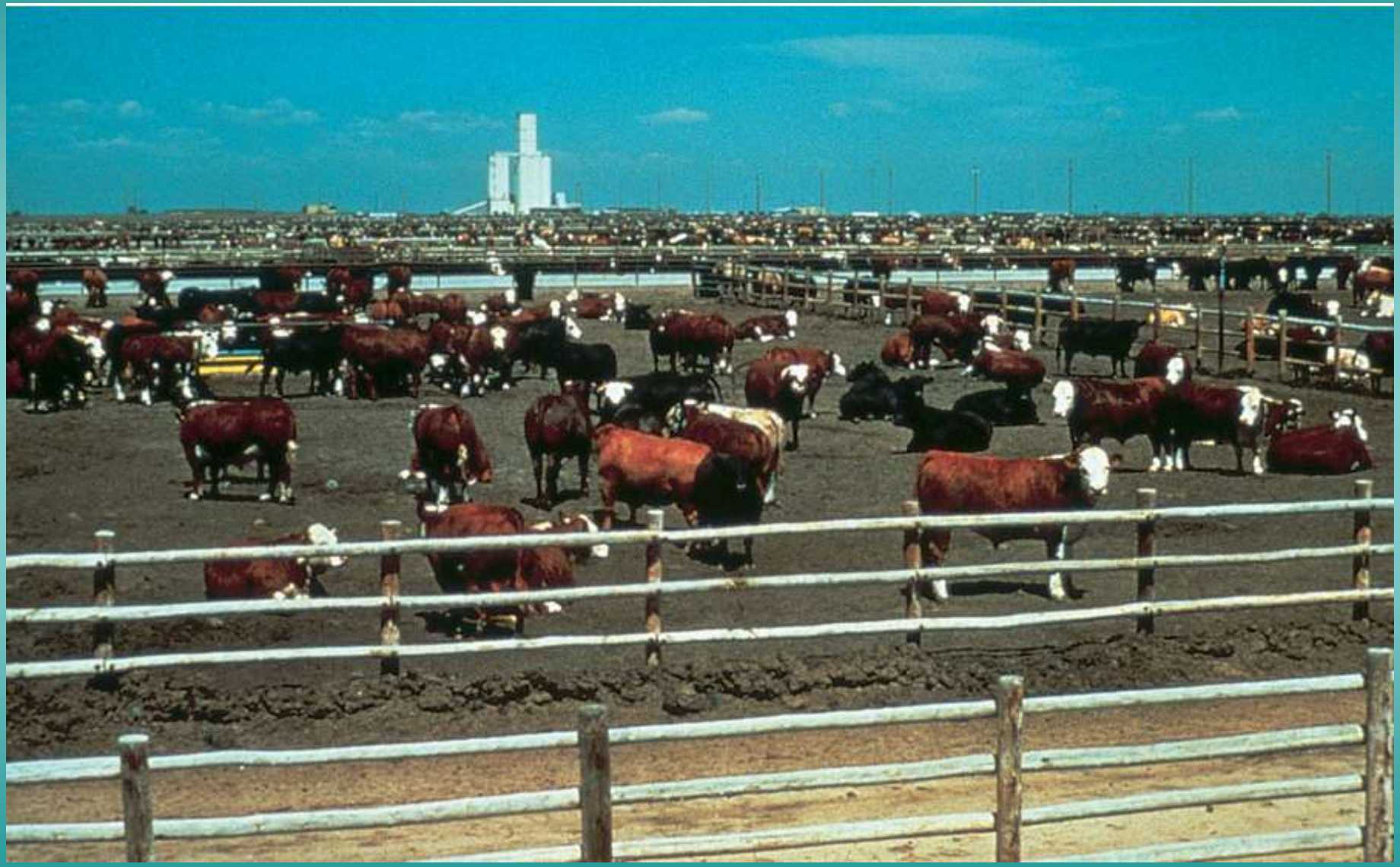
- **Nature and Impacts**
  - In general organic matter is the substances of living or dead organisms and their by products
  - Organic matter includes:
    - Algae in a pond
    - Human or animal waste
    - Run off from an animal feedlot
    - Discharge from food processing plants
    - Run off from municipal streets or highways
  - In time organic matter is broken down by microscopic organisms (bacteria)
    - If ample oxygen is available then **aerobic** decomposition occurs
    - If oxygen is depleted then **anaerobic** decomposition occurs

Harmful health effects of organic compounds

- The main problem is that there are so many synthetic organics and that we know so little about the toxicity of the vast majority of them.
- It has also been discovered that many are toxic in very low concentrations and are persistent in the environment.

Uncontrolled runoff from a livestock yard

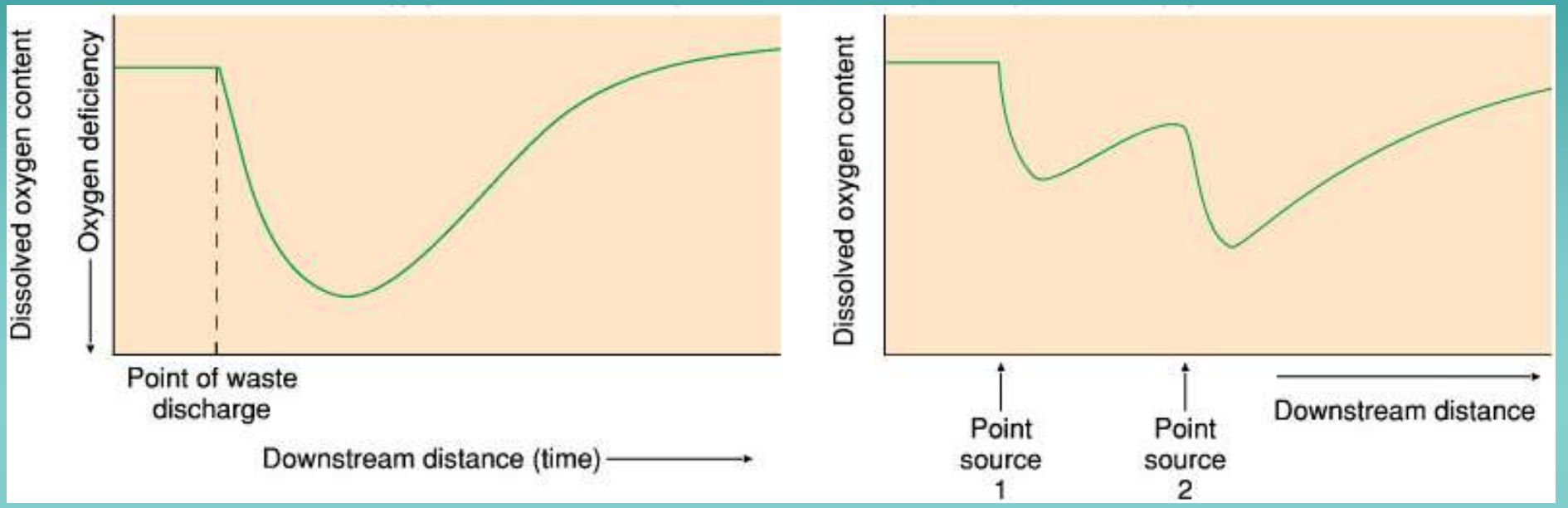
Feedlots a Major Source of Organic Wastes



Organic Matter

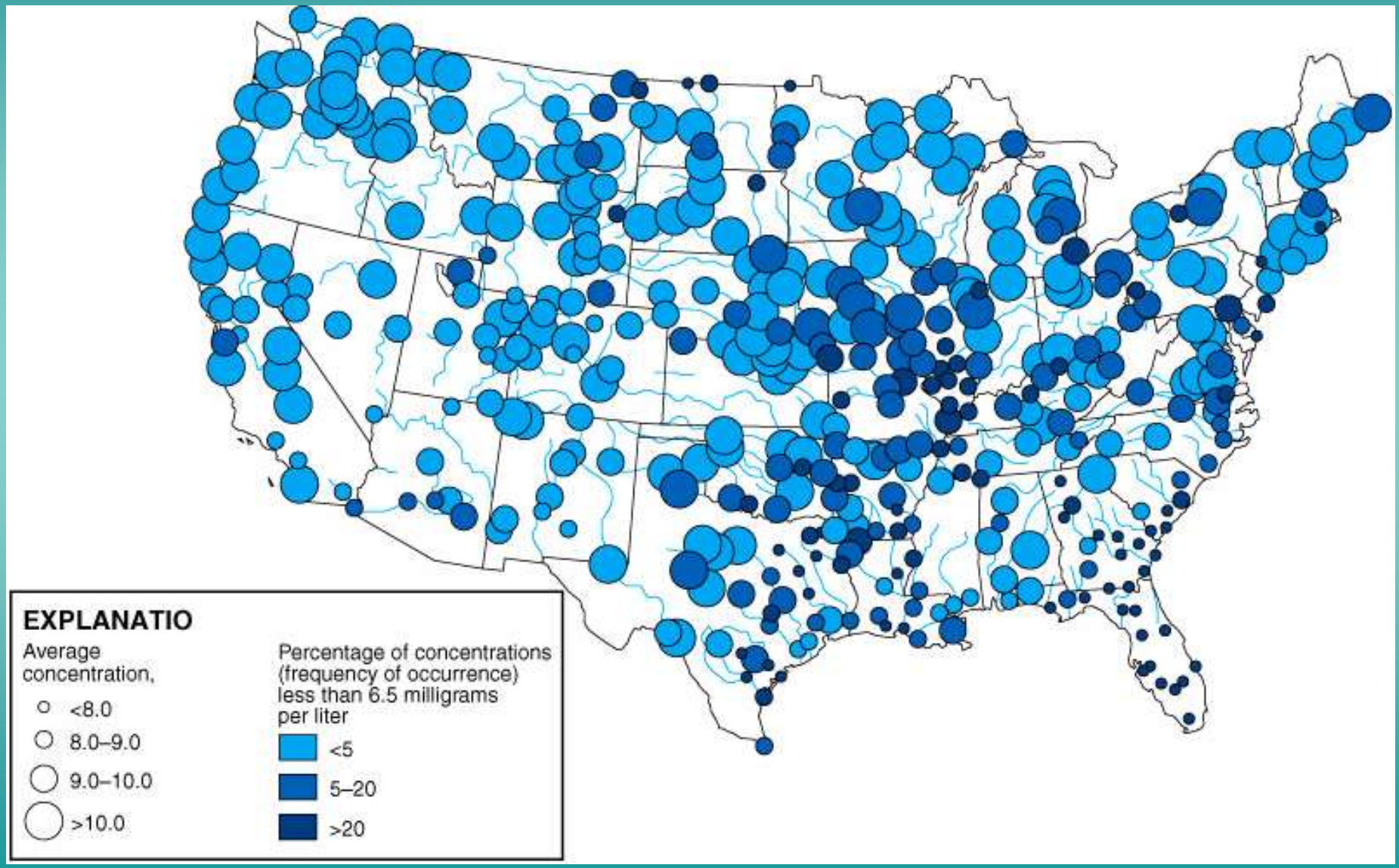
- **Biochemical Oxygen Demand** (BOD) (الاكسجين المتطلب بيوكيميائيا)
  - Measure of organic-matter load in a body of water
  - BOD of a system is the measure of the amount of dissolved oxygen consumed by aquatic microorganisms to breakdown the organic matter aerobically
    - **The more the organic matter, the higher the BOD**
      - BOD may exceed the amount of dissolved oxygen in the system
      - An **oxygen sag curve** is a graph of dissolved oxygen content as a function of distance from the waste source

Effects of wastewater and organic matter on dissolved-oxygen content



- Oxygen shows sharp depletion near the source and recovering downstream
- Persistent oxygen depletion occur in a body of standing water, such as lakes or reservoirs

Dissolved-oxygen concentrations in U.S. surface waters



Organic Matter

- **Eutrophication (عملية الاثراء الغذائي)**
  - The process of accumulation of high levels of nutrients such as nitrates, phosphates, and sulfates in aquatic environment.
  - Plants such as algae thrive on these nutrients and can produce algal blooms
  - As algae dominate a system and kill other plant life, the dead plants contribute to the total organic matter and increase the BOD

Eutrophication

- Algal growth proceeds in the photic (well-lighted) zone near the water surface
- These dead plants drop to the bottom of the pond where they become part of the organic-matter load and increase the BOD
- This process consumes oxygen and re-releases abundant nutrients into the water and the cycle is repeated
- Layers of water become depleted in oxygen and will kill oxygen dependent animals
- Sources of excess nutrients contribute to the eutrophication include human and animal wastes, phosphates in detergents (المنظفات), and fertilizers runoff (الاسمده)

Algal Bloom
(غطاء اخضر على سطح الماء)

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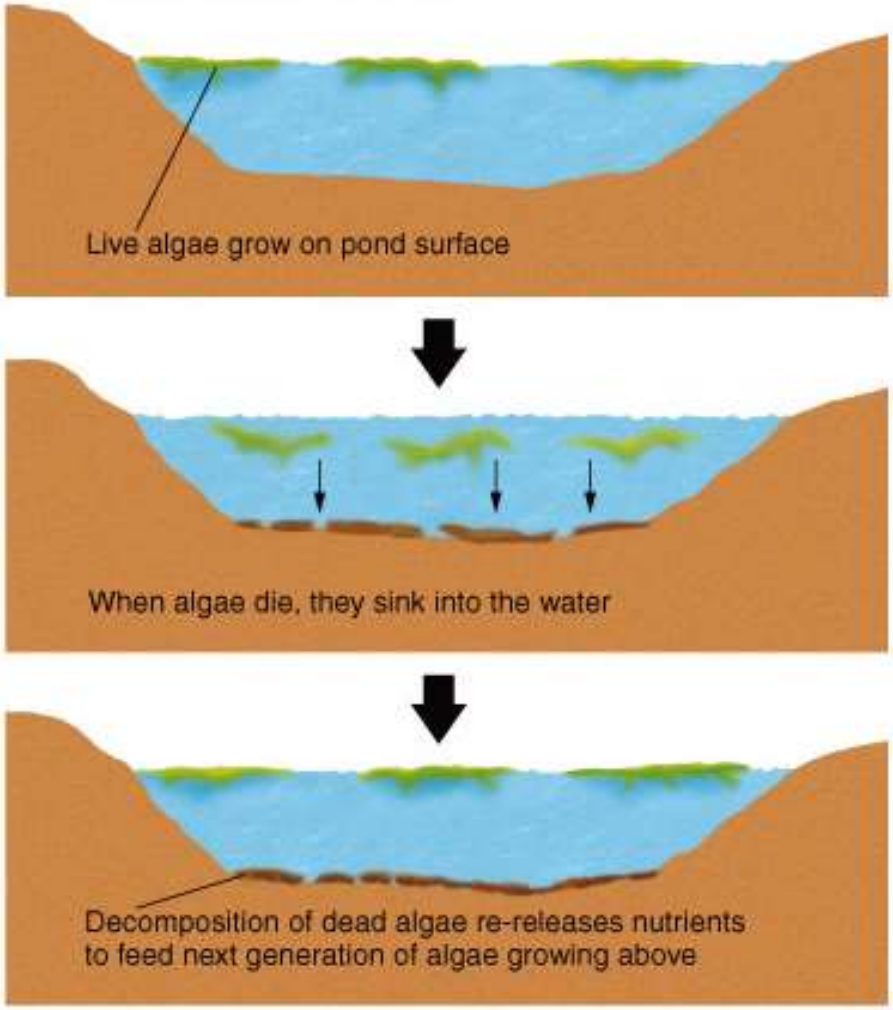

Organic Fertilizer Can be a Problem

Algae-Covered Lake in Wisconsin

Algal Bloom on Lake Tahoe