- 2.5 ï
Aquatic Ecosystems
2-5 AQUATIC ECOSYSTEMS

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Online Module Water Quality Assessment
An **aquatic ecosystem** is any watery environment, from small to large (*i.e.* from ponds to oceans), running or still (rivers or lakes) that contain a group of interacting organisms (plants, animals, microbes) that are dependent on one another and their water environment for energy and food (carbon), nutrients (*e.g.* N, P) and shelter.

Aquatic ecosystems are features in the landscape that participate in the processing and transport of materials from continents to oceans.

Aquatic ecosystems are sources of biodiversity, and they sustain livelihood and economic activities around the world.
Therefore, the health of aquatic ecosystems is critically important to downstream ecosystems (i.e. what happens upstream affects downstream), and in turn the health is critically important to the well-being and sustainability of food and economic resources of many people world-wide.
Food chain or food webs

Phytoplankton → zooplankton → fish → birds/man

Energy flow through the trophic layers

- Producers
- Consumers
- Predator-prey interactions
At the bottom of a food chain, we find the primary producers (algae; plants) which take their energy from sunlight and use it in photosynthesis; simplified:

\[
\text{Light} \quad \text{algae} \\
\text{... CO}_2 + ...\text{H}_2\text{O (+P, N,..)} \rightarrow ...\text{CH}_2\text{O..P..N.. + .. O}_2
\]

The reverse reaction, respiration "wins" at night and can lead to very low O\textsubscript{2} contents \(\rightarrow\) fish kills, in the early morning.

During the day, CO\textsubscript{2} (=acid) is used up, so the water gets high pH (>9-10). This will also lead to shift of NH\textsubscript{4}\textsuperscript{+} \(\rightarrow\) NH\textsubscript{3} (see Course 3) toxic
Producers

- At the bottom of the food chain
- Take energy from sunlight
- Phytoplankton
- Are highly dependent on available nutrients
Cyanobacteria
Blue-green algae

filamentous colonies

HETEROCYSTS

Anabaena sp.

Chlorophyta
Green algae

Chlamydomonas sp.

Ulothrix sp.

Chroococcus sp.
Euglenophyta
Euglenids

Chrysophyta
Golden-brown algae

Euglena sp.

Phacus sp.

Cyclotella
Stephenodiscus

Fragilaria

Diatom sp.
Consumers

- next trophic level
- take energy by consuming producers
- zooplankton, *e.g.* *daphnia* (‘water flea’)
Food chain or food webs

Energy flow through the trophic layers

Producers
Consumers
Predator-prey interactions

Bottom-up (1) or top-down (2) regulating mechanisms;
1: light, nutrients..
2: e.g. predators
## Eutrophication/Trophic states

<table>
<thead>
<tr>
<th>Trophic status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligotrophic</td>
<td>Clear waters with low nutrients contents and, therefore, minimum biological activity</td>
</tr>
<tr>
<td>Mesotrophic</td>
<td>Water with more nutrients, and therefore, more biological productivity</td>
</tr>
<tr>
<td>Eutrophic</td>
<td>Waters extremely rich in nutrients, with high biological productivity. Some species may be choked out.</td>
</tr>
<tr>
<td>Hypereutrophic</td>
<td>Murky, highly productive waters, closest to the wetland status. Many clearwater species cannot survive.</td>
</tr>
<tr>
<td>Dystrophic</td>
<td>Low in nutrients, highly coloured with dissolved humic organic material.</td>
</tr>
</tbody>
</table>
Oligotrophic lake
Mesotrophic lake
Eutrophic lake
Diel cycles

- **Daytime**: net $O_2$ production $\rightarrow$ often $\text{supersaturation} (>100\%)$
- **Night**: $O_2$ consumption; (very) low oxygen contents $\rightarrow$ fish kills

Dissolved oxygen in the river Dender at Geraardsbergen.

- Similar pH cycle with high values (up to $> 9-10$) during daytime, and around 7 at night
Redfield \( ð \) N:P ratios

Algae require nitrogen and phosphorus in specific N:P ratio

\[ \text{Algae, roughly,: } C_{106}N_{16}P \quad \text{N:P}=16:1 \text{ (molar)} \]
\[ \text{N:P } = \text{ about } 10:1 \text{ (g/g)} \]

Thus when N:P < 10: = N-limited
When N:P > 10: = P limited

P limitation mostly in rivers and lakes; N limitation in many coastal waters, estuaries

One can check limiting factor by looking at results of N, P additions in the lab, or in the field: ñwhole lake experimentsñ

Redfield (1958)
The biological control of chemical factors in the environment
The American Scientist, 46(3):205-221
Established in 1968
Consists of 58 small lakes and their watersheds and a year round field station
Establishment of this research station marked the beginning of an on-going tradition of whole-ecosystem manipulations, including lake acidification, metals especially Hg
Whole-Lake Experiment

Lake 227 - ELA

Schindler (1974)
Excessive nutrients --> extreme productivity --> increased photosynthesis rates --> pH increase --> decreased solubility of CaCO$_3$ --> precipitation