Quality assessment of freshwater in France and the Netherlands using a biotic index

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Observations:
Pollution is relative in many ways. For example, polluted water can affect humans but cannot harm fish. And water which looks polluted because it is not clear can be drinking water for us.
Water pollution is characterised by its cause (accidents, waste and residue elimination and over excessive use of water), its type (physical, chemical, bacteriological and radio-active), its size (local or extensive, occasional or seasonal), its source (farms and industries) (table 1) in space and time.
Table 1. Description of the types, natures and sources of pollution:

Types of pollution	**Nature of the pollutants**	**Source or causal agents**
1. Physical	Thermal pollution, hot water rejection Radioactive pollution, radio-isotopes	Electric power-stations Nuclear installations
2. Chemical	-Fertilisers : nitrates, phosphates -Metals and toxic metalloids: mercury, cadmium, lead, aluminium, arsenic, etc… -Pesticides, organic chlorine matters and other synthesized organic matters : insecticide, weed-killers, fungicides, chlorine solvent -Detergent : tensioactive agents -Hydrocarbon oils: crude oil and their derived (fuels…)	-Agriculture(washing powder) -Industry, agriculture, combustion (acids rains) -Agriculture (industry) -Domestic effluent -Oil tanker industry, transport -Industry -Industry (some with dissipation uses)
3. Organic matters	Fermentable Glucids, fat proteins, protids	Agricultural, domestic, food-processing, wooden (paper mill) effluents
4. Microbiological	Bacteria, virus, fungi	Urban effluents, breeding, food-processing sector
5. Biological	Pollution by the migration of exotic species, disturbing local species	Boats throw water which comes from a different zone and contains different species out in an area.

Water pollution is also characterised by its consequence (for example in the case of animals and plants).
Between 1976 and 1991, the toxic matter rejections decreased by 62%. The agglomeration rejects 49% of these matters, which can be oxides, contained in the used water. The new processes to eradicate pollutants are the

elimination of nitrates and nitrites, the using of activated carbon against the pesticide, and the membrane filtration.
Pollution can seriously disturb and poison, not only the current fauna and flora, but also other animals of the food chain. To control polluted areas as best as we can, and prevent these consequences, we must first identify the affected zones, and the degree of pollution that they contain.

In fact, the concern for environmental protection dates back to much longer than we can think of. The Liebig's law had indeed been made in 1840 :
The Liebig's law of the lowest limit required of essential materials means that The growth of an organism is dependent on the amount of essential material which is presented to it in the minimum quantity, applicable only under steady-state conditions (i.e. when matter and energy inflows and outflows are balanced and the material that is "limiting" does not change from one material to another).
Leibig's Law was extended by **Shelford** (1913) to describe not only the lowest limit required of essential materials, but also the upper limit of tolerance of these materials. Organisms have an ecological minimum and maximum which represent the limits of tolerance. (See the bibliography)
We have organisations which supervise industries and people in order to ensure that they respect the laws. The Federal Republic of Germany, **France**, Luxembourg, the **Netherlands** and Switzerland, respect the same Convention Concerning the Frontier Waters Against Pollution, conventions which date back to 1972.
"When congress passed the Clean Water Act in 1972, states were given primary authority to set their own standards for their water. In addition to these standards, the act required that all state beneficial uses and their criteria must comply with the "fishable and swimmable" goals of the act. This essentially means that state beneficial uses must be able to support aquatic life and recreational use. Because it is impossible to test water for every type of disease-causing organism, states usually look to identify indicator bacteria. An example of this is a bacterium known as faecal coliform. These indicator bacteria suggest that a certain selection of water may be contaminated with untreated sewage and that other, more dangerous, organisms are present. This legislation is an important part in the fight against water pollution. They are useful in preventing environmental catastrophes" (see the bibliography).

Main question : How can we know the quality of water ?

Hypotheses : We can know the quality of water thanks to animals that we find in the water (by analysing the proliferation and disappearance of animal species contained in this water).

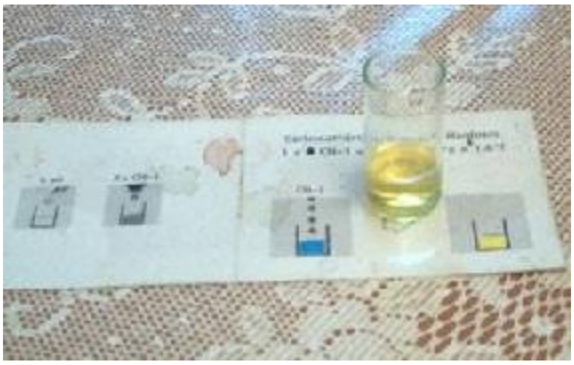
For this, we have to study biological and chemical characteristics of water.

Experiments protocols:

We will do two different lists of protocols to evaluate the quality of water. In the first list we will evaluate the content of minerals and in the second list we look for the animals which live in four different aquatic environments : a heap of manure (water which form a pool in the farmyard), a pond, a lake and a river just next to a field and so polluted by fattening food.

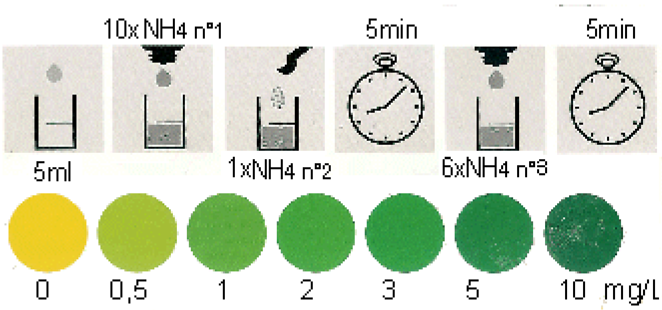
Chemical contents of the water samples :
As for each sample, we used a compact laboratory which contains reagents and accessories for the determination of: pH, ammonium, nitrite, nitrate, calcium, oxygen.

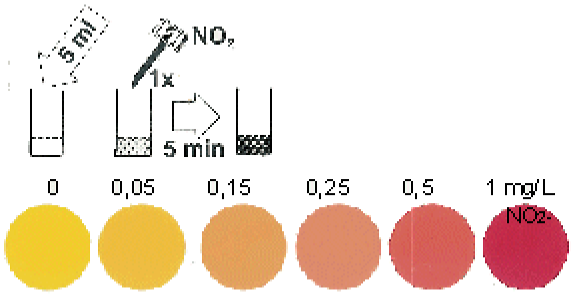
As for the pH, we took 5mL of water and we added three drop of the pH indicator. Then we had to wait for five minutes and we watched what colour it turned into. We placed the sample on a colour scale to compare and to evaluate the content of pH. Here, we have pH = 6 to 7,5 : it is a neutral pH, so a good pH.



As for calcium Ca^{2+}, if the water which runs in the ground is rich in mineral salts, water which has a lot of salts is hard : 1°d = 10mg/L of CaO = 17,8mg/L $CaCO_3$ = 7,2mg/L MgO .
So we have to add chloride hydroxide HCl (0,1N) , then the blue water becomes yellow water and each HCl drop indict 0,36mmol/L of carbonate CO_3^{2-} then of Ca (because Ca^{2+} like to be associated with CO_3^{2-})

As for ammonium NH_4^+, we added 10 drops of the first ammonium indicator and then we added one tiny spoonful of the second indicator. We waited for 5 minutes and we added of third indicator. After 5 other minutes we compared the sample's colour with the scale of colour.





As for the nitrite NO_2^-, in the sample, we added one tiny spoonful of the nitrite's indicator. After 5 minutes we compared the sample's colour to the scale.

As for nitrate NO_3^-, we added one tiny spoonful of the nitrate's indicator to the sample. After 5 minutes we placed it on the scale.

We also looked for the oxygen content with another compact laboratory: we took a sample of the water in a covered flask. We did this very carefully because we had to have water without any bubbles of air.

Then we added five drops of manganese sulphate and sodium hydroxide.

The sample turned orange.

One minute later, we added ten drops of sulphuric acid, we put the top back on and we shook the flask.

In a little glass we filled 5mL of the sample and we added one drop of the fourth reagent. The solution turned purple.

Then we took a syringe titrimetric which we filled until the graduation 0mL of titrating solution. We added the solution in the sample until it became colourless. We noticed that we needed 0.76mL of the titrating solution. This quantity is proportional to the oxygen concentration.

Since all natural waterways contain bacteria and nutrients, almost any waste compounds introduced into such waterways will initiate biochemical reactions (which will be shown later). Those biochemical reactions create what is measured in the laboratory as the Biochemical Oxygen Demand (BOD).
The so-called 5-day BOD measures the amount of oxygen consumed by biochemical oxidation of waste contaminants in a 5-day period. The total amount of oxygen consumed when the biochemical reaction is allowed to proceed to completion is called the Ultimate BOD. The Ultimate BOD is too time consuming, so the 5-day BOD has almost universally been adopted as a measure of relative effect of pollution.
We measured the content of oxygen in each sample in the dark (to stop photosynthesis of micro algae) at 15°C for five days, the temperature of the water was 15°C with apressure of 1bar, if we changed the temperature or the pressure, the results would change too.

Biological indicators of the water samples :

The pond

For a long time the testing of the quality of the water has only been done using analytical chemistry.
The quality of the water can be determined by the presence or absence, condition and number of the types of plants, fish, insects and algae. These types of organisms are called biological indicators, or for short: bio-indicators.

We visited the area and recorded general impressions of the water and surrounding area. We looked for organisms living in aquatic vegetation and in mud. We brought at least two buckets for collecting water. We used one for sorting critters from the water and mud, and then transferred them to a second bucket filled with clear water. Good indicators of water quality are the small plants and animals who live here.

The lake

We used a net which made the water turn cloudy in order to gather animals and plants in a little bottle in the various waters. The more important are benthic macroinvertebrate. Benthic means bottom dwelling: animals which are in sediments and debris at the bottom of a pond or lake. Macro means that the animal is big enough to be seen without a microscope. Invertebrate describes a whole group of critters without internal backbones, unlike you and I.

After we returned to school, we looked at the benthic macroinvertebrates that the different waters contained and put their name in a determination key. To see plankton which is micro plants and micro invertebrates, we used a microscope. We had to count each species but not each animal to use biotic index, so his or her identification had to be precise.
A definition of bio-monitoring is to map the conditions of water by taking samples and analysing the organisms which are found, just like we have done in the other experiments.
Another part of bio-indication is bio-monitoring. In stead of looking at which organisms are living in the water, the temperature and the pressure at the time of the experiments are very important. Indeed the organisms belonging to a certain type of water change with these indicators. Our sample and our experiments have been made in October. For example, we wouldn't be able to see what kind of animals are in what type of water because it is winter and so it is too cold. Animals are dead. To get correct results, it is advisable to do several experiments.

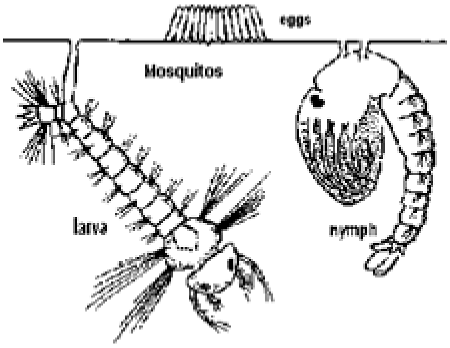
Results in France and in Netherlands

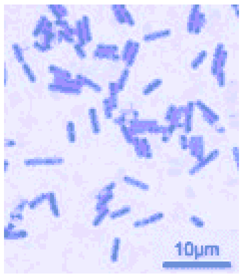
Chemical contents of the French water samples :
For our first sample which comes from **manure**, looking at the colour that the sample became we could find out their contents.
For the pH, we placed the sample on the colour scale and the colour corresponded to the content of 8,2.
For the calcium: we counted the number of droops we added to the sample until the water turned from blue to yellow. And we found 1,08 mmol/L of $CO_3$2- which correspond to 1,08 mmol/L of Ca2+.
For ammonium: the sample's colour corresponded to 5mg/L.
For nitrate: the sample's colour corresponded to 25mg/L.
For nitrite: the colour of the sample corresponded to 0,05mg/L.
For oxygen we needed 0.20mL of titrating solution. We must multiply it by 10 to find out the content of oxygen. So the content of oxygen is 2mg/L.
For BOD we obtained 5mgO_2/L, so a little concentration.
The results of the water from a **pond** are: 6,8 for the pH ; 1,8mmol/L for the calcium, 0mg/L for the ammonium, 0mg/L for the nitrate, 0mg/L/ for the nitrite, 7.6mg/L/ for the oxygen and 5mgO_2/L for the BOD.
The results of the water from the **lake** are: 7 for the pH, 2,16mmol/L for the calcium, 5mg/L for the ammonium, 0 mg/L for the nitrate, 0,5mg/L for the nitrite, 7mg/L for the oxygen and 20mgO_2/L for the BOD

so a normally concentration.
The results of the water from the **river** are: 6,5 for the pH, 2,52mmol/L for the calcium, 9mg/L for the ammonium, 68mg/L for the nitrate, 3,7mg/L for the nitrite, 6,5mg/L for the oxygen and 25mgO_2/L for the BOD.

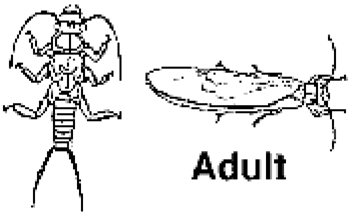
Biological indicators of the French water samples :
Most benthic macroinvertebrates are insects throughout of the stages of their life cycles. Eggs become larvae, nymphs, adults, through gradual metamorphosis. We identified those animals thanks to a determination key.

In the water which came from the manure we found many mosquito larvae (between 1 to 10mm).
When we came back, we saw many bacteria in microscope (nearly 2µm).

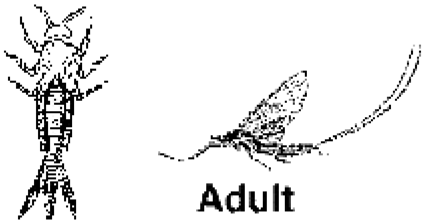




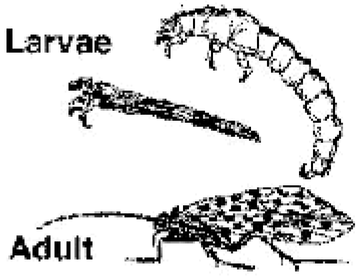
In the water which came from a pond :



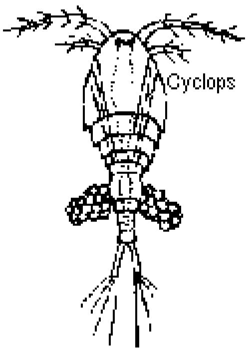
twelve species of stonefly nymph (insect plecoptera, 2-4cm)



twelve species of mayfly nymph (insect ephemera, 2-3cm)



ten species of caddisfly larvae (insect, 2-3cm)

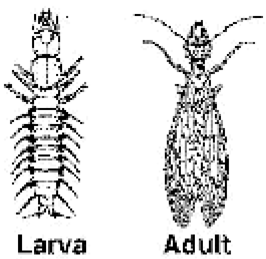


four
copepod (shellfish, 2mm)

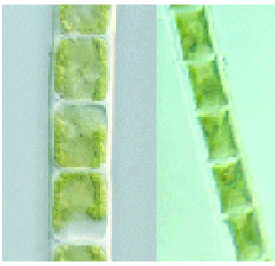
one
philodina (rotifer, 0,1mm)

two species of
chlorococcales (green algae, 0,1mm)

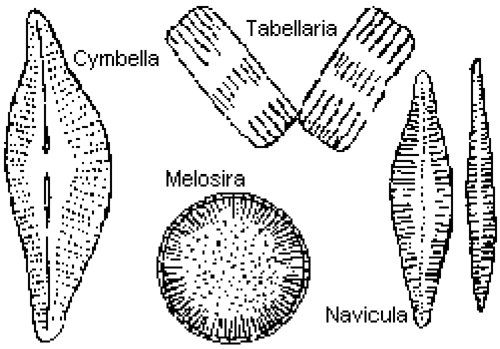
In the water which came from the lake we found invertebrates : two species of caddisfly larvae,



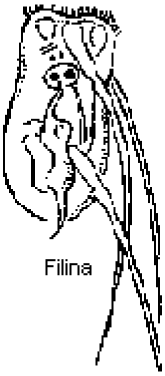
five
species of dobsonfly larvae



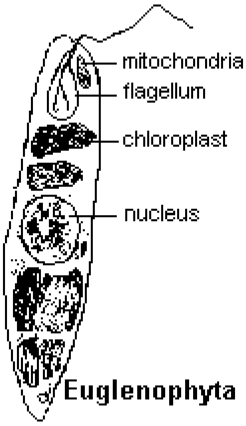
two
ulothricales, (filamentous algae, 2mm large)



four
diatoms, (unicellular, 0,1mm)



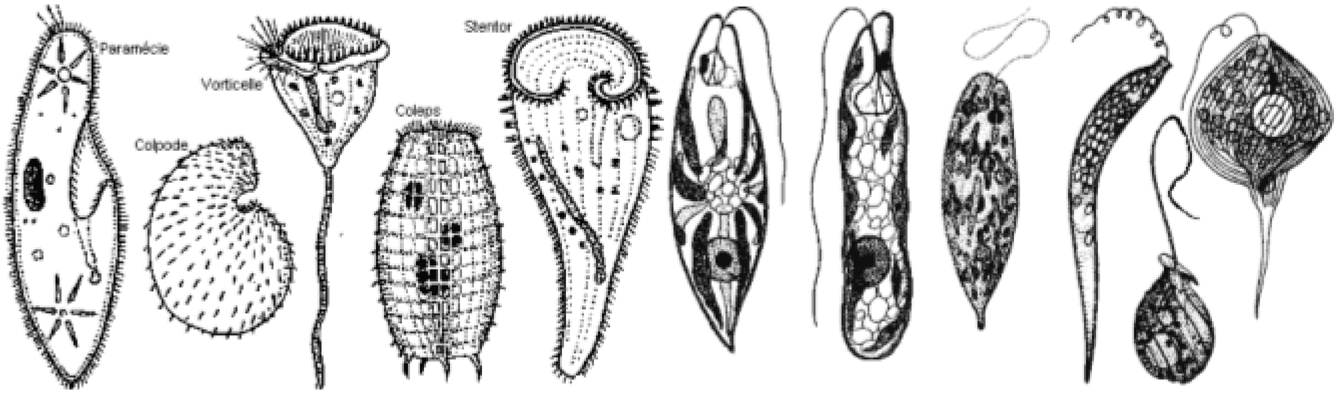
one Filina (rotifer 0,1mm)



two euglenophytas (unicellular green algae, 0,1mm)


two species of chlorococcales (unicellular green algae, 0,1mm)

In the water which came from the river next to the field, we found the same animals as in the water which came from the manure. We also found lots of unicellular algae like ciliata and euglenophyta:



In the Netherlands:
Our colleagues have taken a sample of water of :
=> Dead branch, not running water in which they found five Copepoda, one ciliata and three Euglenophyta
=> A canal in which they found two Peridinae (which are diatom), two Copepod, three species of Chlorococcales, one Rotifer, two Euglenophyta and two species of Diatom.
=> The river The Dommel in which they found five Peridinae, one Chlorococcale, two Euglenophyta and three species of Diatom.

Interprétation

Chemical contents of the French water samples :
Specialists estimate that water quality depends on mineral concentration. These factors are physical and chemical. As we took our samples in September, the temperature (about 15°C) and pressure were the same for all, so we will study only chemical factors :

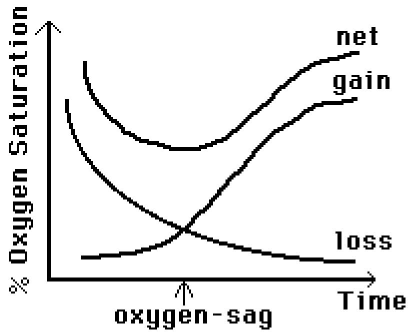
Quality	Really good	Good	Middle	Bad	Really bad
Ammonium(mg/L)	From 0 to 0,1	From 0,1 to 0,5	From 0,5 to 2	From 2 to 8	8 and more
Nitrate(mg/L)	From 0 to 50			From 50 to 100	100 and more
Nitrite(mg/L)	From 0 to 0,1	From 0.1 to 0,3	From 0,3 to 1	From 1 to 2	2 and more
Oxygen(mg/L)	7	From 7 to 5	From 5 to 3	3 and less	
BOD(mgO_2/L)	From 0 to 3	From 3 to 5	From 5 to 10	From 10 to 25	25 and more

So we can see that the quality of our first sample is polluted by organic matters. The quality of our second sample is really good. The quality of our third sample is moderately polluted and the quality of our fourth sample is polluted by minerals.
The concentration of organic matters in an aquatic system is directly proportional to oxygen demand, measured

by three techniques: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC). We used BOD because it is more adapted to our object. Oxygen concentration depends on biochemical reactions:
- Animals and plants breath all the time : $C_6H_{12}O_6 + 6O_2 \Rightarrow 6CO_2 + 6H_2O$ + energy
- When the sun shines, plants make photosynthesis : $6CO_2 + 6H_2O$ + solar energy $\Rightarrow C_6H_{12}O_6 + 6O_2$
- Bacteria make nitrification of ammonium into nitrate : $NH4_+ + 2O_2 \Rightarrow NO_3- + 2H_+ + H_2O$

We observe two effects :
=> loss of oxygen due to BOD,
=> gain of oxygen due to photosynthesis and reventilation (atmospheric oxygen is injected into water by rain in a pond or by the current in the river)

The net reaction is the difference between the two, it's characteristic of water quality.



It is an important indicator since most aquatic plants and animals need oxygen in order to survive. The river system produces and consumes oxygen. At the same time, the river gains oxygen from the atmosphere through the aerating action of wind or turbulence (cascading water) and from plants through photosynthesis. Respiration from aquatic animals, decomposition, and various chemical reactions consume oxygen. The decomposition of organic matter discharged in wastewater consumes oxygen. If more oxygen is consumed than produced, dissolved oxygen levels decline and some sensitive animals may disappear.
Nitrogen is an atomic element, an essential part of amino acids and nucleic acids which are vital to all life. Plants convert ammonium or nitrate into this nitrogen oxides and amino acids to form proteins. The increase in available nutrients promotes plant growth, favouring certain species over others and forcing a change in species composition. The more there is dissolved nitrogen, the more available plants will grow quickly.
Most aquatic animals thrive in water whose pH is in the neutral range (6,5-8,5). Acid rain is the main contributor to aquatic pH changes.
The pollution infects and therefore contributes to the degradation of the environment. The quality of water is defined by its composition of dissolved salt minerals, and matters in suspension. As Micro-organisms depend on the pollution, their population may change with the quality of the water.

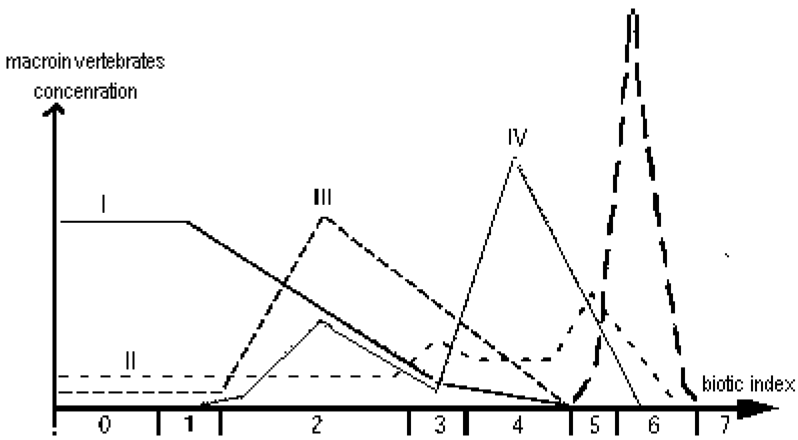
Biological indicators of the French water samples :

With the microscope, we have found different animals in each kind of water. When the quality of the water changes, the animals change too. In doing the same, specialists have made the reference board which follows:

Quality biotic index	Really good 10-9	Good 8-7	Middle 6-5	Bad 4-3	Really bad 2-0
1st : stonefly nymph mayfly nymph	From 11 to 16 species	from 2 to 8 species	0 species	0 species	0 species
2nd : ephemera larvae, caddisfly larvae, damselfly nymph, dragonfly nymph	16 and more species	from 6 to 15 species	from 1 to 5 species	0 species	0 species
3rd : snail (viviparus, valvata, gyraulus), leech dendrocoeleum, dobsonfly larva	0 species	from 11 to 15 species	from 2 to 10 species	0 species	0 species
4th : leech, scud, Physella (clam)	0 species	16 and more species	from 6 to 15 species	From 1 to 5 species	0 species
5th : psychoda larvae	0 species	0 species	from 11 to 15 sp	from 2 to 10 sp	1 specie
6th : midge fly larva, chironomidae	0 species	0 species	0 species	From 6 to 10 species	from 1 to 5 species
7th : eristalomia, horsefly larvae, mosquito larva	0 species	0 species	0 species	0 species	from 1 to 10 species

The animals we found correspond to this biotic index. Each animal corresponds to a quality because it has nutritive and oxygen needs.

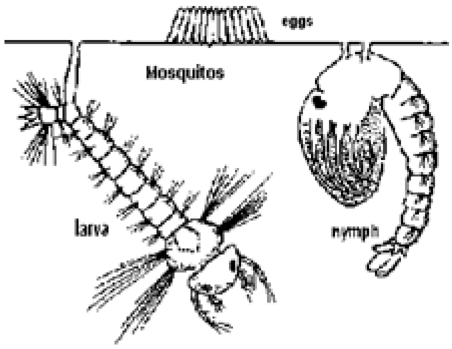
Group I: organisms are sensible to eutrophication. They are selective carnivores and detritivores tubicoles. They die when the organisms concentration goes up because oxygen concentration goes down.
Group II: organisms are indifferent to eutrophication, carnivores and necrophages are less selective, that is to say they eat what is available to them!



Group III is organisms who live in mud, they are detritivores and they show water that has too much organic matter.
Group IV contains little detritivore organisms who live for less than one year.
Group V contains only detritivores that eat mud.
The other animals found are only visible with a microscope, so they don't belong to the board of biotic index created to be used during a day out. Nevertheless, they have the same needs as the invertebrates visible to the naked eye.

As for the first sample: In water polluted by dead organic matters, there is an active decomposition time where bacteria multiply. They break down the organic matter with an enormous oxygen consumption. According to the amount of oxygen as available in the water, bacteria changes organic matters into mineral matters. Animals which can survive without much oxygen are animals corresponding to the fifth and sixth groups with a biotic index of 1-2. They are detritivores, smaller tolerant organisms, they cut dead organic matter as little as it will be dissolved, indispensable state to absorption by bacteria.
If all of the oxygen is consumed, it is the septic time where anaerobic bacteria, which can live without oxygen, will form reducing molecules. There is a large variety of bacteria in water polluted by fermentable organic matters. Some species degrade cellulose, starch, lipid or protein; some others use the decomposed products of these matters. These animals stop to respire but they can survive because they practice fermentation.

The other animals asphyxiate and die except insect larvae like mosquito larvae or some small worms as Tubifex or Limndrilus which proliferate, air breathing thanks to a long respiratory siphon. This corresponds to the seventh group with the biotic index 0.
For the same reason, pulmonate snails can survive. Also, We can see in this water quality filamentous algae (Cladopora) and a lot of bacteria (Sphaerotilum)



As for the second sample: It comes from a pond, dead water area only renovated by rain. After two months of dryness, the water almost corresponded to the water which comes from the manure. Here we can see an organic pollution which will become a mineral pollution: this water is progressively overloaded by mineral salts. It results in a growth of nitrates which enables the phytoplankton and the aquatic plants proliferation. The chlorophyll concentration measure gives a good indication of eutrophication intensity (high biologic production). During this summer, the oxygen concentration decreases. The ecological condition will become similar to those in current water after organic pollution which will be layered by fermentation. The pond will evolve into the septic zone. The number of aquatic larvae, which only lives in clean water, will decrease; contrary to mosquito larvae.
A month later, after a week of rain, we returned to this pond. We had clean water thanks to the self-treatment which restores the water's good characteristics. We passed to a better biotic index, between seven and eight. When the organic nutritive matters become less concentrated, the density of bacteria population will decrease.

The animals which need more oxygen will be able to increase. We can observe green alga as Spirogyra and some colony of phytoflagelle. With the increase of oxygen concentration, created by the photosynthesis and reventilation by rain, animals appear in the order of the grid in according to their sensitivity. When the self-treatment has ended, really good conditions are restored and we can see clean water fauna: stoneflies and caddisfly larvae which build a wall of twigs to protect itself, nonpulmonate snails, daphnia... The biotic index is really good, 7-10, with a majority of animals of the first and second groups.

Our third sample comes from a lake which is a semi-enclosed water renovated by a little river. Lakes are characterized by large still water surfaces. Their volume is considerable, compared to their slow flow. The consequence is that their renewal and their oxygenation are slow but enough if there is no pollution. The sample is characterized by a poor presence of minerals and by the presence of insect larva which correspond to fairly oxygenated water: dragonfly nymph, damselfly nymph are numerous. This water has a biotic index between five and eight.
With a geologic time scale, lakes will ineluctably disappear by packing, because of matters coming from the side basin and of the phenomenon linked with the increase in the number of plants and other organisms which live there.

Our fourth sample comes from a river near a field. We can observe the same animals as in the pond which came from the manure. Rain washed off fields: nitrate fertilizer flows in the river, that's a major source of water pollution. As a result of extensive cultivation of vegetables with chemical fertilizers, human beings have more than doubled the annual fixation into a biologically available form. This has occurred due to the detriment of aquatic habitats. The minerals, brought by the flow, feed the plants. In the same way, in this river, bacteria turn organic matters into minerals salt which make plants grow too much and so animals haven't enough oxygen during the night and die.

In running water, an intermingling homogenizes the natural or polluted contents all the time. This creates a better oxygenation so the pollution disappears quicker.

With all these information we can conclude that communities are composed of two or more populations of organisms adapted to a particular habitat. Organisms are genetically adapted to environmental factors. However, populations within a community may not share the exact same tolerance distribution as other community members. When change occurs in the habitat, some populations will be resistant to the change while others will be more sensitive. Every organism has, to be healthy and reproduce successfully, his own particular requirements for the environment he lives in. One organism can live very well in water with properties where the other organism can't live in.

In the Netherlands

They used a different biotic index with four groups instead of seven groups. It is the quotient of Dresscher and Van Der Mark, that shows the measure of pollution with a formula : $\frac{3D+C-B-3A}{A+B+C+D}$

Indicator group	Water quality	Results of the formula
A. Ciliata	Extremely polluted	-3 to -1,2
B. Euglenophyta	Much polluted	-1,2 to 0
C. Diatomae, Chlorococcales	Moderately polluted	0 to 1,2
D. Conjugatae, Peridinae, Chrysophyceae	Almost not polluted	1,2 to 3

They have counted the number of species they found and they calculated the quotient of Dresscher and Van Der Mark. The grid just which follows shows their results:

Place	Number of species in indicator group				Result of the formula	Water quality
	A	B	C	D		
Canal (NL)	0	2	4	1	0,714	Moderate polluted
Dead branch (NL)	1	2	0	0	- 1,67	Extremely polluted

River Dommel (NL)	1	2	5	1	0,33	Moderately polluted
Small river (FR)	0	2	4	0	0,33	Moderately polluted
Pond (FR)	0	0	2	0	1	Moderately polluted

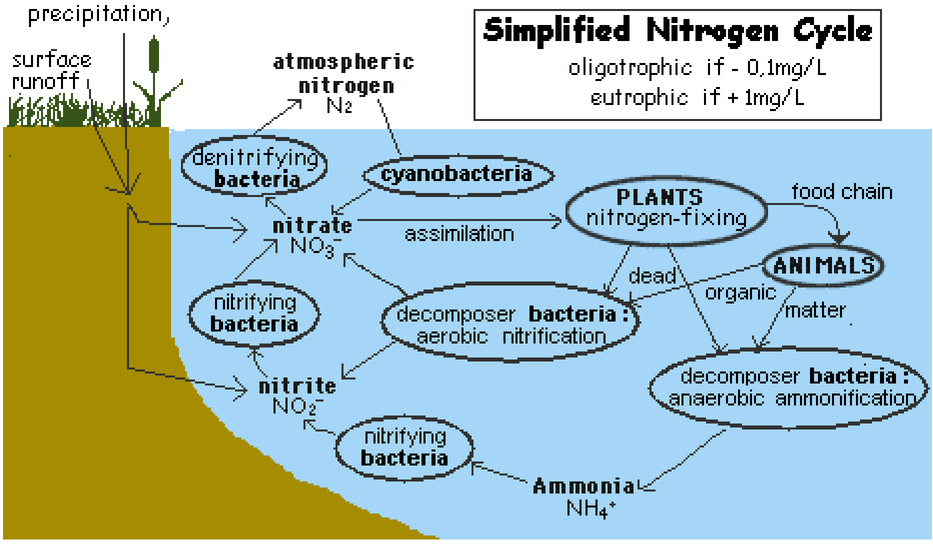
So they show that the quality of water in the Netherlands is better than in France. Also the quality of running water is better than stagnant water.

Conclusion

So we can see that if humans don't add pollution to natural water, nature is able to clean itself alone. That's what the Dutch also said to us:
"Nature is able to clean the water. Nature does this with the help of micro-organisms. Micro-organisms can clear the waste of other organisms. Micro-organisms are for example bacteria, virus and other animals that consist of one cell. The micro-organisms use the waste as food. They break off the waste products to water and carbonic acid gas. These waste products are organic, for example rests of dead animals and plants."
So we can see that there is a natural cycle which permits to nature to stay clean enough and so allows animals and plants to live in.

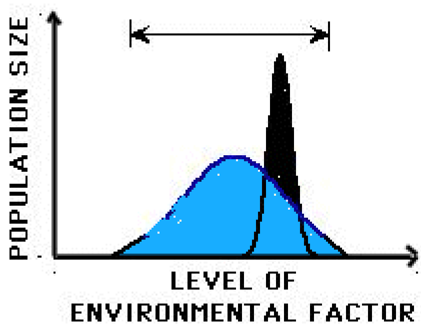
Oxygen depletion and nutriment enrichment effects on organisms:

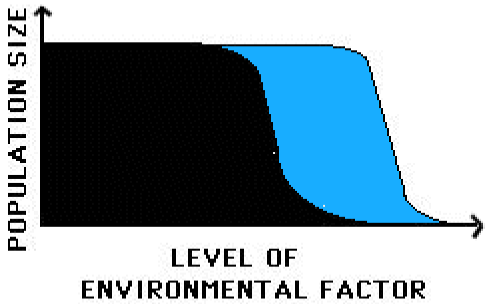
A pond, a lake, or a river are oligotrophic systems, that is to say non productive. If rates of photosynthesis and respiration are low, BOD is bigger than oxygen gain, water will be bad.
If rates of photosynthesis and respiration are high, we have a productive eutrophic system.
Oxygen depletion and nutriment enrichment increase in detritivores, heterotrophic smaller and tolerant organisms.



Overall increase in biomass but decrease in diversity: that is to say that tolerant organisms population increase but there is little diversity of species because organisms more sensitive decrease.

When chemical or organic concentrations change in natural conditions :
=>the blue population accepts large changes but there are few species.
=>the black population only lives in specific concentrations and so the population size is higher.





When chemical or organic concentrations change by adding of exogenous materials (that is to say materials which come from outside), generally, all the populations are affected in the same way: when the concentration of the pollutant is farther than the range of tolerance, the population size decreases brutally. The black one more sensitive and die with a smaller concentration.

Populations interact with one another within a community and with the ecosystem such that any change at the population level will cause alterations in the community or ecosystem level. The effect will be determined by the magnitude of change.
The net result of any change outside the range of tolerance for any member of the community is either loss of an ecosystem component or structural and/or functional replacement by more tolerant organisms. It can be expected that food webs and energy-flow will be altered.
Benthic macroinvertebrates are good storytellers, especially when it comes to water quality. They are sensitive to both physical and chemical changes in the water. Although fast enough to escape predators, they can't swim away from pollution. They tolerate it, but only to a certain point when they get sick and die. Some criterions are more tolerant and even flourish as the water quality declines, while others die or disappear with the slightest change. The saying "the more the merrier" applies to benthic macroinvertebrates as well. The greater the variety that lives in any body of water, the healthier it is.
We can see that the excess of mineral or dead organic matter concentration provokes the excess of plant production. In aquatic environments, enhanced growth of choking aquatic vegetation or phytoplankton disrupts normal functioning of the ecosystem, causing a variety of problems. If bacteria BOD increases too much, oxygen concentration decrease in proportion and animals die. And after, there is not much oxygen for bacteria so they denitrificate in place of nitrificate. It is the beginning of an end, plants will die too. This evolution is named dystrophication. In newspapers, the word "eutrophication" is always used in place of dystrophication.
Human society also has an impact on: dystrophic conditions that decrease the value of the resources of rivers, lakes, and estuaries such that recreation, fishing, hunting, and aesthetic enjoyment are hindered. For example, toxic bacteria, Cyanobacteria create cyano- compounds, poisonous salts, deadly to many animals and all mammals. Different dystrophic evolutions are explained in the annex.
To conclude, if you have determined the habitat of an organism, you can, the other way round, by determining organisms, say what the qualities of the water are.

Widening of the subject:

In France:
Factories of the production of drinking water treat water which comes from rivers and from underground water. These waters are relatively clear. So what all citizens must do is to try to economise water and to pollute it less.
To economise water people can privilege shower than bath (a bath take between 150 and 200L of water whereas a shower take between 30 and 80L), shorten their shower, repair all equipment which leak, not let the tap run when you brush your teeth, use the washing machine only when it's full, use a bowl to wash up and water plants during the night or the evening to avoid evaporation.
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A law requires that all buildings are joined to a system of a collective purifying in order to make the collection of used water easier. These waters are forward by canalisation, collectors, station of recovery, wells of interconnection between different sewers.
For example, the law on water of January third 1992 imposed a development of the systems of collection and used water treatment. Moreover, the government imposed on the industries a rate of pollution not to overshoot. Nowadays, 20200 cultural installations respect the norms in France.
Stations of purification of used water are at the end of the system of collect. Water is considered clean enough when pollutants are taken off or destroyed. The station uses chemical, physical and biological proceedings like

the destruction of pollutants by bacteria, which digest these substances and agglomerate into mud of purification, which we can also recover by allowing. We have a station of purification called "biological" because only the micro-organisms participate in the destruction of pollutants.
There are primary treatments: the goal is to eliminate the biggest wastes, which could constrain the next treatments. The steal grate: used water goes through grating which take off the biggest wastes like bottle or wood. The sifting: water goes through gratings with smaller spacing of the rails, which take off smaller wastes. The disable and de-oiling: water stay in basin during a long time for the sand to fall at the seat and for the grease to float. Then the sand is pumped and the grease is scoured at the surface.
Then pollutants are digested by micro-organisms like in nature but more rapidly because of the selection and the concentration of bacterium in the basins.

In the Netherlands:
To keep the water clean in the Netherlands, the government has made a lot of statutes, for example the Statute Pollution Surface-water.
This Statute contains rules such as domestic effluent may not be drained off on soil ; domestic effluent may not be drained off to the surface-water ; enterprises have to have a Licence to drain of effluent-water in the surface-water.
The government also has organisations that check the quality of water. There are some independent organisations too. These organisations check the water by taking measurements.

They survey a few different aspects, namely the chemical water-quality, the biological water-quality and the quality of water that we can swim in.
When these organisations notice that the water quality is declining, they will alert the government, so they can take measures.

There is also an international hall-mark, the Blue Flag. In the Netherlands, they use this hall-mark. The hall-mark is being handed over after the water has been approved, that means that the water is clean enough to swim in.
"For a decade people dumped their waste water in the nearest brook and nature itself took care of the rest. But when the number of habitants increased, the ground- and surface water got too much polluted. That affected the ability of water to clean itself.
That's why in the 20e century the government decided that they should give nature a hand. They developed a system which imitated the biological purification process.
The waste water that first leaves your house goes through the sewer to a water purification plant. There they pump it up, where after the water can be cleaned in three steps.
The first step is the mechanical purification. With a steal grate the 'big' pieces of trash are filtered out of the water first. Then the water goes to a sand catcher. The sand and fat that is caught from the water here is recycled for road-building. Meanwhile the water streams calmly to the pre-sedimentation tank, where the rest of the floating material is kept from the water. The silt from the base of the tank is carried down to the silt thickener. The waste silt gets burned. In some purification systems there is no pre-sedimentation tank and the water is immediately biologically cleaned.
The second step is the biological purification. The water is put into water basins which contain many bacteria just as in natural brooks. The bacteria break up waste products. Meantime, while that is getting taken care of the bacteria's get enough oxygen for instant blowing of air from the bottom of the basins or by using surface aerators. Because of the oxygen, the bacteria's keep moving and can't sink in, which is necessary in this stage of purification.
The last step is the after-sedimentation. The water streams slowly from the middle to the outside, over the edge of the after-sedimentation tank. The bacteria's are so heavy from eating the waste that they sink to the bottom. There they are caught and a big part of them goes back to the water basins. The cleaned water can go straight to a brook or a river.
They do use nature in their water purification plants. This is called biological purification. During biological purification micro-organisms, especially bacteria, clean water. They break off organic material, nitrates and phosphates.
There is aerobic and anaerobic biological purification. Aerobic purification means that the bacteria that clean the water need oxygen for the process. Anaerobic purification is without oxygen."

So we can see that in France and in the Netherlands, the stations of purification work approximately in the same way.

The measures taken by the state:
- The state takes all action to change agriculture methods into biological ones.
- To intensify the use of renewable sources of energy in transports and electricity production.
- To reduce the use of the motor vehicle.
- To encourage local councils to stamp organic wastes.
- The state takes measures for industries to treat their own used water.
- To avoid the use of chlorine even as a disinfectant for drinking water.
- To use detergent without phosphate.
- Doctors, surgeons and veterinary must reduce the use of antibiotics.
- The state finances research about the consequences of the exposition of pharmaceutical products in water reserves and pawns some preventive actions about the reliability of the results.
- To reduce urbanisation and create "green belt".
- The wastes of human's origin are not mixed with chemical wastes to be recycled.
- To build biological factories of treatment instead of chemical factories.
- The state should financially help the developing countries for the system of evacuation and treatment of used water.
- It should distribute educational programs about the consequences of the pollution of water and the building of stopping places to reduce it for the industries, farmers and citizens.

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Annexe :
Excessive eutrophication examples :
Dystrophication will be the right word for excessive eutrophication!
When eutrophication increases, we can notice changes of the organic composition because of the fermentation and the lack of oxygen : some anaerobic bacteria species live in the water without oxygen or in reducing silt and produce methane by hydrogen and carbon molecules deterioration with a simple structure. In areas poor in oxygen or without it, we can see some sulfobacteria, such as Desulfovibrio desulphuricans, which reduce sulphide sulphates and produce hydrogen sulphide.
Other anaerobic bacteria metabolize nitrogen compounds and emit ammoniac. Some bacteria species, which feed decomposed organic matters, which, proliferate in polluted waters, gather in a large colony, with a visible gelatinous and stringy shape. As for the Sphaerotibus natans: a heterotrophic bacterium common in waters polluted by carbohydrate organic matters, because it uses sugar as its main nutrition.
Beggiatoa alba is a sulfobacterium which lives in anaerobic silt in contact with water not completely devoid of oxygen by organic pollution: they need hydrogen sulphide and oxygen.
Numerous species of anaerobic sulfobacterium proliferate in water loaded with organic matters. Nevertheless, this kind of water also contains rich flora of fungi.
Contrary to the heterotrophic bacteria, the autotrophic bacteria help to carry oxygen to the waters.
When the oxygen levels increase at a suitable rate, we could see bacteria, which transform ammonia into nitrates.

The apodya lacteal brings mycelium colony that look like fleecy filament. This species needs a sufficient quantity of oxygen and organic nitrogen.
The fusarium aqueductum is a red fungi living in waters that are rich in organic matter.
A lot of others fungi species such as Mucor, Geotrichum, Penicillium... proliferate in waters and are infected by biochemical matters.
The metabolic needs of these organisms caused a huge drop of dissolved organic content.

In the active decomposition zone and in those nearby the downstream part, when the self-treatment start to show a result, ecological conditions are favourable to the proliferation of unicellular animals, because many of these species eat bacteria. In the deterioration zone, only very resistant microorganisms and a few flagellated can develop. But after this zone, Colpidium, Glaucoma, Penicilium, and sessile species (Carchesium, Epistylis) with a bacterium regime, proliferate.
Algae totally disappear from waters deoxygenated by an organic pollution. However, if the oxygen level stays sufficient, algae first decrease, and then grow. The proliferation of these autotrophic organisms results in the release of nitrates and phosphate by the bacteria, from organic matters present in the effluent.
The maximum density of alga phytocoenose is located near the beginning of the effluent emission. Species which proliferate there are adapted to rich in nutritive element areas: Oscillatoria, Phormidium (blue alga), Ulothrix (green alga), Euglena (phytoflagelle). In waters overloaded with nitrates, we can often observe a green alga Stigeoclonium.
Some Melosira and diatoms such as Gomphonema and Nitzschia paela meet each other in abundance, even in active decomposition zone, with sometimes species as Navicula and Surirella. The Cladophora Glomerata green alga often lives in rich in nutritive element areas. This specie proliferates when the degree of organic matters which turn into minerals is reached. It floats with a branched filament shape, larger than two metres.