Investigate and compare, the biodiversity of freshwater invertebrates, of two water bodies, with high and low dissolved oxygen levels.

Abstract

The aim of the study was to compare the biodiversity of two water bodies dependent on the fixed variable of dissolved oxygen levels. The hypothesis was that there would be a greater biodiversity at the water body with a high dissolved oxygen level. The biodiversity was measured by 10 samplings of the water body with a net, and the organisms found were identified, counted and then returned. The samples were taken from River Stour a large lotic (flowing) river with high dissolved oxygen levels, and Dead River a lentic (still) water body with very low dissolved oxygen levels. The results showed there was a significantly greater biodiversity at River Stour with the high dissolved oxygen levels, this is because adequate dissolved oxygen is needed and necessary for good water quality. Oxygen is a necessary element to all forms of life. Adequate oxygen levels are necessary to provide for aerobic life forms which carry on natural stream purification processes. As dissolved oxygen levels in water drop below 5.0 mg/L, aquatic life is put under stress. The lower the concentration, the greater the stress.

Hypothesis

The biodiversity of freshwater invertebrates will be greater at the water body River Stour with a higher dissolved oxygen level, than Dead River with low oxygen concentration levels.

Null Hypothesis

The biodiversity of freshwater invertebrates will be greater at Dead River the lotic water body with low dissolved oxygen levels, than River Stour the lentic water body with high dissolved oxygen levels.

Variables

Depth of the water
The temperature of the water.
The pH of the water.
The light intensity on the water surface.
Where the samples are taken from, in the water body.

The nitrate levels of the water.
The phosphate levels of the water.
Water velocity

The key variables must be controlled, if possible within the limits of the investigation.

Temperature governs the type of organisms that can live in a stream and has profound effects on its water chemistry. Organisms have a preferred temperature range; temperature affects life span and development. Colder water holds more dissolved oxygen, and the rate of chemical reactions, such as photosynthesis, increases at higher temperatures. Although the temperature of the water cannot be directly controlled, I will take water temperature readings with a water thermometer, from all sampling sites to ensure there is no large variance.

The pH of the water should be around neutral and shouldn't have a great effect of the biodiversity of freshwater pond life. Most aquatic organisms prefer a range of 6.5 - 8, a very high or very low pH is deadly, and developing eggs and larvae have specific narrow pH requirements. Low pH can also allow toxic elements and compounds to become more mobile and available for uptake by aquatic plants and animals.

The light intensity may affect the distribution of some freshwater invertebrates, therefore I will take samples from both shaded and exposed areas of the water body for both sites.

I will take samples from the surface, middle, edge and bottom of the water body, for both sites, to record a greater range of freshwater invertebrates.

Water Velocity will affect the results because Stream velocity determines the kind of organisms that can live in a stream (some need fast-flowing areas; others need quiet pools.) Also, fast moving streams generally have higher levels of dissolved oxygen than slow streams because they are better aerated.

Deeper water tends to have lower dissolved oxygen levels because oxygen mixing does not occur at the bottom levels.

Phosphate test kits measure the form of phosphate applied as fertiliser to agricultural fields, grass lawns, or golf courses. Phosphates accelerate the growth of algae and aquatic plants. Total P > 0.03 ppm will increase plant growth and eutrophication, therefore decreasing the dissolved oxygen content.

Nitrogen is essential for plant growth, but the presence of excessive amounts in water

supplies presents a major pollution problem. Nitrogen compounds may enter water from agricultural fertilisers, human sewage, industrial wastes, livestock wastes, and farm manure.
Nitrate in drinking water must be 10 ppm.

Outline method

Using a net, move it through the water slowly 10 times then empty the contents into a plastic dish the using a species identification sheet, identify, count and record the species, repeat this 12 times taking samples from the surface, edge, middle and bottom of the water body.
Taking samples from 4 different sites of the same water body.
Remember to take readings of water temperature, pH and take samples to test for nitrate and phosphate levels.
Repeat this method at the second comparable water body. There is no need for a pilot study however the two water bodies should be checked beforehand to check its suitability for the investigation.

Risk assessment

The captured freshwater invertebrates should be safely returned to the site they were taken from so not to disturb to ecosystem of the water body.
Care should be taken by the edge of the water as is wet and slippery.
Rubber gloves should also be worn when dealing with the water, as there is a risk of infection.
It would also be advisable to have partner nearby when working near water in case of an accident.
The freshwater invertebrates are not dangerous, however unnecessary handling should be avoided.

Apparatus

Pond net, plastic tray, dropper pipette, hand lens, digital thermometer, dissolved oxygen meter, water sample bottle, identification sheet (animals), recording sheet, pH meter, nitrate test strips, phosphate test strips.

Introduction

Biological knowledge to support the hypothesis, The biodiversity of freshwater invertebrates will be greater at the water body River Stour with a higher dissolved oxygen level, than Dead River with low oxygen concentration levels.

Dissolved Oxygen (DO) is found in microscopic bubbles of oxygen that are mixed in the water and occur between water molecules. DO is a very important indicator of a water body's ability to support aquatic life. Fish "breathe" by absorbing dissolved oxygen through their gills. Oxygen enters the water by absorption directly from the atmosphere or by aquatic plant and algae photosynthesis. Oxygen is removed from the water by respiration and decomposition of organic matter.

Waters with high levels of dissolved oxygen are usually considered healthy and stable ecosystems capable of supporting many different kind of organisms.

Much of the DO comes from the atmosphere and through aquatic plant and phytoplankton photosynthesis. Dissolved oxygen level rises from morning through the afternoon as a result of photosynthesis, reaching a peak in late afternoon. Photosynthesis stops at night, but plants and animals continue to consume oxygen. As a result dissolved oxygen levels fall to a low point just before dawn. The DO may dip below 4 mg/l in such waters - the minimum amount of needed DO to sustain warm water fish.

Dissolved oxygen is affected by certain things such as salinity, decomposition, water current, and temperature. Saline water can absorb even less oxygen than freshwater. The breakdown of organic matter will also affect the DO because it will consume large amounts of oxygen. This will deplete the water of oxygen and make it uninhabitable for other species. When the temperature changes so does the DO. Cool water can hold more DO than warm water. Water current has a lot to do with the DO because it mixes the oxygen. A river with stronger current will have more DO than a river with a slow moving current. Most animals can grow and reproduce when the DO is above 5 mg/l. When it drops to 3-5 mg/l living organisms often become stressed. If it falls below 3 mg/l, a condition known as hypoxia occurs. Many organism will move and the non mobile ones will die. A second condition known as anoxia occurs when the water becomes totally depleted of oxygen (under .5 mg/l) and results in the death of any organism that requires oxygen for survival.

Dead River is a lotic water body, it should have lower dissolved oxygen levels than River Stour a lentic water body because, areas of water such as ponds or lakes, in which the water does not move, suffer from pollution more than rivers as they are not able to get rid of the pollutants as effectively as a river, or any other fast moving water body. As the water becomes more polluted, there are more organic nutrients available for the bacteria to break down which leads to an increase in mineral salts. This is known as eutrophication ("good eating" conditions). However, the breakdown of these nutrients leads to a depletion in oxygen and an increase in CO_2, which can lead to the death of many of the other organisms such as fish and invertebrates, which depend on the ecosystem remaining balanced. Eutrophication encourages the growth of algal blooms, which cover the surface and prevent light from reaching the submerged plants in the water thus preventing photosynthesis. The problem is greatly enhanced at night-time, when plants have been unable to produce sufficient levels of oxygen for the invertebrates to respire. Eutrophication has the following effects on the ecosystem:

1. affects animals, by causing lower oxygen levels, too low for animals to respire effectively
2. increases turbidity / cloudiness, reducing light levels and thus reducing photosynthesis by plants
3. increase substrate (fine muds), which block the gills of many organisms.

An example of an excellent stream site with high dissolved oxygen levels; Here we find a variety of organisms with very different body shapes and ways of making a living. High biodiversity (or taxa richness) indicates a site with low human influence: Several different types (or taxa) of stoneflies, mayflies, and caddisflies indicate a healthy site. More than one type of riffle beetle may also be identifiable, some are longer and skinnier than others. Some caddisflies are tolerant of degradation, so a large number of caddisflies does not necessarily indicate a good site, especially if they are the same species.

An example of a moderate site with medium dissolved oxygen levels; The total number of different types of organisms (taxa richness) declines as degradation increases. About half to two-thirds the number of taxa found at an excellent site are found in a moderate site. The primary change from an excellent site is that there will be many fewer taxa of stoneflies. Mayflies will be present, but probably fewer taxa as well. Several types of caddisflies may be present depending on the type of degradation. The relative proportions of soft-bodied worms, baetid mayflies, simuliid flies, or amphipods may increase. Beetles are probably still present; molluscs are not.

An example of a poor site, with low dissolved oxygen levels; The total number of taxa will be low. Most of the taxa found are soft-bodied animals, e.g., fly larvae, oligochaetes, nematodes, and in very poor sites, leeches and planaria. Worms are often difficult to distinguish from each other because their shapes are similarly adapted to living in soft sediments. Stoneflies are absent entirely. The only mayflies present are probably baetids (a family of mayflies). Caddisflies may be present, but only a few tolerant types. Amphipods are often present. There may be a large proportion of a single type of animal. In general, animals present may be smaller than those found at an excellent site.

Method

The investigation was carried out at 12 locations along two different water bodies, Fen bridge, Dead River, TM 068337, a lotic water body with low dissolved oxygen levels, and Fen bridge, River Stour, TM 068336, a lentic river with high dissolved oxygen levels.

Working at the first site Dead River, Firstly the variable data was collected, a sample from the water was taken from each sample location along the site, to be tested back at the lab with nitrate and phosphate test kits, recordings of water temperature and pH were also taken at each sampling location.

At each location 4 samples were taken from the surface, edge, middle and bottom of the water body, these samples were taken by using a net which was lowered and cut through the water 10 times, the net was then taken out and the contents immediately transferred to a plastic tray filled with water, then using a dropper each species was removed and put in a smaller tray to be easily counted and identified. The invertebrates were then identified using a recording sheet and counted, once the results were collected, the captured invertebrates were released back to the location where they were taken.

This method was carried out to take 4 samples from the surface, edge, middle and bottom of River. The samples were taken from 3 different locations along the river, giving a total of 12 samples, this will be enough data to allow the statistical 't' test to be carried out.

The method should then be repeated for the second site, River Stour to get two sets of comparable data.

Results

The first tabulated results are of the water sampling carried out at the beginning of the
method, this can be used to analyze the differences between the water bodies and the effect on
the biodiversity of the freshwater invertebrates.

Site: Dead River

Variable (averages from the samples)ResultWater temperature22.5 oCDissolved oxygen levels
(mg/l)1.1 mg/lNitrate levels (mg/l)18 mg/lPhosphate levels (mg/l)15 mg/l
Site: River Stour

Variable (averages from the samples)ResultWater temperature16.9 oCDissolved oxygen levels
(mg/l)8.5 mg/lNitrate levels (mg/l)6.10 mg/lPhosphate levels (mg/l)8 mg/l
Site: Dead River, (Results taken from 4 locations along the site, a total of 12 samples make up
this table)
Name of speciesSample from surface of waterSample from edge of waterSample from middle
of waterSample from bottom of waterTotalsLeech51208Water flea
(Daphnia)302613675Lesser water boatman545216Water beetle21003Non biting midge larva
(red)745117Water mite44008True worm20002Blackfly larva42129Total number of species:
8/79
Total number of invertebrates captured: 138
Site: River Stour, (Results taken from 4 locations along the site, a total of 12 samples make up
this table)

Name of speciesSample from surface of waterSample from edge of waterSample from middle
of waterSample from bottom of waterTotalsLeech42118Mollusca (spire
shell)34007Ranshorn
snail02002Water flea (Daphnia)51332113118Lesser water boatman
(tiny)1056223Lesser
water boatman (elongate)1371021Greater water boatman946120Mayfly
nymph753015Stone
fly nymph534012Water beetle (tiny black32117Water beetle larva433212Phantom midge
larva53008Water mite24129True worm22105Caddisfly larva435012
Total number of species: 15/79

Total number of invertebrates captured: 279

The results clearly support the hypothesis, as there are more species in the lentic water body with high dissolved oxygen levels, and also a greater number of organisms, therefore the null hypothesis can be rejected. In general River Stour is far more capable at sustaining life, as it is slightly cooler than Dead River, it has a higher level of dissolved oxygen and lower levels of nitrate and phosphate in the water. Also as there is lower dissolved oxygen levels deeper in the water far less organisms were captured at the bottom of the water body, once again supporting the effect low dissolved oxygen levels have on freshwater invertebrates.

The species that were captured in Dead River were mainly soft bodied invertebrates that were able to survive in conditions with very little dissolved oxygen, many of the organisms that were found at River Stour, were unable to survive in Dead River. Therefore there is a greater biodiversity at the lentic water body with high dissolved oxygen levels.

Discussion and Evaluation

There is a significant difference between the biodiversity of River Stour and Dead river, the conditions of River Stour are obviously more suitable to freshwater life than that of Dead river, River Stour is lentic, has a greater amount of dissolved oxygen and lower amounts of nitrate and phosphate these are all ideal factors to support freshwater life, meaning River Stour has a healthy rich biodiversity. Dead river is a lotic water body, has low levels of dissolved oxygen and high levels of nitrate and phosphate, this has caused many freshwater invertebrates to move from the water body, or to die, leaving only a few species which can tolerate low dissolved oxygen levels, therefore it has a low biodiversity.

Dissolved oxygen is required by all aquatic animals. Low dissolved oxygen levels (hypoxia) can impair animal growth or reproduction, and the complete lack of oxygen (anoxia) will kill animals. Animals with limited mobility such as molluscs are particularly vulnerable to hypoxic or anoxic conditions, which is why many of the immobile species found at River Stour could survive but were not found at Dead river. However some species like red midge larva can be found in water bodies such as Dead river as they have adapted, and contain hemoglobin which allows them to store oxygen to survive in areas with very low oxygen.

Although the results have proved the hypothesis and the variables taken into consideration there were limitations that affected the investigation, the sampling method was unlikely to catch every species in the water body even after 12 samples, therefore the results are only an estimate of the true biodiversity of the water body. Also many of the freshwater invertebrates although of a different species look very similar and are difficult to distinguish, although a hand lens, and a identification sheet was used, accuracy couldn't be guaranteed.

With more time, more samples could have been taken to attempt a better estimate at the true biodiversity of the water body, a more exact identification procedure could have also been developed, the sites used were perfect examples of an excellent and poor site for maintaining life.

The biological significance of this investigation has shown how a excellent site that can support a rich biodiversity, can very easily become a poor site, freshwater invertebrates are the most sensitive to organic pollution which takes up the oxygen from rivers, this investigation shows just how much of a difference dissolved oxygen levels have on the biodiveristy of a water body, and the effect organic pollution such as nitrates and phosphates have on dissolved oxygen levels.

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