Wastewater Characteristics

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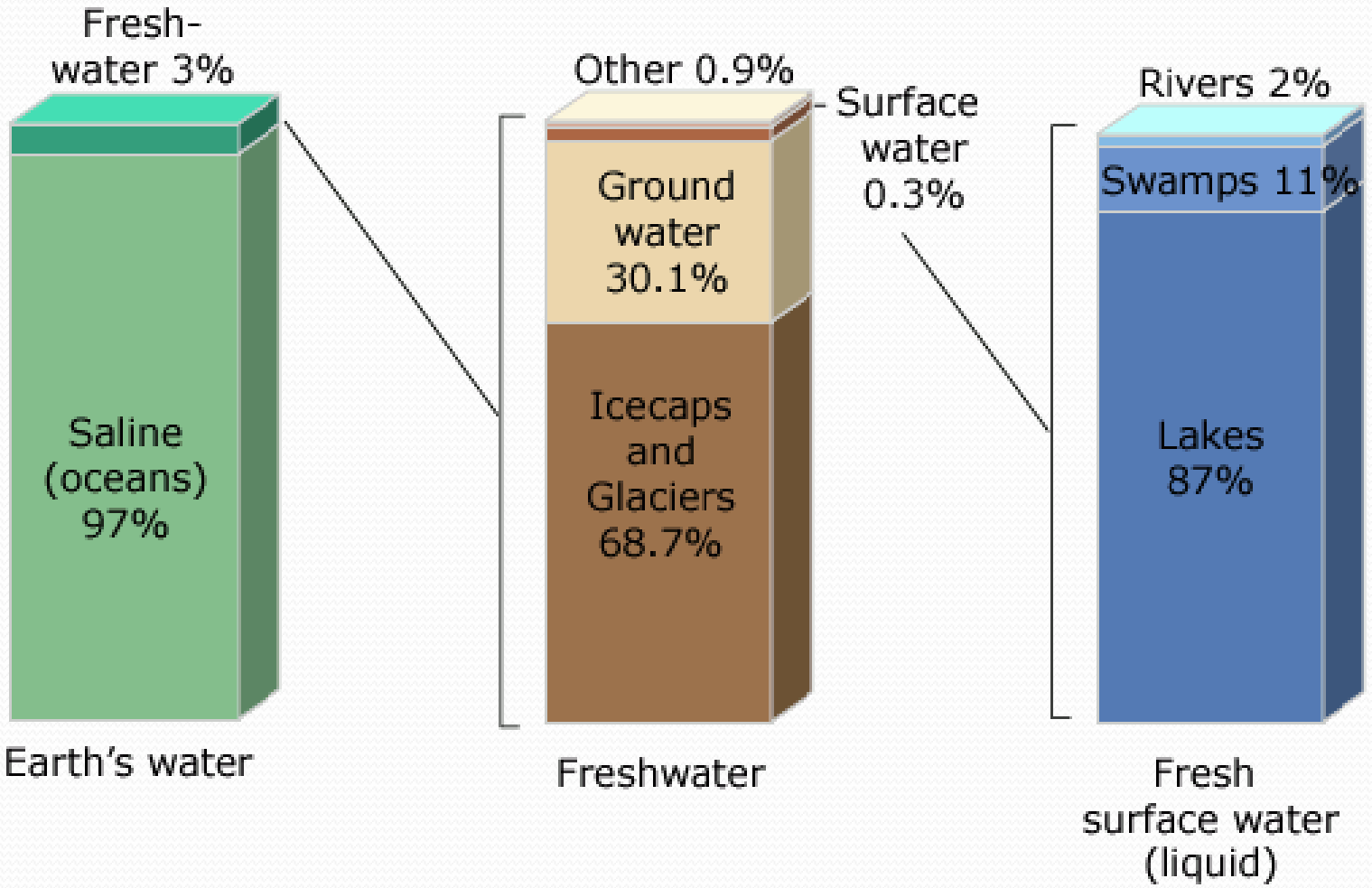
Distribution of Earth's water



Consequence of pollution

2 types of water pollutants

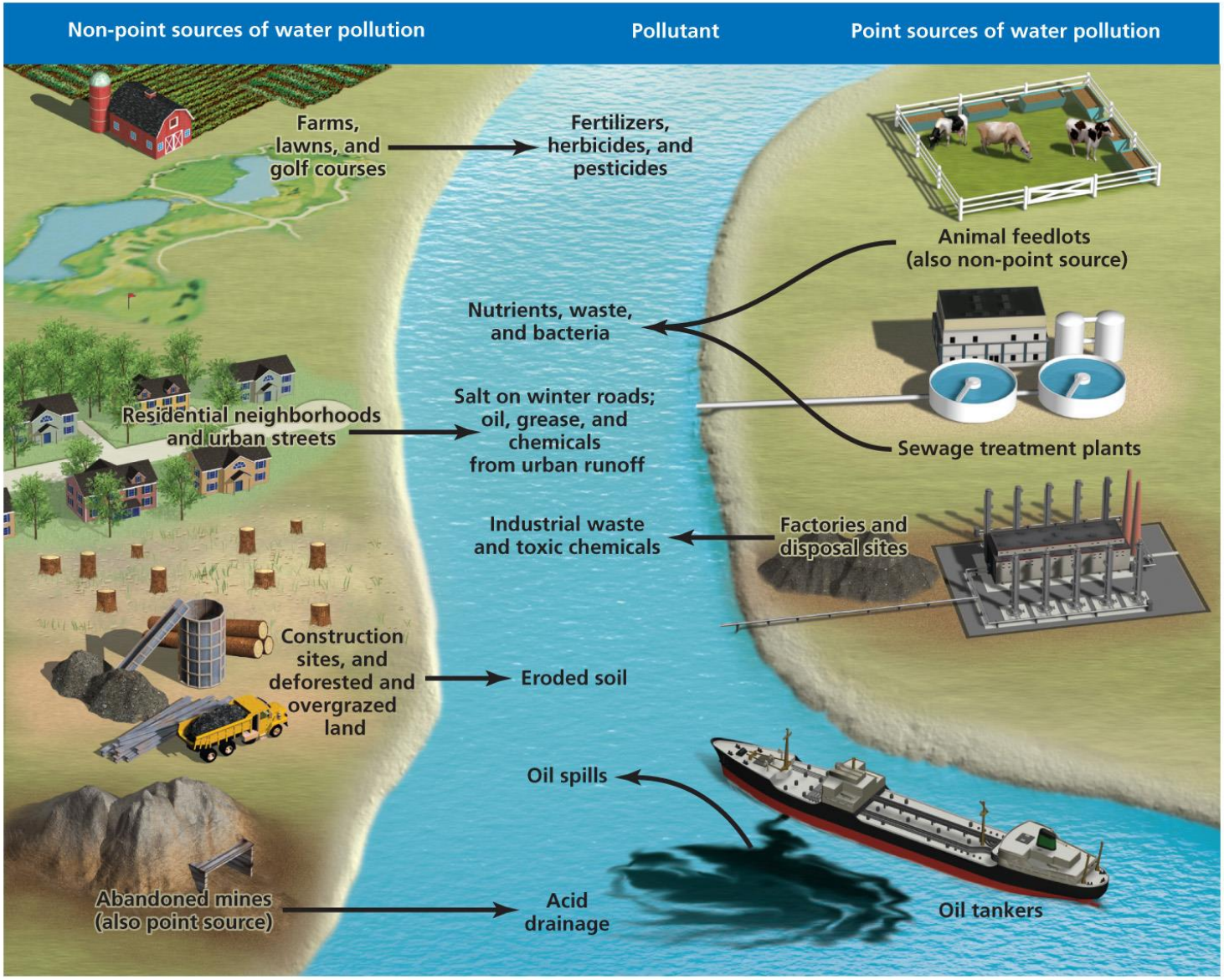
POINT SOURCES

- pollution of our water resource can occur directly from sewer outfalls or industrial charges

- occur when harmful substances are emitted directly into a body of water.

Ex: Oil spill best illustrates a point source water pollution.

Freshwater pollution sources



NONPOINT SOURCES

- indirectly from air pollution or agricultural or urban runoff.

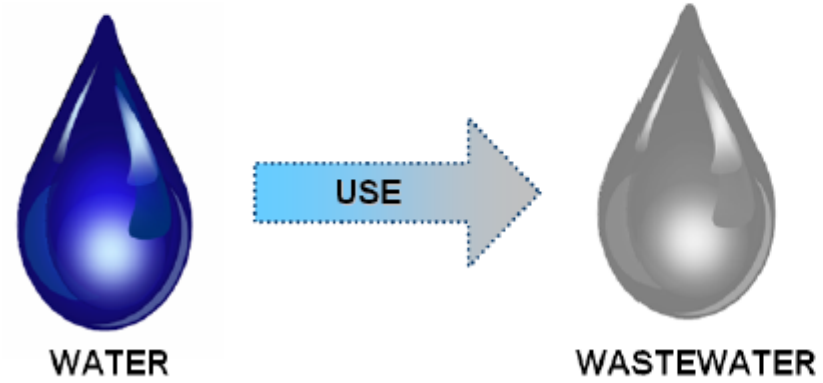
- delivers pollutants indirectly through environmental changes.

Ex:
when fertilizer from a field is carried into a stream by rain, in the form of run-off which in turn effects aquatic life

What is wastewater?

- Wastewater is used water

Water is used for many purposes. Water that has been used and contains domestic, industrial, institutional and commercial waste products is called ***wastewater***.



- Wastewater requires treatment before it can be returned to the environment or reused.
- Another common term for municipal wastewater is ***sewage***.

Domestic Wastewater

- ***Domestic wastewater*** (from homes) includes toilet waste and water used for laundry, bathing, and dishwashing.
  - In Istanbul, each person produces about 170 L wastewater/day

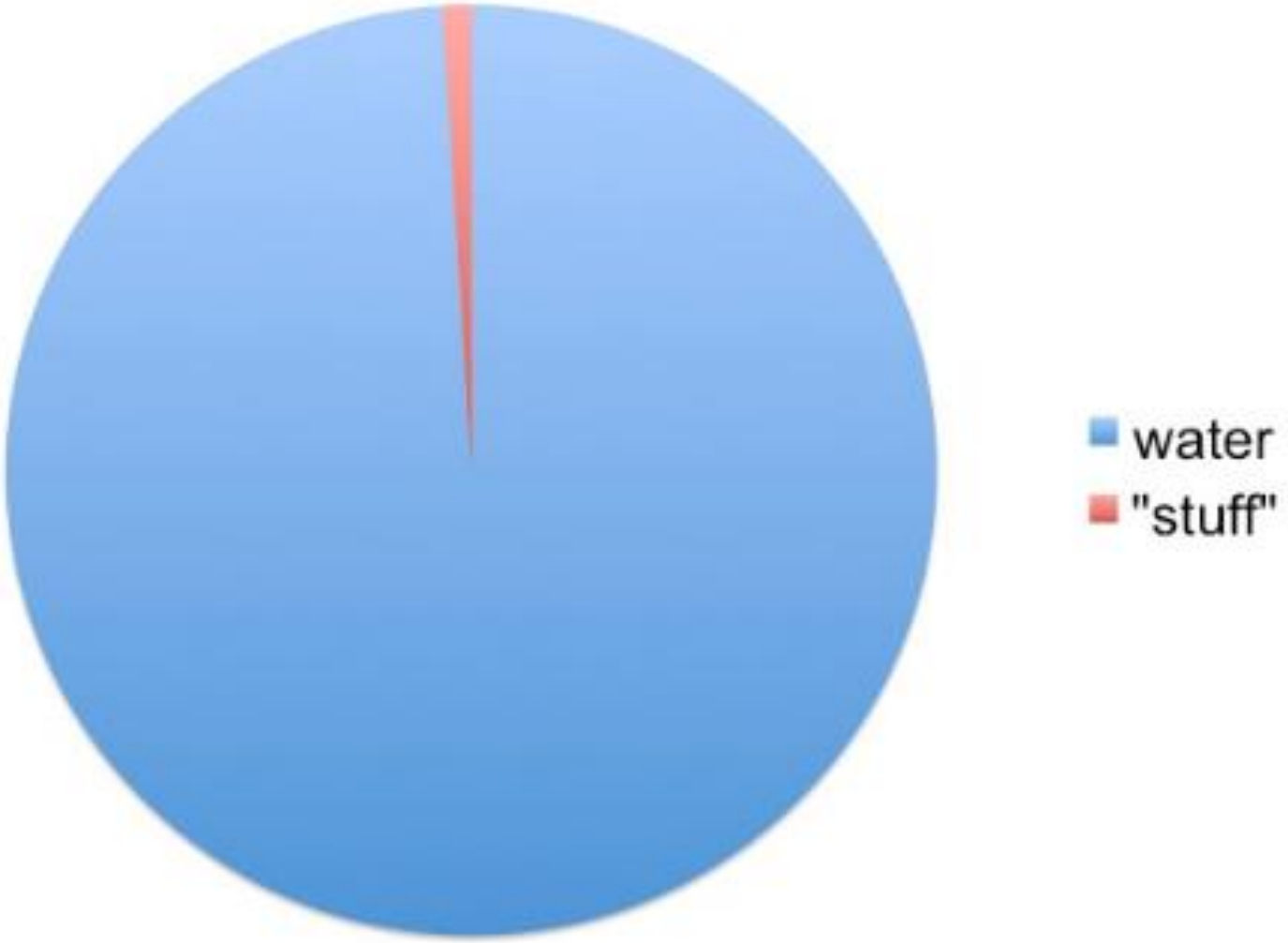
Where does wastewater go? How does it get there?

- All sources of wastewater in a sewage service area are connected to sewers, which join together to form a network called a ***collection system*.**
- The collection system leads to a wastewater treatment plant

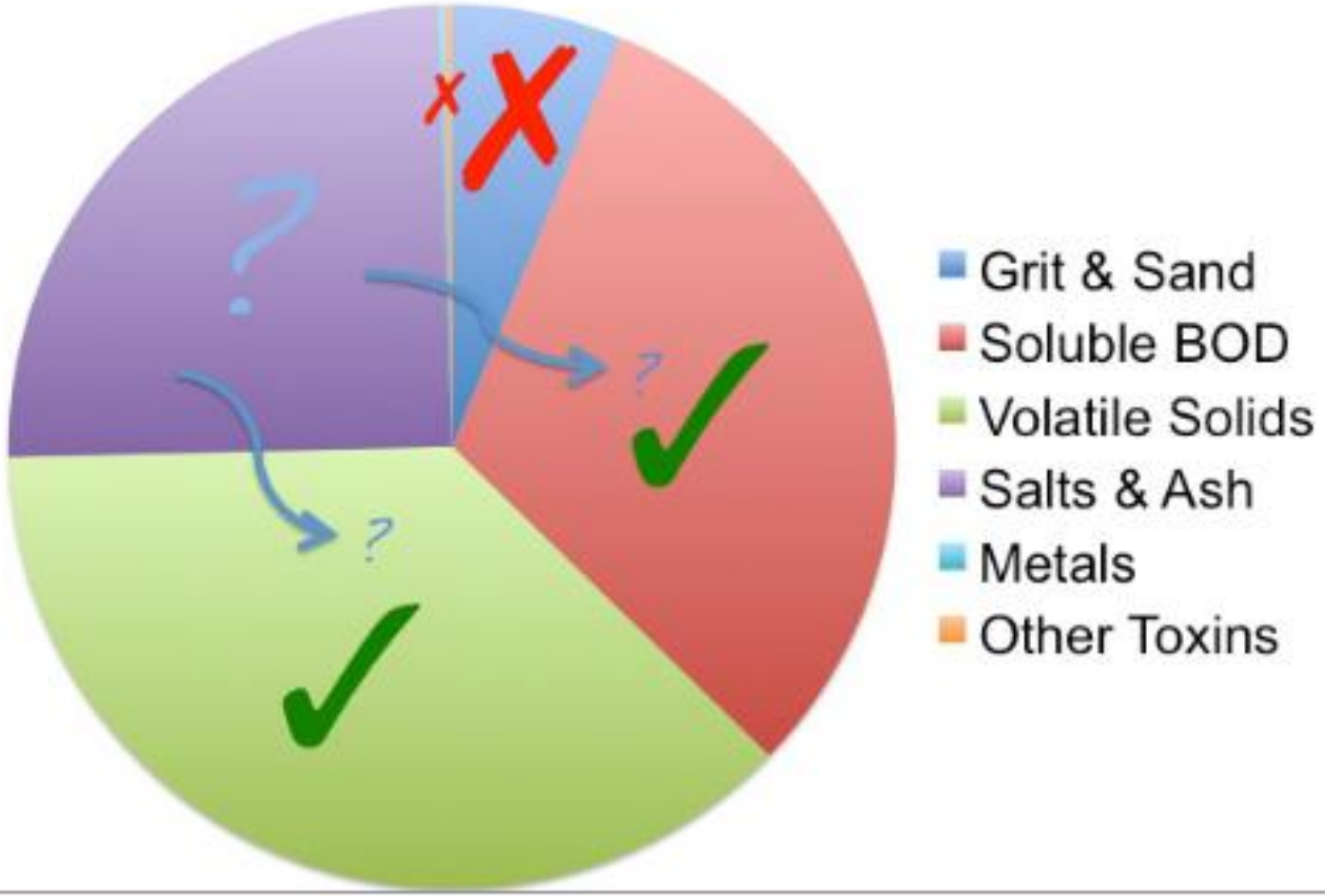
Why do we need to treat wastewater?

- Wastewater treatment is important to remove constituents or contaminants that could harm people or the environment.
- Common constituents in domestic wastewater are:
  - Organics
  - Solids
  - Nutrients
  - Pathogens

So, What's in Wastewater?



OK, What's in "The Stuff"?



Chemical Characteristics

- Organics: Predominant biodegradable fraction, BOD

  -Protein -Fats, Oils, and Greases

  -Carbohydrates -Surfactants (detergents)

  -Urea

- Priority pollutants
  - Industrial solvents, pesticides, etc.
  - Pre-treatment standards control concentrations to trace levels

Organic Matter

- 90% are proteins and carbohydrates
- sources of biodegradable contaminants are excreta and urine from humans, food wastes from sinks, soil and dirt from bathing, washing and laundering
- various parameters are used as a measure of the organic strength of wastewater.
  - BOD
  - COD
  - TOC

Measurement of organic strength of wastewater

1. **TOC (**total organic carbon) – determined by measuring the amount of CO_2 produced when the organic carbon in the sample is oxidized by a strong oxidizing agent and comparing with the amount in a standard of known TOC
2. **COD** (chemical oxygen demand) – the measured amount of oxygen needed to chemically oxidize the organics present

3. **BOD** (biochemical oxygen demand) – measures how fast organisms use oxygen in water, and indicates amount of organic material in raw wastewater and effluent.

Chemical Characteristics cont.

- Inorganic Matter
  - **Nitrogen: from protein and urea.**
    NH_2, NH_3, NH_4^+ forms ammonia and organics.
    An essential nutrient for growth of bacteria.
  - Oxygen Demand:
    $NH_4^+ + 2O_2 = NO_3^- + 2\,H^+ + H_2O$

Chemical Characteristics cont.

- Phosphorous: phosphate (PO_4^{-3})
  - Inorganic-detergents
  - organic-food and metabolic wastes

- Trace nutrients: S, Fe, Mn, Mg, Ca, K, Zn, Mo, etc. . . . . plentiful

Chemical Characteristics cont.

Chlorides and sulfates – normally present in water and in wastes from humans

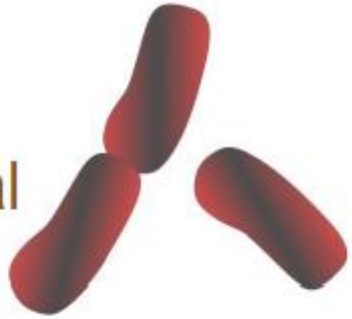
Nitrogen and phosphorus – forms in wastes from humans, with additional phosphorus detergents

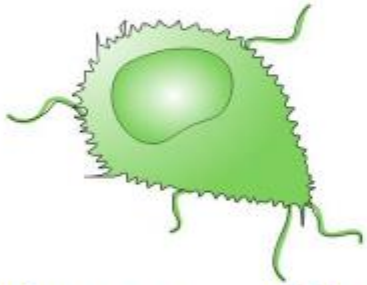
Carbonates and bicarbonates – normally present in water and wastes as calcium and magnesium salts

Toxic substances – arsenic, cyanide, and heavy metals found in industrial wastes

- "Most" microorganisms known to microbiologists can be found in domestic wastewater.

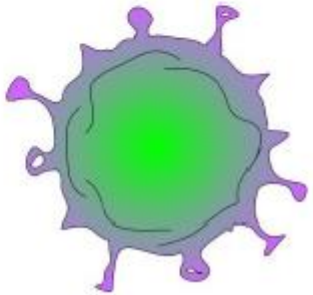
- Bacteria - Many types of bacteria are excreted in human feces and some, like *Salmonella* and *E. coli*, have the potential to cause disease.





- Protozoa - Disease-causing protozoa like *Cryptosporidium* and *Giardia* may be found in wastewater.

- Viruses - More than 100 different types of viruses capable of causing disease are excreted by humans.



WATERBORNE BACTERIAL DISEASES:

- *Cholera*
- *Typhoid*
- *Tuberculosis*

VIRAL DISEASES:

- *Infectious hepatitis*
- *Protozoan-caused dysentery*

Solids

- The total solids (organic plus inorganic) in wastewater.

"SEWAGE"

- Domestic wastewater is the ideal mixture of biodegradable nutrients for microorganisms:
  - BOD (organics)
  - Nitrogen (N)
  - Phosphorus (P)
  - Miscellaneous Micronutrients (S, Fe, Ca, . . .)
  - Bacteria

TABLE 3-16
Typical composition of untreated domestic wastewater

Contaminants	Unit	Concentration		
		Weak	Medium	Strong
Solids, total (TS)	mg/L	350	720	1200
Dissolved, total (TDS)	mg/L	250	500	850
Fixed	mg/L	145	300	525
Volatile	mg/L	105	200	325
Suspended solids (SS)	mg/L	100	220	350
Fixed	mg/L	20	55	75
Volatile	mg/L	80	165	275
Settleable solids	mL/L	5	10	20
Biochemical oxygen demand, mg/L: 5-day, 20°C (BOD_5, 20°C)	mg/L	110	220	400
Total organic carbon (TOC)	mg/L	80	160	290
Chemical oxygen demand (COD)	mg/L	250	500	1000
Nitrogen (total as N)	mg/L	20	40	85
Organic	mg/L	8	15	35
Free ammonia	mg/L	12	25	50
Nitrites	mg/L	0	0	0
Nitrates	mg/L	0	0	0
Phosphorus (total as P)	mg/L	4	8	15
Organic	mg/L	1	3	5
Inorganic	mg/L	3	5	10
Chlorides[a]	mg/L	30	50	100
Sulfate[a]	mg/L	20	30	50
Alkalinity (as $CaCO_3$)	mg/L	50	100	200
Grease	mg/L	50	100	150
Total coliform[b]	no/100 mL	10^6–10^7	10^7–10^8	10^8–10^9
Volatile organic compounds (VOCs)	μg/L	<100	100–400	>400

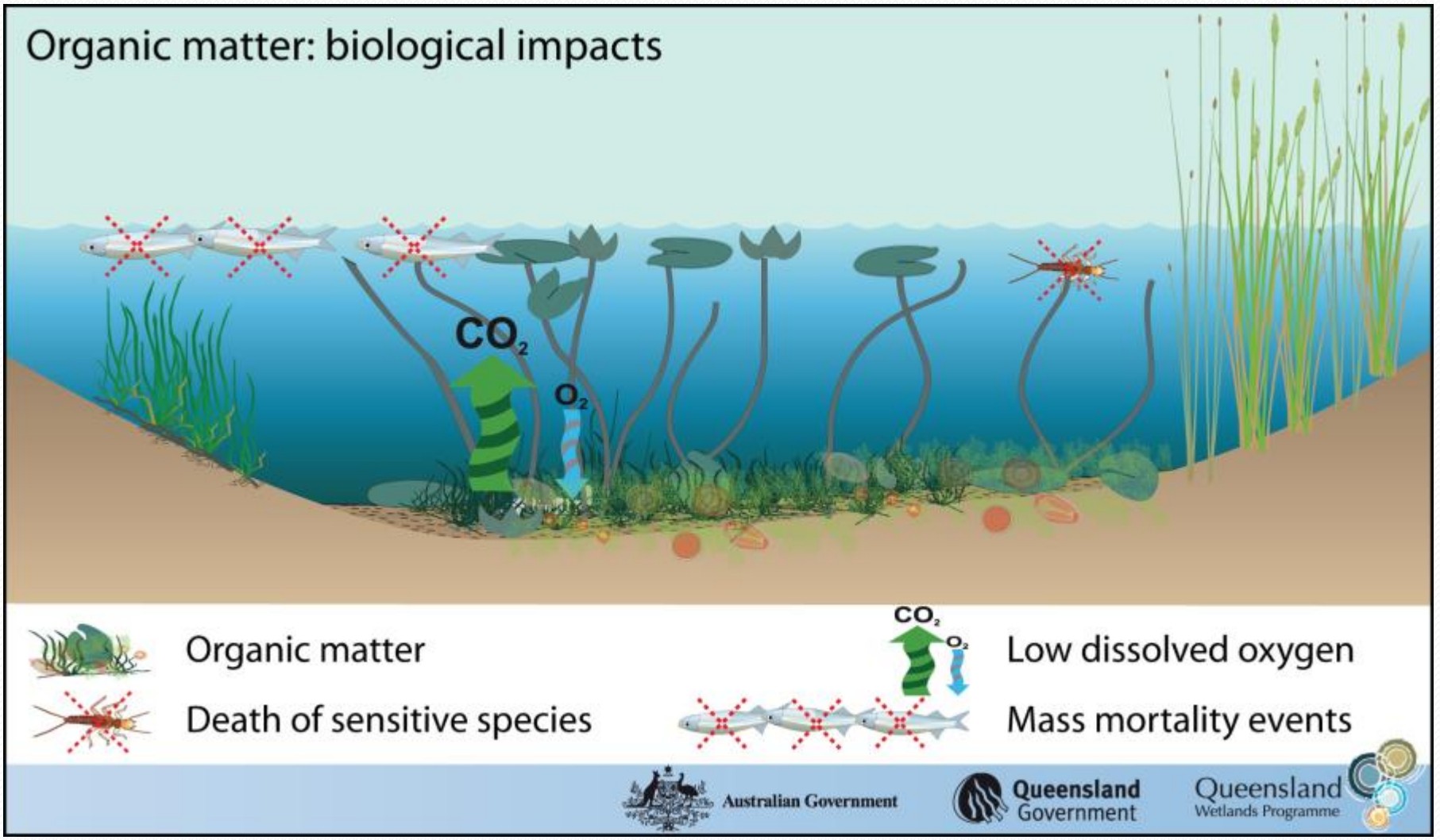
[a] Values should be increased by amount present in domestic water supply.

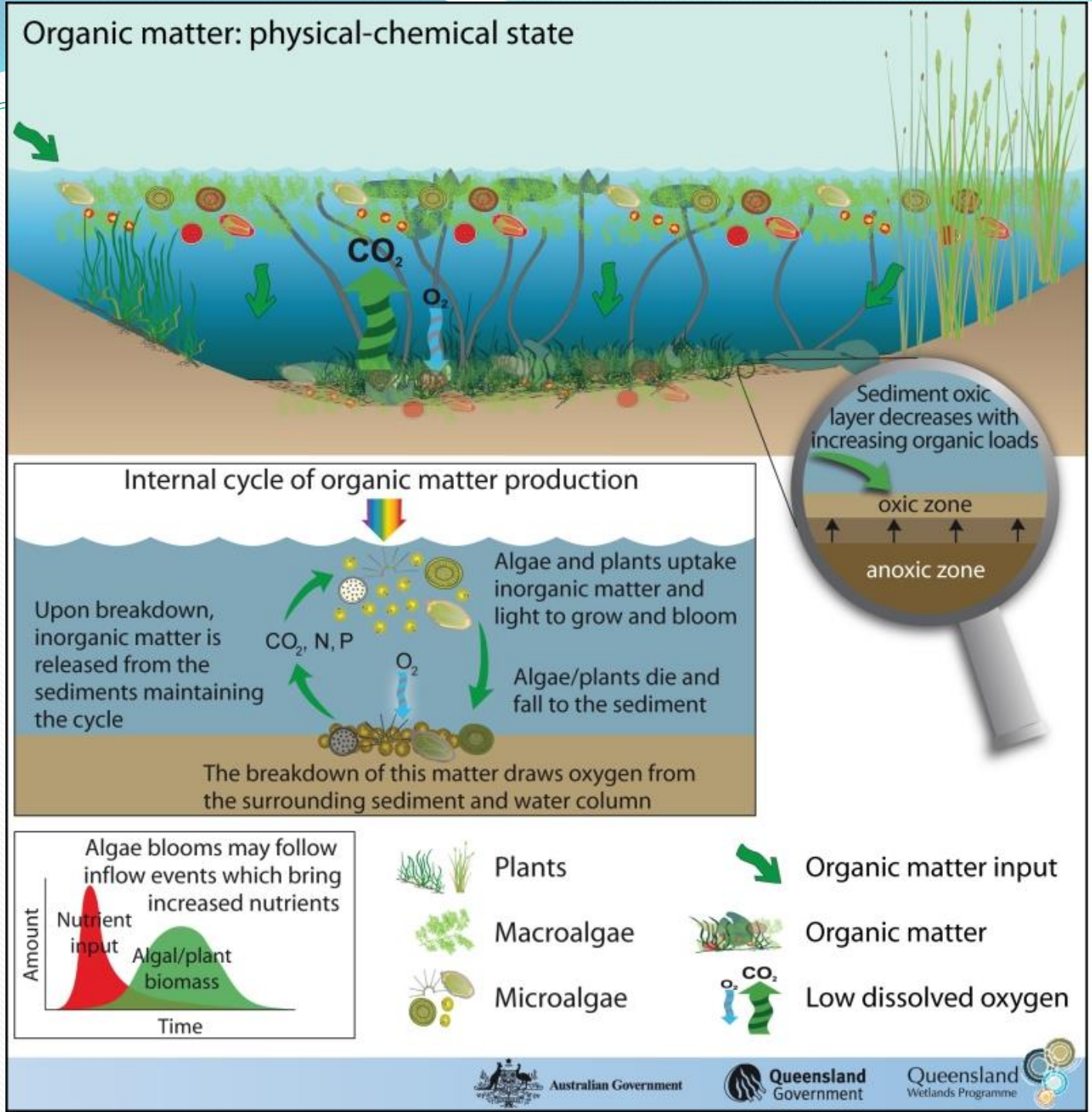
[b] See Table 3-18 for typical values for other microorganisms.

Note: 1.8(°C) + 32 = °F.

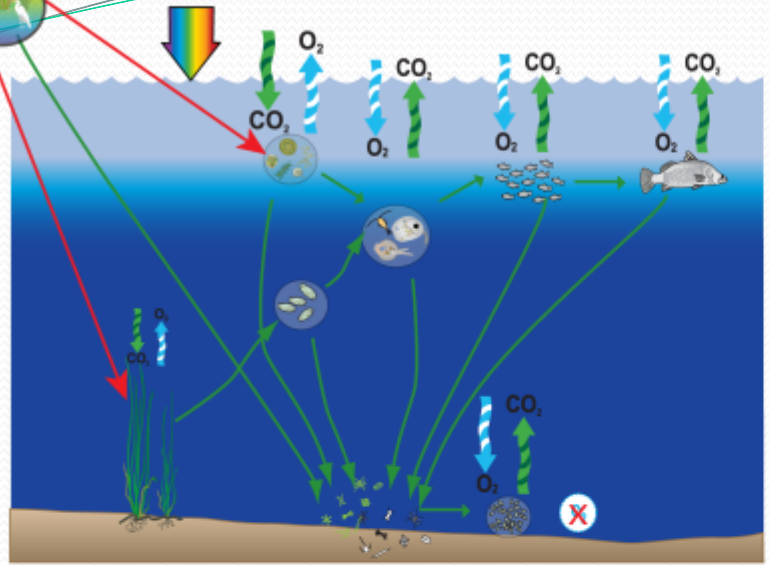
What happens to treated wastewater?

- Treated wastewater (effluent) may be discharged to a nearby water body such as a stream or lake.
- It may also be reused, for example, for irrigation or industrial processes

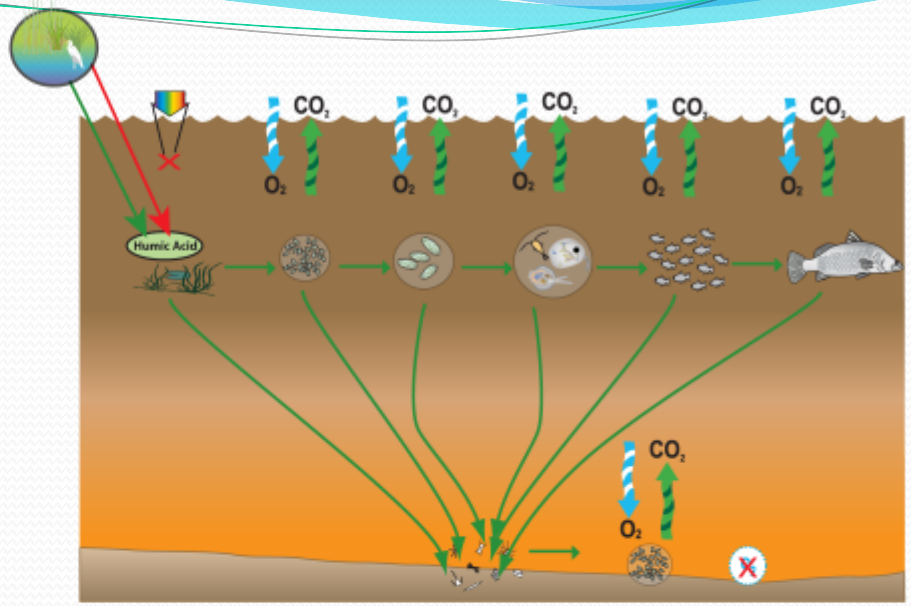

Organic matter: biological impacts
CO_2
O_2
Organic matter
Death of sensitive species
CO_2
O_2
Low dissolved oxygen
Mass mortality events
Australian Government
Queensland Government
Queensland Wetlands Programme


Organic matter: physical-chemical state
CO_2
O_2
Sediment oxic layer decreases with increasing organic loads
oxic zone
anoxic zone
Internal cycle of organic matter production
Algae and plants uptake inorganic matter and light to grow and bloom
Upon breakdown, inorganic matter is released from the sediments maintaining the cycle
CO_2, N, P
O_2
Algae/plants die and fall to the sediment
The breakdown of this matter draws oxygen from the surrounding sediment and water column
Algae blooms may follow inflow events which bring increased nutrients
Amount
Nutrient input
Algal/plant biomass
Time
Plants
Macroalgae
Microalgae
Organic matter input
Organic matter
CO_2
O_2
Low dissolved oxygen
Australian Government
Queensland Government
Queensland Wetlands Programme

Carbon Cycle – Grazing Food Chain and Terrestrial Organic Food Chain



Carbon Cycle – Detritus Food Chain



Water clarity can have an impact on food web processes– clear water allows aquatic photosynthesis while turbid water can provide a source of carbon in the form of particulate matter or Coloured Dissolved Organic Matter (CDOM such as *Melaleuca* tannins).

Where sunlight can enter waterbodies, plant growth (including phytoplankton) can occur. Plants can capture carbon from the atmosphere and therefore provide a carbon source for the aquatic ecosystem

CO_2

In waterbodies where there is only very limited light penetration (e.g. due to turbidity or CDOM) very little plant growth can occur and ecosystems rely more on external sources of carbon

Flow of Carbon

CO_2 Inflow - photosynthesis

Outflow - respiration CO_2

Flow of oxygen

O_2 inflow - respiration,

outflow - photosynthesis O_2

Nutrients can enter the food chain from sources within the waterbody, from ecosystems fringing the waterbody and from the catchment.

Submerged and emergent vegetation provide a source of carbon and oxygen when photosynthesising and can be the basis of aquatic food webs

Humic Acid

Detritus (dead organisms and other particles of organic matter) and dissolved humic substances, both of which can come from a mixture of sources within the wetland and nearby the wetland, form the basis of the detritus food web

Aerobic and anaerobic bacteria consuming detritus

Pytoplankton photosynthesis in the presence of sunlight and nutrients, capturing carbon from the atmosphere and providing a source of carbon for the food web

Microzooplankton - graze on phytopankton

Zooplankton - graze on microzooplankton

Fish that eat plankton and other aquatic plants

Fish that eat other animals

Dead zooplankton and algae and other dead organisms and detritus from the waterbody food web and zooplankton faeces accumulated/ buried in the sediment

Low dissolved oxygen