Big Windermere Survey: Water Quality Guide

This document aims to provide an overview of the various parameters measured using water samples collected during the Big Windermere Survey (BWS) for water quality assessment. The BWS sampling instructions video can offer additional context. For more information or to sign up for the next BWS, please contact windermere@fba.org.uk.

Background

What do we analyse from the water samples collected by volunteers?

At each site sampled for the BWS, volunteers collect water that goes into a bottle or a centrifuge tube (blue cap) without being filtered. Volunteers also collect water that is passed through a filter into a centrifuge tube (orange cap). Filters are used to stop anything in the water that is bigger than 0.45 micrometres (equivalent to 0.00045 millimetres!) getting into the sample for analysis. This is the standard pore size for filters used in water quality research.

Parameters that are analysed using the filtered sample are known as 'dissolved' or 'soluble' water quality parameters, because the filter **excludes** any larger particulate material. These parameters are **soluble reactive phosphorus, nitrate, nitrite, total oxidised nitrogen, total ammonia** and **silica**.

Parameters analysed on the unfiltered sample **combine** both dissolved and particulate material. These parameters are **water temperature**, **pH**, **electrical conductivity**, **total phosphorus**, **total coliforms**, **intestinal enterococci** and ***E. coli***.

Analysing both filtered and unfiltered samples is important as part of assessing water quality through the survey. For example, the filtered and unfiltered samples allow us to understand more about the specific forms of nutrients within a sample, and how available these forms of nutrients may be to organisms such as algae that live in rivers and lakes.

The BWS uses national monitoring standards to provide context for some of the data in terms of water quality. One set of standards come from the **European Union Bathing Water Directive**. These are based on concentrations of **intestinal enterococci** and ***E. coli*** bacteria within the samples. If present in a sample, these bacteria indicate that faecal matter, which is matter coming from human or animal digestive systems, may be present in the water. Thresholds for concentrations of these bacteria exist to classify a sampling site as Excellent, Good, Sufficient or Poor, indicating the suitability of water for human use.

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Evidence based implementation of actions to improve water quality in Windermere.

For the chemical water quality parameter phosphorus, we have used standards from the **European Union Water Framework Directive**, which focusses on the ecological health of water bodies. The concentration of **total phosphorus** is used for lakes and the concentration of **soluble reactive phosphorus** is used for rivers to assign each sampling site to one of the following status classes: High, Good, Moderate, Poor or Bad. 'Good' status is the minimum target for most water bodies under the Water Framework Directive.

However, official classification of water quality against standards requires long-term data sets, comprised of multiple samples taken from each location to capture variation in water quality between seasons and years. As the BWS monitoring programme has been running for less than a year, we cannot use the data to classify the status of water bodies in the same way as reported by organisations such as the Environment Agency. Instead, water quality standards are used to provide context for the results.

As future surveys generate additional data, we will be able to undertake more robust comparisons of water bodies against water quality standards. Regular sampling will allow us to pinpoint areas for further investigation, using evidence to underpin the design and implementation of appropriate actions to improve water quality in the catchment.

Parameters

Temperature – the temperature of an unfiltered water sample. Water temperature may seem uninformative when the results of each BWS are examined independently. However, when water temperature data from multiple surveys over increasing durations of time are combined, the potential impacts of climate change can be assessed. Long-term data collected over the last 30 years has shown that the water temperature of Windermere has increased by 0.8˚C overall, with greater warming happening in spring and summer. Warmer temperatures mean earlier onset, greater stability, and longer duration of thermal stratification, where warming of lake surface water causes a 'separation' in the water column within the lake, in which cooler water towards the bottom does not mix with warmer surface water. Although this is a natural process in deep lakes like Windermere that is maintained between spring and autumn each year, earlier onset, greater stability, and longer duration can support greater (and even uncontrollable) growth of algae at the surface of the lake. This results in less light and photosynthesis (process by which algae and plants create oxygen) towards the bottom of the lake. The water becomes less hospitable for aquatic life that relies on cold water, such as Arctic charr, forcing them down to deeper depths with suitable temperatures but less oxygen or up to shallower depths with unsuitable temperatures but more oxygen. Populations of cold-water species may decline due to lethal temperatures or oxygen levels.

pH – is the concentration of hydrogen ions in water, which describes how acidic or alkaline a sample is. The pH of a sample is measured using a probe at the science hubs on the day of the survey. Sample pH can be influenced by natural factors, such as the geology of a catchment, and by human influences like acid rain. It is used as an initial, high-level descriptor of water quality for a sampling site.

Electrical conductivity – is a measure of the capability of a water sample to pass a flow of electric current. Similar to pH, it is measured using a probe at the science hubs on the day of the survey. The electrical conductivity of water is a measure of the amount of ions (atoms or molecules with an electrical charge) dissolved in a sample. This can be influenced by natural factors, such as the geology of a catchment, and by human influences such as the input of wastewater to a river or lake. Alongside pH, it is used as an initial, high-level descriptor of water quality for a sampling site.

Soluble reactive phosphorus – this is the concentration of the most chemically 'reactive' forms of phosphorus dissolved in a sample, excluding any interference from particulate material by using a filtered sample for the analysis. These reactive forms of phosphorus are likely to include those which are most readily available to aquatic life such as algae.

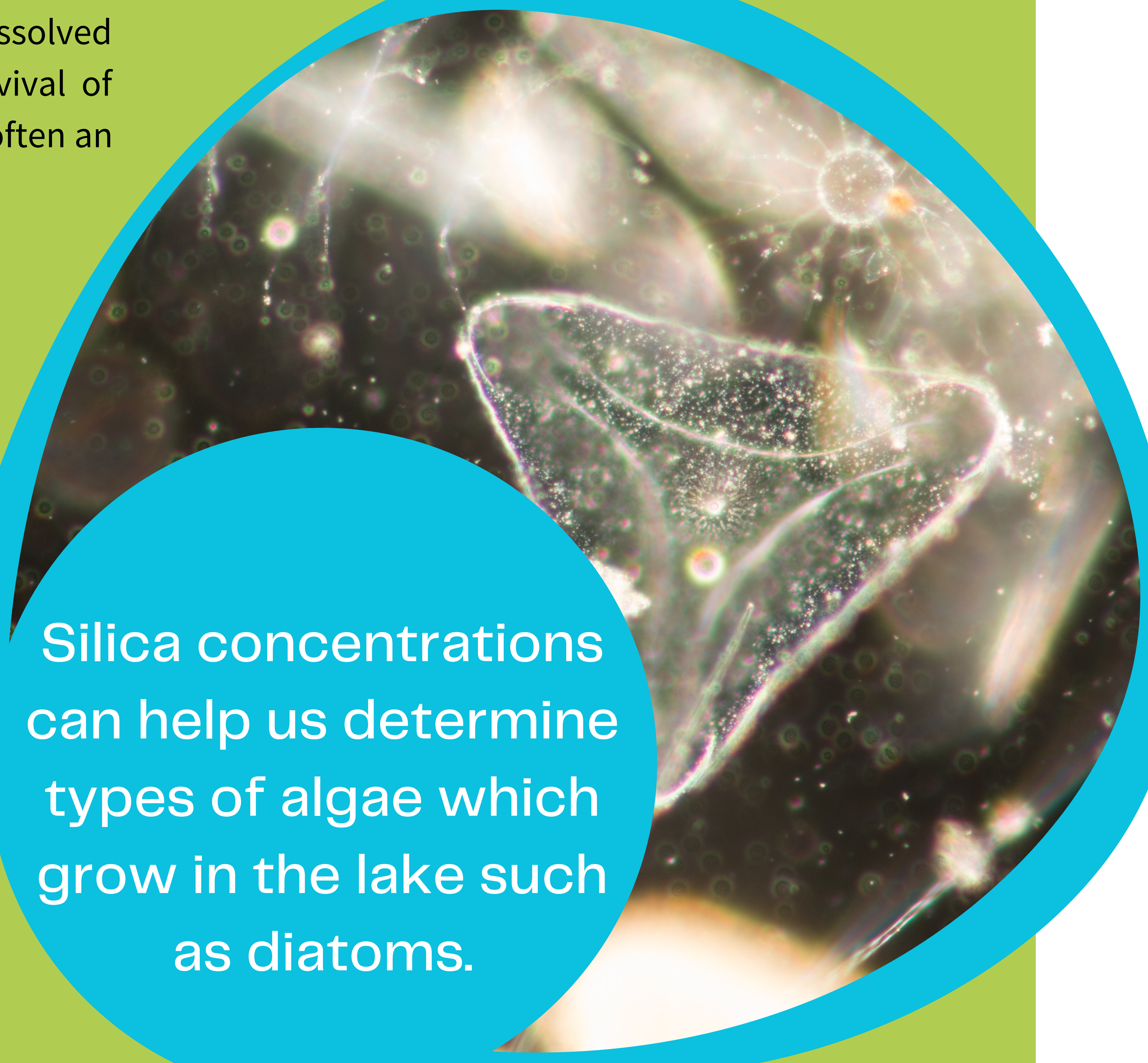
Total phosphorus – this is the concentration of all the phosphorus found in an unfiltered sample, including both particulate and dissolved forms and a wide range of different chemical forms. For example, phosphorus may be attached to the surface of soil or sediment particles, present with dead or living bacterial cells, or fully dissolved within a water sample. To analyse total phosphorus, an unfiltered sample is digested using acid at high temperature and pressure. Digestion converts all the different forms of phosphorus in a sample to a single form that can be analysed using machines in the laboratories at Lancaster University. Examining soluble reactive phosphorus and total phosphorus concentrations together is important in order to understand the sources and likely impacts of phosphorus in a water sample.

Nitrate – this is the concentration of one form of nitrogen dissolved in a sample. Nitrogen is essential for the growth and survival of aquatic life, such as algae, in rivers and lakes, and nitrate is often an important source of nitrogen in the samples from the survey.

Nitrite – is not the same as nitrate! Nitrite is an additional form of nitrogen dissolved in a sample. Nitrite is usually present at very low concentrations in the samples from the survey. This is because it is converted quickly by bacteria living in rivers and lakes to nitrate, with the bacteria obtaining energy for their growth when they convert nitrite to nitrate.

Total oxidised nitrogen – this is the sum of the nitrate and nitrite concentrations.

Total ammonia – this is the concentration of another form of nitrogen dissolved in a sample. Total ammonia includes forms of nitrogen that may be preferred as a source of nitrogen by some aquatic life in rivers and lakes, compared to nitrate. However, total ammonia also includes specific forms of ammonia that are toxic at higher concentrations to other aquatic life, such as fish.



Silica concentrations can help us determine types of algae which grow in the lake such as diatoms.

Silica – dissolved silica in rivers and lakes is used by a specific group of algae, called diatoms, to build their hard cell walls (known as frustules). Changes in silica concentrations over time and space may therefore be important for determining which types of algae are growing in lakes and rivers.

Total coliforms – provides a measure of all coliform bacteria in a sample, with coliform bacteria being one type of bacteria that can be found in rivers and lakes. Coliform bacteria come from the intestines of humans and animals, alongside other sources like soil. This analysis provides a general measure of the sanitary condition of the sampling site.

Intestinal enterococci – are a group of coliform bacteria that are found in the intestines of humans and animals and are used to indicate the potential presence of faeces within a sample. Whilst intestinal enterococci are typically not seen as harmful to humans, other disease-causing organisms are associated with the presence of faecal material in water.

E. coli – *Escherichia coli or E. coli* are a specific group of coliform bacteria commonly found in the intestines of animals and humans. Their presence is used to indicate that faeces from humans or animals may be present a water sample. Some bacteria within this group can cause illness in humans, whilst faeces can contain other potentially harmful organisms.

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