**Eutrophication**
Supplemental Material for Instructors – Memory/Domino and Kahoot! online games

Eutrophication is what happens to large bodies of water, when larger amounts of nutrients make their way into the water. Most of the sources for additional nutrients are anthropogenic – that means they are caused by human activities.
For example, humans use agriculture and animal husbandry to fulfil their food needs. Larger populations or more food consumption means that more food production is necessary.

More food production means that more fertiliser is used and the more animals are kept, which in turn also need more feed.
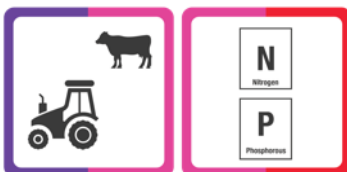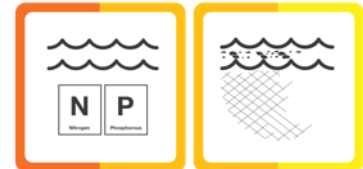
Both add to the amount of nutrients on the fields, which can be washed into rivers by rain.

The rivers then bring the nutrients to the larger bodies of water, such as the Baltic Sea.

The first effect that the excess nutrients have is that the water becomes murkier and begins to lose transparency. The degree to which the water loses transparency is measured by turbidity.

The more suspended particles are in the water, the higher the turbidity is.

Other effects of eutrophication:
- *The rapid growth of phytoplankton blocks sunlight from entering the water causing some subaquatic vegetation to die.*
- *Some common species are:*
  - *Blue-green algae - which can be toxic to humans and animals*
  - *Zostera Marina - common eelgrass*
  - *Dinoflagellate - causes red tides which are toxic [1]*
  - *Pylaiella Littoralis - brown algae*
- *Species diversity is reduced due to a change in species composition in bottom dwelling aquatic communities.*
- *Coral reefs are damaged because the nutrient levels favor algae growth over coral larvae.*
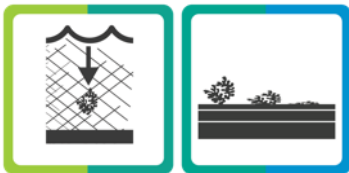
One of the following effects is a phenomenon called Algal bloom – or a rapid increase in the population of algae in the water.
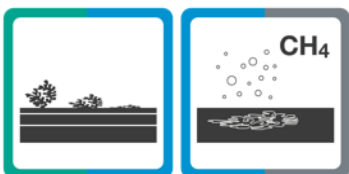
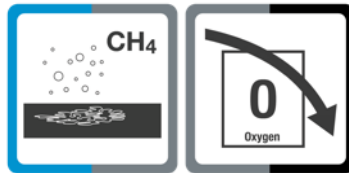The excess algae fall to the bottom of the water.

There the algae begin to accumulate and rot.

As it is covered by other layers the decomposition process turns into an anaerobic process – meaning it takes place under the absence of oxygen.

Although the process is anaerobic, the bacteria also quickly use up any oxygen that comes near it.

This creates so-called "dead zones" in the water, in which it is impossible for marine life to exist.
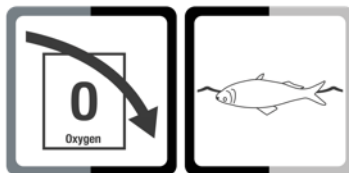
Our health and well-being are tied to the well-being of our environment.

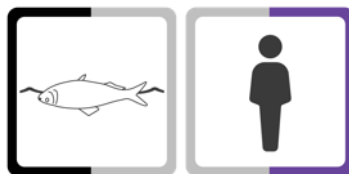Image: Lynn Betts, photographer / Public domain

Image: By Alexandr Trubetskoy – Own work, CC BY-SA 3.0

In more detail:
There are a few parameters used to indicate the degree of eutrophication in a given marine area. These parameters are [2]:

- *Nutrients*
- *Chlorophyll*
- *Visibility or Turbidity*
- *Biological water quality*

You can find more information on each parameter on the next page.

Nutrients

The main nutrients that lead to eutrophication are nitrogen and phosphorus. They cause phytoplankton present in bodies of water to grow and multiply.

The main sources of excess nutrients come from [3]:

- *Agriculture*
- *Human sewage*
- *Urban run-off*
- *Industrial effluent*
- *Fossil fuel combustion*

Combustion from industries and transport releases nitrogen into the atmosphere that can be carried by the winds and deposited in other bodies of water. This process is known as atmospheric deposition and is one of the main anthropogenic inputs of nitrogen. [4]

We can measure eutrophication by the total phosphorus and the total nitrogen in the water. [2]

Chlorophyll

Algae are similar to plants and use sunlight and oxygen to grow and multiply. We can measure eutrophication by measuring the concentration of chlorophyll a. [2]

Visibility or Turbidity

Turbidity is the optical determination of water clarity. Excessive algal blooms will create turbid waters making sunlight unable to penetrate to the bottom.

Turbidity effects water quality in the following ways:
Causes a decrease in the amount of light for water plants,
Can also increase the temperature because suspended particles absorb heat,
Affects marine life by clogging fish gills and making it difficult for them to hunt in turbid waters.

Biological water quality [2]

This indicator is based on the present organisms (species and numbers) living in that body of water. Some species, which are less sensitive to the nutrient ratio will outcompete those, which are sensitive.

Sources:

[1] University of Berkeley Introduction to Dinoflagellate [accessed on 02.06.2020]
[2] Iseca. How to measure Eutrophication [Accessed on 02.06.2020]
[3] World Resource Institute (2008). Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge
[4] Ospar Commissions (2010). The Quality Status Report. Chapter 4, Eutrophication [Accessed on 03.06.2020]
[5] Caitlin Pilkington (2019): Eutrophication in coastal environments. Available from http://www.coastalwiki.org/wiki/Eutrophication_in_coastal_environments [Accessed on 04.06.2020]
[6] Helcom - Baltic Marine Environment Protection Commission [Accessed on 02.06.2020]

Instructions for the Memory/Domino game

The Memory/Domino game can be played similar to memory – only the pairs are based on the steps before and after them, which can be identified by the "connecting" colours. Once a pair has been found, the students can explain how they relate to one another as described above.

**Instructions for Kahoot!**

The Kahoot! quiz game can be found here.
Kahoot! can be played alone or with a class. If it is played alone the best method is to select "Preview".
If you play in a group, the instructor clicks on "play" and controls the game while the students play on the Kahoot! app on their smartphones.
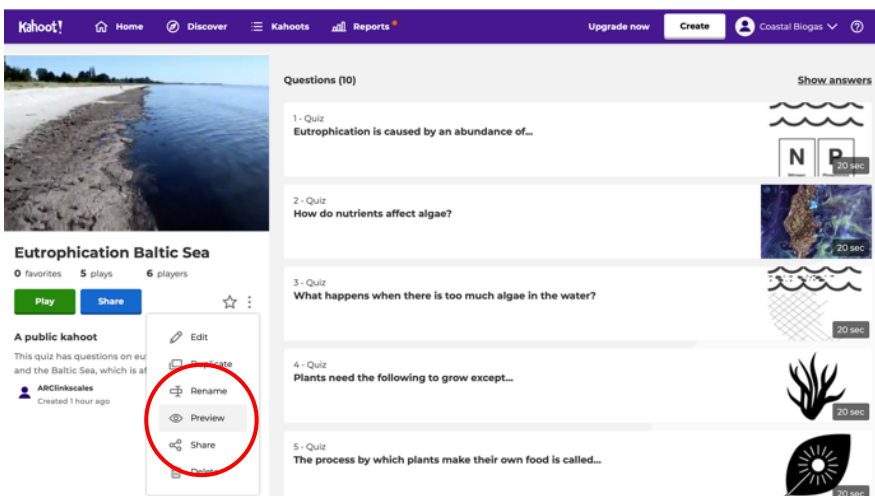
If playing alone the screen will show the game PIN and a smart phone as a game console. Copy the PIN into the field in the on-screen smartphone. If the students are playing with the Kahoot! app, they will enter the PIN on their devices. The instructor will click on "play" and "teach" and typically select the "classic" mode.
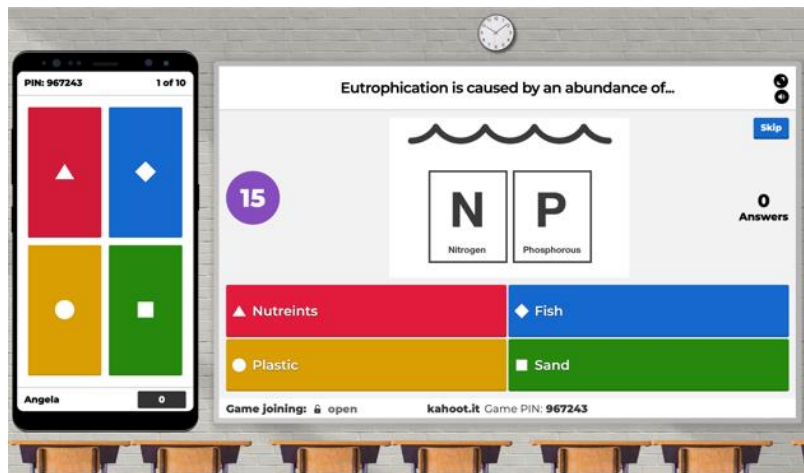

Single players:
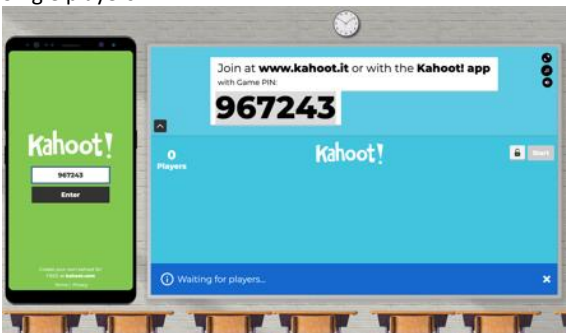
In a group:

After entering the PIN, the players are asked to enter a nickname. Then the game begins. The students select the answer in the field that looks like a smartphone or on their own device. If multiple players are playing, the students will be able to compete.
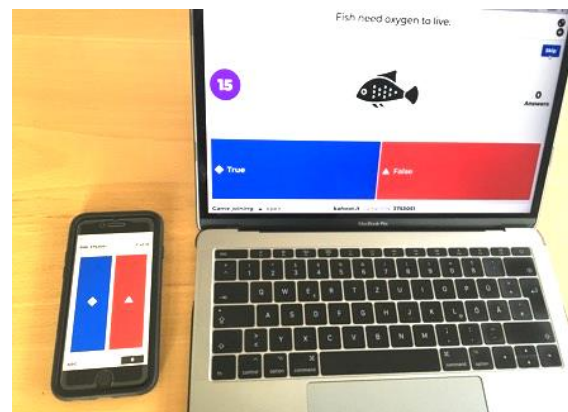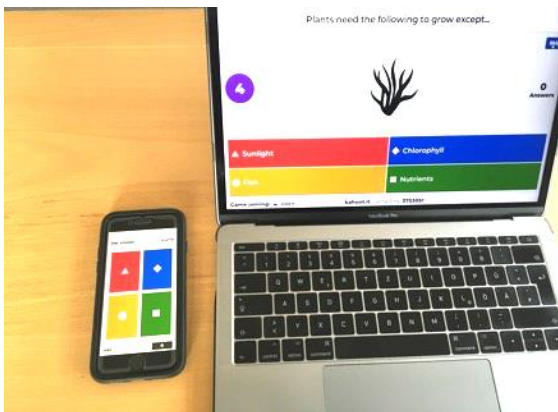

Try it out!

Kahoot! quiz questions and answers

1. Eutrophication is caused by an abundance of…
   a. <u>Nutrients</u>
   b. Fish
   c. Plastic
   d. Sand

2. How do nutrients affect algae?
   a. <u>They make them grow</u>
   b. They make them decompose
   c. They make them poisonous
   d. None of the above

3. What happens when there is too much algae in the water?
   a. The water becomes clearer
   b. <u>The water becomes murkier</u>
   c. The water turns purple
   d. All of the above

4. Plants need the following to grow except…
   a. Sunlight
   b. Chlorophyll
   c. <u>Fish</u>
   d. Nutrients

5. The process by which plants make their own food is called…
   a. Digestion
   b. <u>Photosynthesis</u>
   c. Eutrophication
   d. None of the above

6. True or False. Seaweed is not algae.
   - False

7. True or False. Fish need oxygen to live.
   - True

8. Which of these is a cause of eutrophication?
   a. Sunlight
   b. <u>Run-off from farmlands with fertilisers and manure</u>
   c. Seagulls and pelicans
   d. All of the above

9. The Baltic Sea is located within which continent?
    a. North America
    b. <u>Europe</u>
    c. Australia
    d. Africa
10. Which country does not border the Baltic Sea?
    a. Sweden
    b. Finland
    c. <u>The Netherlands</u>
    d. Poland

Advanced quiz:
    1. What does Eutrophication mean?
        a. Increase in dissolved oxygen in bodies of water
        b. <u>Overnutrition in bodies of water</u>
        c. Decrease in algal blooms in bodies of water
        d. Undernutrition of bodies of water
    2. Which of these are the negative impacts of eutrophication?
        a. Oxygen depletion, causing dead zones
        b. Change in species composition
        c. Algal blooms
        d. <u>All of the above</u>

3. Which of the following is NOT a main cause of eutrophication?
   a. Agriculture
   b. Fossil fuel combustion
   c. <u>Mining</u>
   d. Sewage
4. Algae decomposition leads to oxygen depletion and dead zones at the bottom of the water.
   a. <u>True</u>
   b. False
5. How does nutrient pollution affect algae? Algae uses nutrients to…
   a. Decompose
   b. <u>Multiply</u>
   c. Neither of the above
6. High levels of nutrients can also lead to…
   a. Higher levels of dissolved oxygen
   b. <u>Lower levels of dissolved oxygen</u>
7. Which of the following is an indicator for water clarity?
   a. Nutrient levels
   b. Dissolved oxygen
   c. <u>Turbidity</u>
8. Atmospheric deposition is one of the main anthropogenic inputs of nitrogen.
   a. <u>True</u>
   b. False
9. Which of these cyanobacteria is responsible for red tides?
   a. Zostera marina
   b. Pylaiella littoralis
   c. <u>Dinoflagellata</u>
   d. Fucus vesiculosus
10. Turbidity affects aquatic organisms in the following way EXCEPT…
    a. Makes it difficult for fish to hunt in turbid water
    b. Blocks sunlight for photosynthetic plants underwater
    c. <u>Blocks sunlight from entering the water and decreases the temperature</u>
    d. The turbidity particles clogs fish gills, therefore killing them as well