



RAPPER – Rapid Assessment of Periphyton Ecology in Rivers: a manual for Citizen Scientists

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Martyn Kelly and Bill Brierley

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RAPPER – Rapid Assessment of Periphyton Ecology in Rivers: a manual for Citizen Scientists

Summary

This is a practical guide to the use of RAPPER by citizen scientists who want to assess the ecological condition of streams and rivers. It is based on a manual produced in 2022 for the Local Authority Waters Programme (LAWPRO) in the Republic of Ireland.

The manual describes a method for surveying the visible algae in streams and rivers for people without access to a microscope, and explains how their data can be used, ideally as one of a number of strands of evidence, to estimate its ecological condition. It includes step-by-step guides to selecting appropriate sites, recording metadata and choosing an appropriate survey method. Visible algae are placed into one of 23 categories and the abundance of each category (evaluated as percent cover of the stream bed and thickness of the algal growths) can then be used to determine stream health. Interpretation originally focussed on nutrient pollution but has now been extended to include other stressors.

This project built on earlier work funded by the Scottish Environment Protection Agency and later developed as a Citizen Science tool with funding from LAWPRO in Ireland. Martyn Kelly and Bill Brierley led the work, with support from Rivers Trust staff and volunteers around the country.

Introduction

Almost half of all rivers in Ireland and about a third of rivers in the UK do not meet the Water Framework Directive's definition of "good status". The primary reason for this is pollution from agriculture and urban areas but other factors, including climate change, also play a role. These rivers are "unhealthy" because some organisms (most conspicuously, fish such as salmon and trout) do not thrive in them. When humans are unwell, for any reason, they visit their doctor who has specialist training to diagnose and prescribe treatments to cure their patients. However, we do not just rely upon highly-trained individuals to help us when we are unwell; many individuals are trained in "first aid" and are able to help treat minor injuries, or to provide emergency treatment until specialist help is available.

The same rationale can also be applied to streams and rivers: we need highly trained specialist scientists but they, in turn, are increasingly dependent on "citizen scientists" who, like first aiders, can make preliminary assessments and whose local knowledge complements the training of specialists. Citizen scientists can perform a "triage" on streams with which they are familiar, spotting symptoms of poor health and passing this information on to the appropriate authorities. Importantly, they also recognise situations where their capabilities are exceeded, and where additional specialist evaluation is required.

Citizen science brings together long-standing interests in natural history with more recent concerns about the state of the environment. In this case, we will be helping you better understand an aspect of natural history that most casual observers overlook - the algae that grow in streams and rivers – and show you how a simple visual and tactile assessment can be used to diagnose the health of a stream. However, bear in mind that environmental decisions are rarely black and white. The algae are most useful when combined with other types of evidence (e.g. phosphorus concentration, invertebrates monitoring, and even observations of other wildlife such as kingfishers). The combined evidence creates a more complete picture than any one measurement or observation alone.

This is called the **Weight of Evidence (WoE)** approach. Here, "weight" means the ability to balance different types of information to build a picture that can guide decisions. **The picture is never perfect or complete.** This approach can help groups develop a shared understanding of the state of the river, identify issues, build trust, reach consensus, and decide what action to take. Different pieces of evidence can either refute or support an assumption.



Fig. 1. An illustration of how the “weight of evidence” approach operates. We can be confident when several independent types of evidence point in the same direction, as in the diagram on the right.

In this handbook we describe a simple assessment that can be performed without a microscope. The assessment is a simplified version of Rapid Assessment of PeriPhyton in Rivers (RAPPER) developed in the UK. It can be used on its own, but can also be used alongside the Small Stream Impact Score (SSIS), Citizen Science Stream Index (CSSI) (in Ireland) and Riverfly Monitoring Initiative (RMI) (in UK).

The first version of this manual was developed with funding from the Local Authorities Water Programme (LAWPRO) in Ireland, and is modelled on the Handbook for Citizen Science: Freshwater Biomonitoring in Ireland – Small Stream Impact Score (M. Kelly-Quinn, J.-R. Baars, B. Kennedy & F. Igoe, 2020). The second version was developed with additional support from the Catchment Systems Thinking Cooperative (CaSTCo), funded by the Ofwat innovation fund.

What are indicators?

“Indicators” are to ecologists what “clues” are to a detective investigating a crime or “symptoms” are to a doctor diagnosing a sick patient. Different organisms prefer different types of environments. Some plants and animals only like very clean water whilst others are tolerant of different types of pollution. This means that an ecological detective who looks closely at the organisms living in a stream can deduce the condition of the stream and, often, what types of pollution are responsible.

What are algae?

The term “algae” encompasses several groups of very different organisms that are relatively simple compared to higher plants and which spend most of their life submerged in water. Algae often get bad press, only being noticed when they are very abundant, unsightly, sometimes smelly and occasionally toxic. In fact, algae are essential components of healthy freshwater ecosystems. They provide a large part of the food on which other aquatic organisms depend, and also pump oxygen back into the water to replace that removed by other organisms for respiration. When they are perceived to be a problem it is usually because humans have altered their natural habitat in some way.

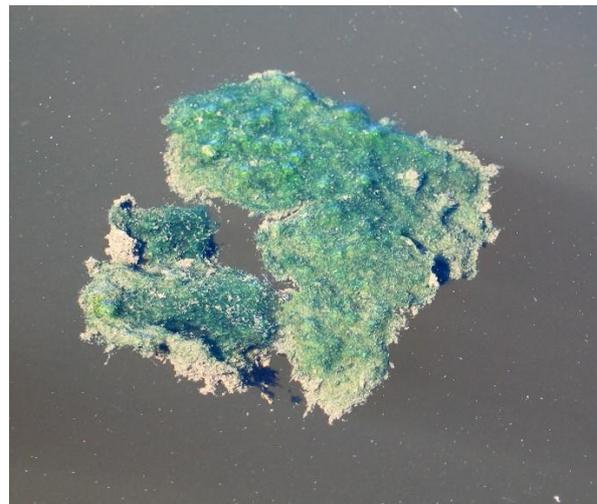
Many freshwater algae are microscopic and cannot be seen with the naked eye. Others, including many that you will learn about in this manual, can be seen with the naked eye but you may need a microscope if you want to identify them properly. Some groups of algae (especially the diatoms and desmids) are beautiful to look at and can be fascinating to examine with a microscope. In this manual, however, we are assuming that not everyone has access to a microscope so will help you deduce the health of a stream using just the naked eye and a hand lens.

The main groups of algae

Most of the algae that are visible in streams belong to the following groups:

Cyanobacteria (blue-green algae)

Very ancient organisms, very widespread and often associated with nutrient-rich conditions in lakes, where they can form toxic “blooms”. The group also includes some important indicators of near-pristine conditions in rivers, although these can be difficult to recognise without a microscope.



Rhodophyta (red algae)

A largely marine group, including many of our common seaweeds, but with some conspicuous freshwater representatives.

Diatoms (Bacillariophyceae)

Mostly microscopic organisms with delicately sculpted silica cell walls. A few form yellow-brown growths that are visible with the naked eye. They can also grow attached to other algae, sometimes making otherwise green filaments brown in colour.





Chlorophyta and Charophyta

Until recently, treated as a single group (the “green algae”) but now recognised to be two distinct types. The Charophyta is the group from which land plants evolved. Many of the common filamentous algae found in rivers belong to these groups

Xanthophyceae (yellow-green algae)

Although members of this group are also green in colour, they are only distantly related to the Chlorophyta and Charophyta. A small group with just two genera that form visible growths, one of which is *Vaucheria*.

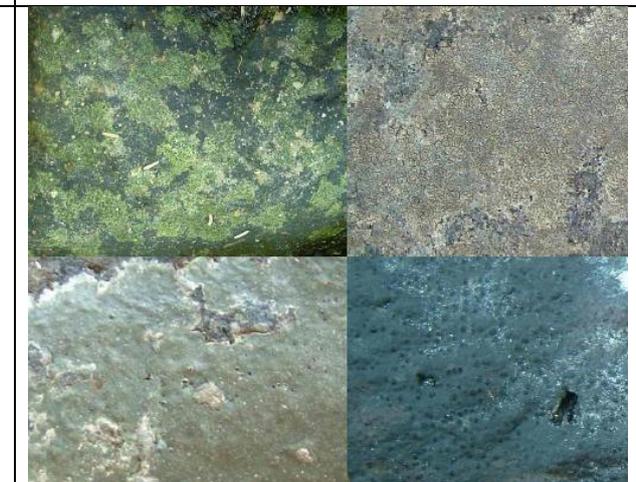
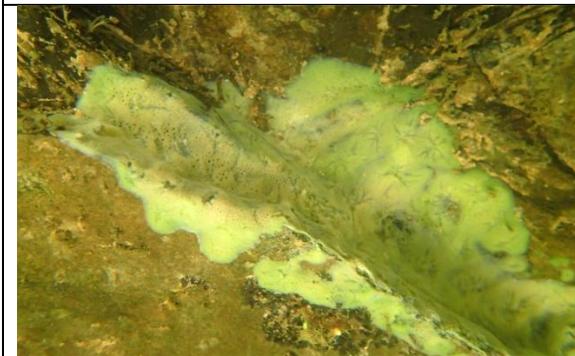


There are also a few groups of river-dwelling organisms that may be mistaken for algae which you will need to watch out for:

Mosses and leafy liverworts (Bryophyta)

These can look like patches of green algae from a distance but, when viewed close-up, have a stem with distinct leaves.



	<p>Thalloid liverworts</p> <p>Some liverworts, particularly at the edges of rivers where they are only periodically immersed, have a flattened green body, often elongated and with lobes. The underside of the plant has hair-like rhizoids which attach them to surfaces</p>
<p>Lichens</p> <p>These are unions of fungi and algae that are common in both terrestrial and aquatic habitats. They can be a range of colours, including green, so it is easy to confuse them with algae. Crustose lichens can be mistaken for encrusting algae but often have distinctive raised fruiting bodies on their surfaces (often darker in colour than the surrounding crust)</p>	
	<p>Sponges</p> <p>These form patches on submerged rocks. Although they are, technically, animals, they often have endosymbiotic algae which gives them a green colour, meaning that they can be confused with algae.</p>

How green is your river?

Algae are natural components of all streams, regardless of their condition. They are mostly inconspicuous, performing the “back office functions” that let healthy ecosystems thrive. However, there are situations when algae can be very conspicuous, with the potential to cause problems for other organisms in the stream, such as invertebrates and fish. There are several reasons why algae might thrive in a river, with elevated concentrations of nutrients, particularly phosphorus, as the most common one. However, there are also situations where nutrient concentrations are high but algae are

not conspicuous. This means that it is helpful to measure both nutrients and algae when we are evaluating the health of a stream.

The implications of excessive algal growths are shown in Fig. 2. This very basic explanatory framework can then be extended to encompass other variables that may influence the quantity of algae and their consequent effects. For example, bankside shade may reduce algal growth, dampening the cycles of dissolved oxygen that these drive. Similarly, a rise in river levels could mitigate the problems of low nighttime dissolved oxygen and, if high enough, could even scour some of the algae away. Obstacles such as weirs may exacerbate problems, whilst reverting to a more natural flow regime (if this is possible) should increase turbulent flow, allowing more gas exchange and, again, lessening the risk of low nighttime.

One consequence is that patterns of algae in rivers can change in both space and time. Shaded and unshaded sections may have different amounts of visible algae, and a mass growth might develop during a long warm period but then be largely stripped away by a sudden spate. This means that several visits to the same location during the year, and also visits to several locations, are helpful to understand the dynamics of algae in a locality.

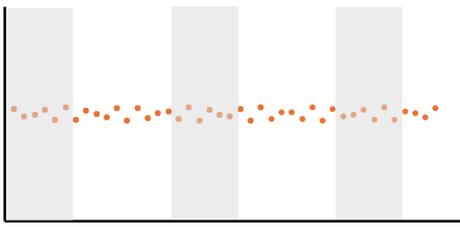
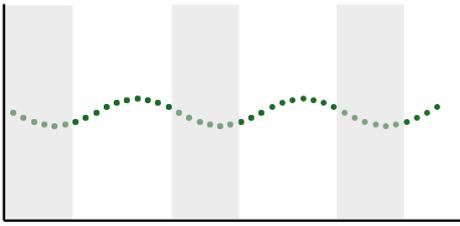
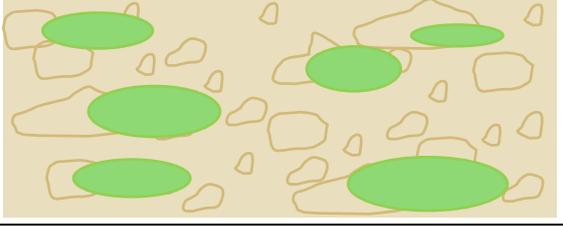
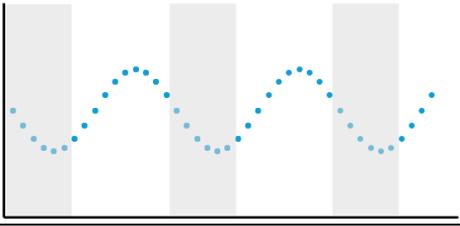
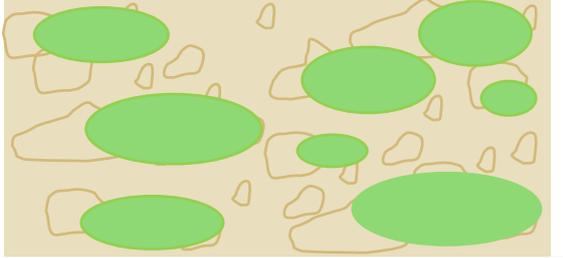
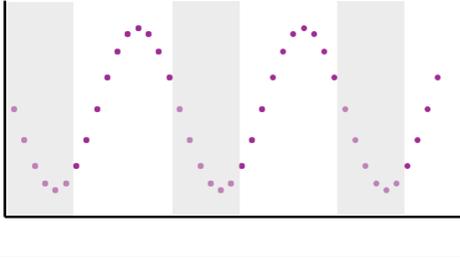
As nutrients are one of the major types of pollution in rivers, arising from both urban and agricultural sources, healthy streams are characterised by algae that do not like high levels of nutrients whilst unhealthy streams have algae that thrive in the presence of nutrients. Differentiating these sensitive types of algae from those that are tolerant to nutrient pollution can help us to understand the health of a stream:

- A healthy stream will have sensitive taxa. Tolerant taxa may be present too, but neither they nor the sensitive taxa are likely to be abundant (meaning that they do not cover much of the stream bed)
- Sensitive taxa will not be present in unhealthy (nutrient-rich) streams, whilst tolerant taxa will be abundant

This simple differentiation covers many, but not all, situations. Some algae, for example, thrive alongside both sensitive and tolerant so we cannot draw any conclusion from their presence. The algae we've designated as tolerant taxa do not thrive in soft water streams, meaning that sensitive taxa may not be out-competed when there are opportunities for growth. We also need to recognise situations where we need more, or different, evidence in order to reach a conclusion.

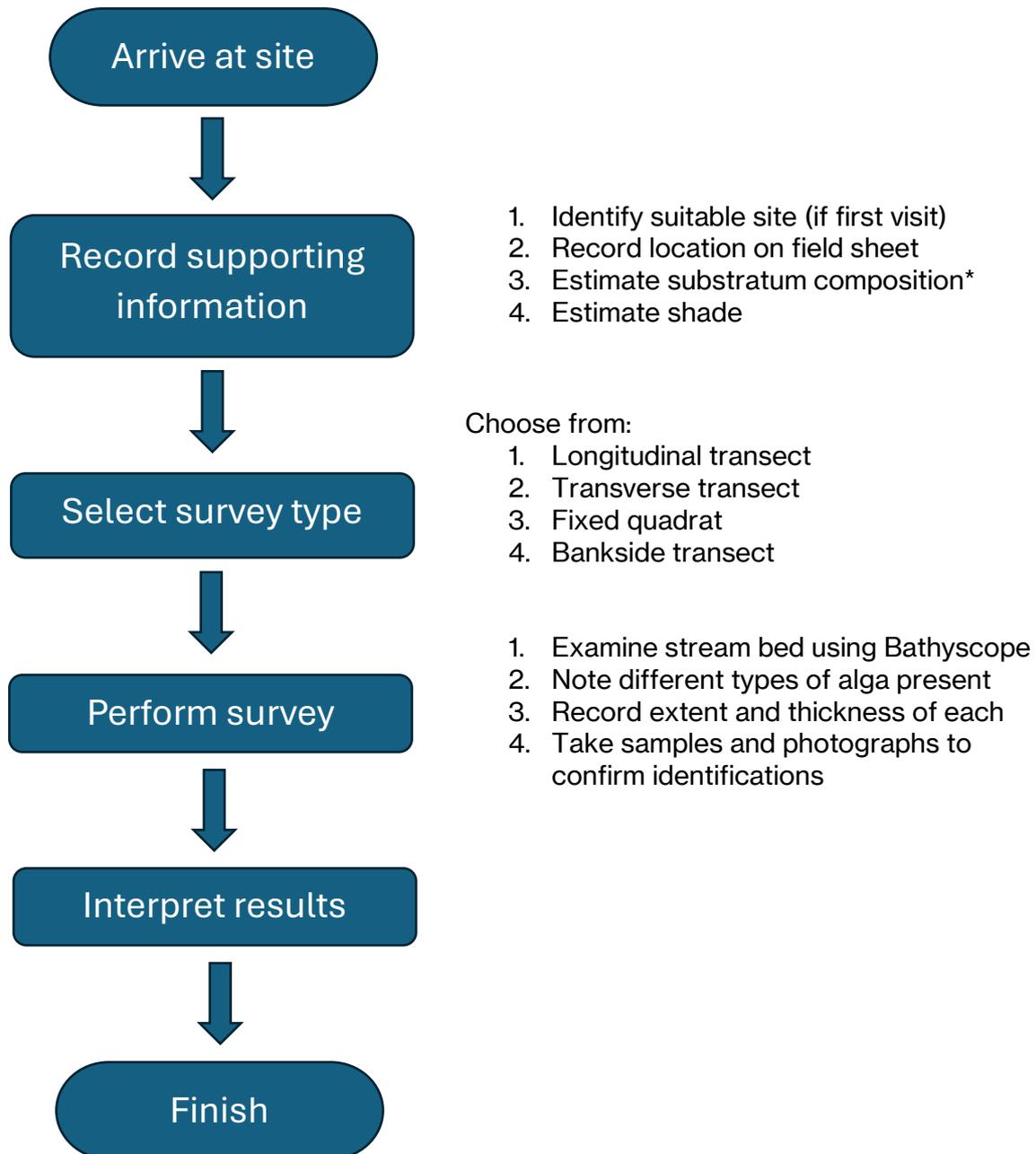
A guide to recognising the sensitive taxa from the tolerant taxa is included later in this manual.

Fig. 2. (overleaf). The relationship between algal growth and likely consequences for stream health. The left-hand column shows a diagrammatic representation of what a citizen scientist might see, the right-hand column indicates plausible patterns of dissolved oxygen arising from this. Grey shaded bars indicate night-time, when plant and algal respiration can reduce oxygen concentrations to the point where other organisms may struggle to survive.

What you see ...	What you get ...
	
<p>High/good status: a few patches of algae may be visible, but will not have a significant effect on the condition of the stream as a whole</p>	
	
<p>Moderate status: several visible patches of algae (> 5% of total stream bed covered). These may have a perceptible influence on stream processes, but are still unlikely to affect the health of the invertebrates and fish across the whole reach, except under extreme conditions (e.g. prolonged periods of warm weather and low flow).</p>	
	
<p>Moderate/poor status: many visible patches of algae, some quite thick, leading to significant fluctuations in oxygen and, potentially, restricting activities of invertebrates and fish</p>	
	
<p>Poor/bad status: extensive growths of filamentous algae, often thick, smothering the substratum and leading to fluctuations in oxygen and, potentially, nighttime anoxia and restricting activities of invertebrates and fish.</p>	

When examining the algae growing in a stream we need to take account of both the types present and their quantities. Overall quantity is important as this will determine the potential to drive fluctuations in dissolved oxygen and modify the habitat for other organisms. However, the types of algae can also tell us something about a site.

Step-by-step guide



* Some people find it more helpful to estimate substrate composition at the end of the survey, in order to give them time to reflect on initial impressions.

Fig. 3. Flow chart summarising the steps involved in RAPPER surveys

What equipment do I need?

The following are the basic pieces of equipment for surveying algae in a stream:

- Waterproof boots / waders, thick rubber gloves, disinfectant (for biosecurity cleaning)
- Aquascope (also known as a “Bathyscope” – see picture on right). This is not essential, but it makes it much easier to examine the bed of a stream. If an Aquascope is not available, a glass-bottomed bucket or a good pair of polarising sunglasses is recommended.
- White tray (not essential but useful for sorting specimens)
- Pair of forceps and a small penknife (for removing specimens from rocks)
- Magnifying lens (preferably 20-40x)
- A copy of the field record form along with a weather writer (see picture) and pencils
- Tape measure (at least 10 m) (or an alternative means of measuring out a survey length – if you know the length of your pace, then this will be adequate)
- Camera or phone to take photos and record the location using the GPS function
- Life jacket or buoyancy aid (necessary if the stream is wide, fast-flowing or deep)



When should algae be surveyed?

Visible growths of algae can be found at all times of the year and some species have distinct seasonal preferences. Surveys between late Spring and early Autumn are recommended as the combination of low flows and warm temperatures will encourage a wide range of algae (including nuisance species such as *Cladophora* and *Hydrodictyon*). The survey period may be extended further into autumn if weather and flow conditions are favourable.

Surveys should be carried out during normal flow. Immediately after spates, rivers may be discoloured, preventing a clear view of benthic algae, as well as creating difficulties when wading across the river. Spates may also move substrata and scour algae. Surveys should not be performed within two weeks of a major spate. Online resources

such as EPAs' hydronet (<https://epawebapp.epa.ie/hydronet/>) or the OPW's Hydro-data (<https://waterlevel.ie/>) are useful for checking that high flows will not impede your survey. Hydronet also covers Northern Ireland whilst www.riverlevels.uk is the equivalent site for Great Britain.

Where to sample

Conditions in a stream can vary considerably over a short distance and it is important that surveys of algae are performed at the locations that are best suited to their growth. As far as possible, find sites that are relatively unshaded and where there are stable substrata. The flow regime can vary considerably over a short distance, with the fast-flowing areas ("riffles" and "runs") preferred to slower flowing sections ("pools"). For small streams, it is possible that a single section will encompass more than one of these "mesohabitats".

We recommend that, as far as possible, RAPPER surveys are performed in well-lit riffles, glides and runs because these will be the most suitable locations for algae to thrive, giving you the best possible insight into the potential for visible algal growths. However, we also recognise that such conditions cannot always be found, and some compromises may have to be made. RAPPER is not suitable when water is deep (greater than mid-thigh) and where the substratum is composed predominately of pebbles, gravel or finer sediments.

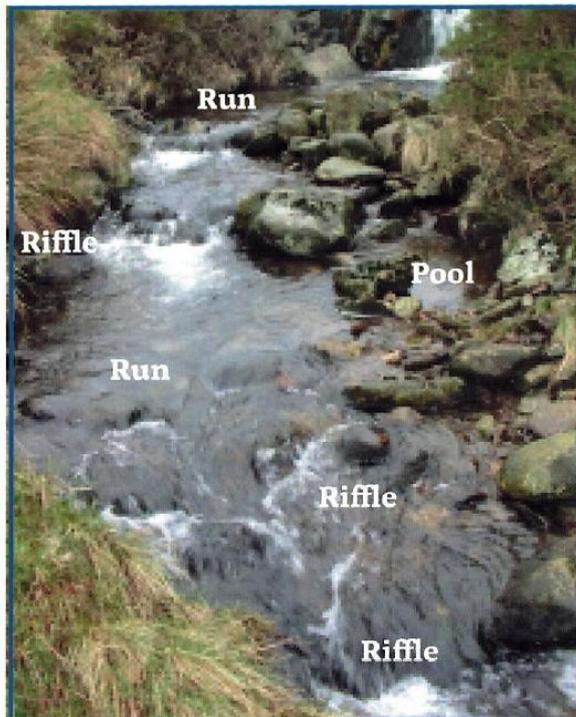
Box: 1

Riffle: Fast flowing, usually shallow water with broken surface. Typically appears white with bubbles on the surface.

Run: Fast to medium flowing water usually 10 to 40 cm deep. Surface of water clearly moving with a rippled surface, typically, not white in colour.

Glide: Medium to slow flow usually deeper than a run (30 to 50 cm). Clear signs of flow but the surface of the water is smooth with few ripples. Atypical in small streams

Pool: Very little flow on the surface, usually deeper than surrounding water. Area of deposition and likely accumulations of silt or leaf litter.



(Reproduced from "Handbook for Citizen Science Freshwater Biomonitoring in Ireland")

Other considerations include easy access from a road (and somewhere safe to park), permission from the landowner and a safe place to enter the stream. If you are comparing two or more sites, then try to make sure that shading, substratum and

mesohabitat conditions are as similar as possible. A risk assessment should always be undertaken before starting a survey.

When you arrive at a site

Observe the range of mesohabitats present and identify a suitable stretch to survey. The idea is to make sure that all RAPPER surveys examine roughly the same area (50 m²), regardless of stream or river size. As RAPPER was originally devised for small streams, we assumed that this would be a longitudinal transect (see Fig. 4) but other options are possible for wider rivers (see Figs. 5 and 6). Use a tape measure to mark out an appropriate stretch. If invertebrates are also being sampled, this should be done downstream from the stretch used for algal survey.

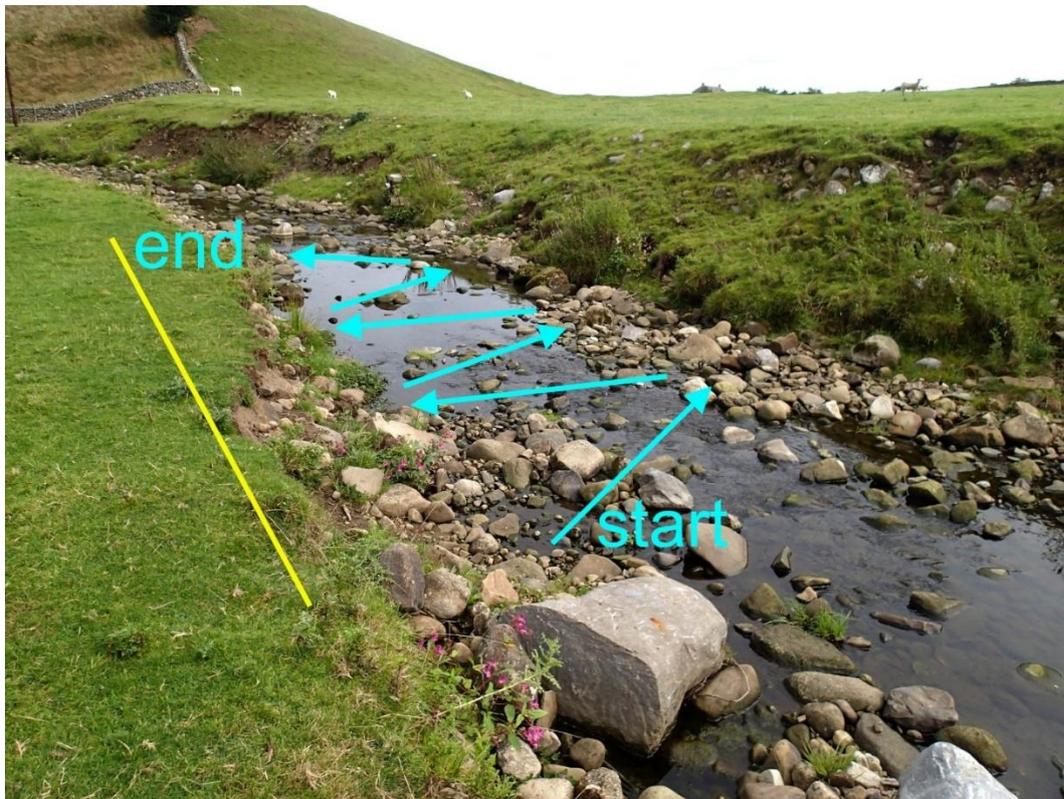


Fig. 4. How to survey algae in a stream. The yellow line indicates the 10 m stretch measured using a tape measure. The blue lines indicate the zig-zag route followed by the surveyor, starting at the downstream end.



Fig. 5. The River Ribble at Bradford Bridge, showing two possible survey options for a medium or large river. The rectangle at the back shows a narrow transect; the rectangle in the foreground shows a fixed quadrat.



Fig. 6. The River Usk at Abervavenney, where the survey transect extended approximately 5 m out from the shore. The area on the right hand side of the image was too deep to permit safe wading, and was also heavily shaded by trees.

How to survey the algae in a stream

First, record “metadata” – the background information that will help you place your survey results into context. Take a photograph of the site, facing upstream, making sure to include the stream banks in the image. Record the location with your GPS device. Fill in the survey details on your field sheet (e.g. location, date, time, approximate percentage of substrata (using the Wentworth scale – see Table 1), approximate width and depth, extent of shade (Fig. 7).

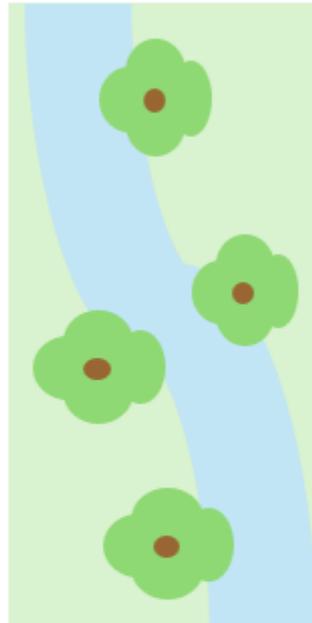
Table 1. The Wentworth scale for recording river substrate composition

Name	Size	Description
Bedrock		Exposure of underlying solid rock
Boulder	> 256 mm	Head size and larger
Cobble	> 64 ≤ 256 mm	Half fist to head size
Pebble	16-64 mm	Broad bean to half fist
Gravel	2-16 mm	Instant coffee granule to broad bean
Sand	> 0.06 ≤ 2 mm	Smaller than instant coffee granule, and abrasive
Silt	< 0.06mm	Smaller than instant coffee granule. Soft in texture, not sticky.
Clay	<0.06mm	Sticky and cohesive
Peat		
Artificial		



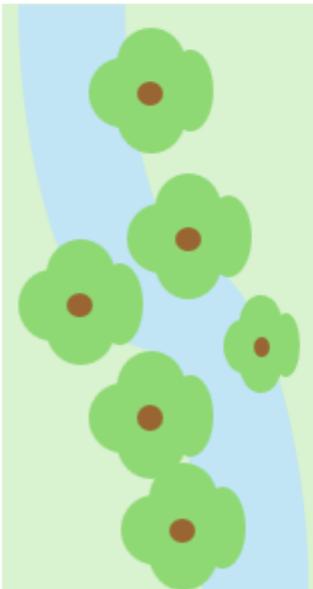
← **No or low shade**

no overhanging trees for the entire length of the survey stretch. Sunlight reaches water surface at all times except very early morning and late evening in summer.



Moderate shade →

Overhanging trees shade up to about 25% of the channel width, intercepting light even when the sun is high in the sky



← **Heavy shade**

More than 25% of the channel width is shaded, even when the sun is high in the sky.

Note that emergent vegetation such as rushes may also shade the channel, especially in smaller streams.

Fig. 7. The three categories of shade that should be recorded on your field record forms.

Now you are ready to start the survey proper. These guidelines assume you are surveying a small stream, but the same principle can be applied to the alternative survey approaches shown in Figs 5 and 6.

Start at the downstream end of the stretch you have delimited (so that your movements do not throw up sediment that may obscure the stream bed) and systematically examine the bed whilst wading back and forth in a zig-zag manner (see Box 2) in order to identify any algal growths that are present. An underwater viewing device such as an “Aquascope” may be useful for this. You will need to remove small portions of each type of growth either with your fingers or a pair of forceps. Rub these gently between two fingers to determine whether or not they are slimy (mucilaginous) or not and examine with a hand lens to see if branching is visible. A white plastic tray can be helpful for comparing several small samples from a reach.

It is possible that two or more types of algae will be found in a reach, so check several specimens for sliminess and branching, and also look for obvious differences in colour. Once you have surveyed the entire length, make an estimate of the percentage of the river bed that each growth form occupies using a four point scale as follows:

- 0 = no obvious filamentous algae;
- 1 = filamentous algae present, percent cover = low (< 5% of stream bed);
- 2 = filamentous algae present, percent cover = moderate (≥ 5 , < 25% of stream bed); or,
- 3 = filamentous algae present, percent cover = high ($\geq 25\%$ of stream bed).

Fig. 8 visualises these cover values. Make a separate estimate for each type of alga you record based on your survey of the 10 metre plot.

You should also record the thickness of each type of algal growth you encounter, using the thickness scale (Table 2). The thickness of a growth may vary across the survey reach – for example, there may be thick growths at edge but no more than a trace on surfaces in the middle of a stream. You should aim to estimate a median value for the whole reach, rounded up where necessary.

Record details of each type of alga onto your field sheet.

If you are uncertain about the identity of an alga, put a small specimen in a labelled tube with a little stream water (make sure that alga + water is no more than 10% of the total volume of the tube) for verification. If this is done within a few days, and the sample is kept in a cool place, no preservatives are necessary.

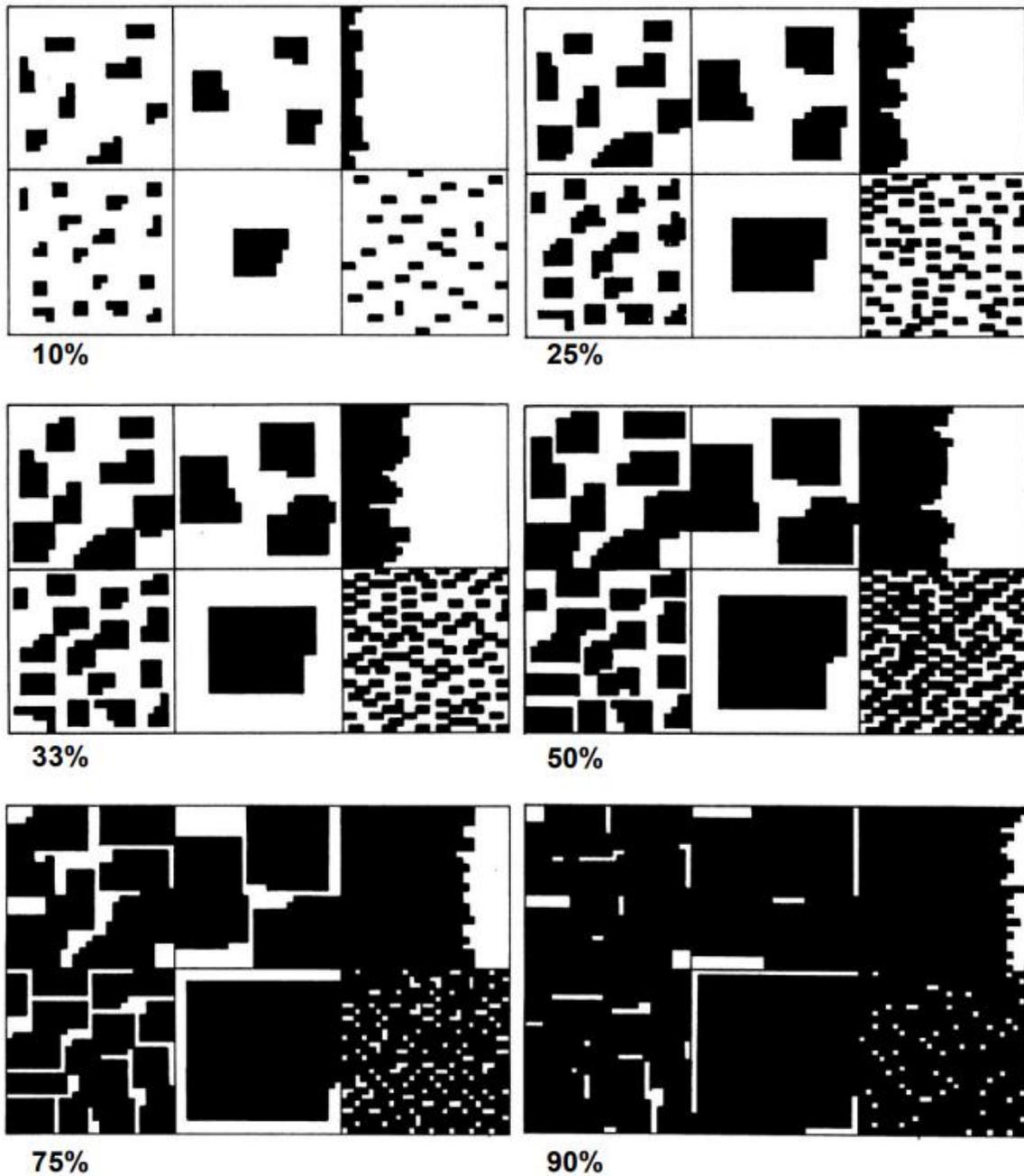


Fig. 8. Visualisations of different cover values of filamentous algae (or substrate categories) on stream beds. From : Environment Agency guidance document OI08_08 Freshwater macro-invertebrate sampling in rivers. Issued 2017

Table 2. The scale for recording the thickness of algal growths.

Score	Description / thickness	Note
1	Trace (< 1 mm)	Algae follows contours of the stone, and the substratum is still visible beneath. A finger pulled across the surface leaves no impression.
2	Thin (1-2 mm)	Algae smothers surface and the substratum is no longer visible. Major contours are still apparent and a finger pulled across the surface leaves a slight impression.
3	Thick (2 – 5 mm)	Algae forms an opaque layer that also obscures most of the contours of the substratum. A finger pulled across the surface leaves a distinct impression.
4	Massive (> 5 mm)	As above but even thicker.

Before you leave the river site

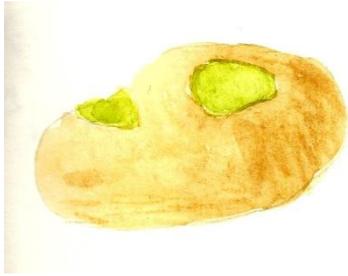
- Return any algae that you have collected to the river (apart from specimens saved for confirmation, which should be stored in a cool, dark place).
- Before you go to another stream you need to clean your boots in a solution of household bleach or Virkon, if available, to avoid taking invasive species or contaminants to other locations. Take the household bleach or Virkon solution home with you in a secure container. Do not dispose of it in the river, or on or near the riverbanks.
- Make sure, too, that you clean your hands with an alcohol-based gel or soap and warm water before handling food or drink.

Identifying algae in the field

The main groups of algae likely to be encountered in streams were described above. In this section, you'll learn more about each of these groups in order to help you identify them in the field. This is not an exhaustive list, but it is as far as we can confidently go without recourse to a microscope. We've also simplified the taxonomy considerably and divided them into three groups to help you interpret the quality of a river: sensitive taxa (green in the tables); tolerant taxa (orange) and "uncertain" (no colour).

Step 1: decide the growth form of the specimen you want to identify

A. Crusts



Organisms that are tightly attached to the substratum. You may be able to remove small fragments by scratching with a fingernail or blade but you cannot lift the crust in a single piece. There may be evidence of calcification. May be green, red, brown or even black in colourA

B. Colonies



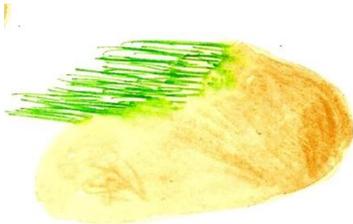
These form distinct three-dimensional patches on the substratum, ranging from just visible with the naked eye to several centimetres across. Often yield when pressed. They can be removed from the substratum using forceps or a blade. Various shades of green and brown in colour. B

C. Mats, flocs and films



Prostrate on substratum, loosely-attached or floating to water surface but lacking the distinct outlines of colonies. Individual filaments rarely visible to naked eye. Often slimy to the touch. Various shades of green and brown C

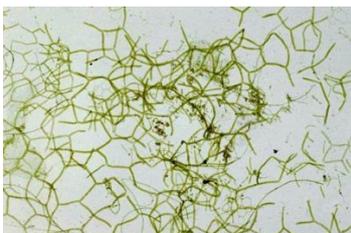
D. Filaments



Attached to hard substrata; individual filaments are visible with the naked eye; generally \pm horizontal to substratum (especially in flowing waters) but, occasionally, \pm vertical. May be rough or slimy to the touch. Usually green in colour but can also be brown D

These two categories often overlap with each other, depending on local conditions.

E. Net-like structures



From a distance these can look like filaments, mats or flocs but, on close inspection, they can be seen to be composed of a mesh of cells. Green in colour. These belong to a green alga, *Hydrodictyon reticulatum*.

F. Thalloid (look like green “seaweeds”)



Simple multicellular organisms which lack differentiation into root, stem, leaf or leaves. For the purpose of this booklet, they are sheets of cells, forming thin membranes or tubes

G. Characeae



A single main stem from which whorls of branches arise at intervals. May be stiff and rough to the touch due to calcification. Green. Easily mistaken for higher plants

Step 2a: learning more about crusts

Colour	Appearance and texture	Likely identity	Habit
Green	2 mm to several cm in diameter, often calcified.	<i>Gongrosira</i>	usually prefers relatively unpolluted conditions.
Red (1)	Patches of irregular shape and various size but always with a distinct outline; on flat and convex surfaces of pebbles and larger substrata that are submerged for most of the time.	<i>Hildenbrandia</i>	Found across a wide range of nutrient concentrations.
Red (2)	Patches of irregular shape and size, lacking a distinct outline, most likely to form in concave surfaces on rocks	<i>Haematococcus</i>	Associated with exposed surfaces that frequently dry out (e.g. bird baths)

Brown / black	Patches of irregular size and outline, typically dark brown to almost black. Difficult to distinguish from some inorganic deposits.	A characteristic growth form of several types of cyanobacteria and also of freshwater brown algae. No further identification or interpretation is possible without a microscope.	Some live fully submerged; some thrive at the air/water interface.
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Aquatic lichens also form crusts. These can be white, green or brown/black in colour and have distinct outlines. Watch out for fruiting bodies (perithecia), usually black and appear as small raised domes or pimples. They tend to be regularly dispersed on the surface of the lichen and range from about 0.2-1 mm in diameter (best seen with a hand lens)

Illustrations of crusts



Gongrosira incrustans



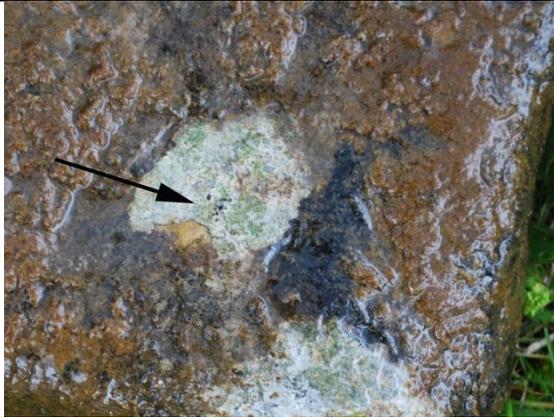
Hildenbrandia rivularis



Haematococcus pluvialis



Chamaesiphon cf. fuscus



Aquatic lichen (fruiting bodies indicated by arrow)

Step 2b: learning more about colonies

Colour	Appearance and texture	Likely identity	Habit
Green	Hard cushions, 2 mm to several cm in diameter, often calcified.	<i>Chaetophora</i>	usually prefers relatively unpolluted conditions.
Green	Jelly-like patches that are slimy to the touch, from 5 mm to about 2 cm in diameter	<i>Tetraspora</i>	Prefers unpolluted conditions
Brown/brown black	Gelatinous or leathery rounded structures with a distinct outer layer. Rubbery texture	<i>Nostoc</i>	Common in terrestrial as well as aquatic habitats; colonies of aquatic forms live on stream beds
Brown	Typically hemispherical growths (sometimes mats) on upper surfaces of stones ranging from 5 mm to about 2 cm,	Other cyanobacteria colonies (e.g. <i>Rivularia</i> , <i>Tolypothrix</i>)	Mostly associated with near-pristine conditions.
Brown or yellow-brown	hemispherical colonies which have the texture of damp cotton wool which grow on rocks, eventually coalescing with neighbours to such an	<i>Didymosphenia</i>	Mostly associated with near-pristine conditions

Colour	Appearance and texture	Likely identity	Habit
	extent that they can, under some circumstances, smother the entire stream bed		
Brown or yellow-brown	Hemispherical colonies often slimy to the touch and without the “cotton wool” texture of <i>Didymosphenia</i>	Other diatoms, especially <i>Gomphonema</i> and <i>Cymbella</i>	Especially abundant in spring. Colonies that are visible with the naked eye are mostly associated with relatively low nutrient concentrations.

Illustrations of colonies



Chaetophora pisum



Tetrastroma gelatinosa



Nostoc commune



Rivularia biasoletiana



Didymosphenia geminata

Gomphonella olivacea

Step 2c: learning more about mats, flocs, films and filaments

Colour	Appearance and texture	Likely identity	Habit
Green	Slimy when rubbed between fingers	Various candidates, including <i>Spirogyra</i> , <i>Mougeotia</i> , <i>Zygnema</i> , <i>Stigeoclonium</i> , <i>Draparnaldia</i>	usually prefers relatively unpolluted conditions.
Green	Rough when rubbed between fingers, branches visible when viewed through handlens. Filaments can be up to about 50 cm in length. Do not include distinct mats in this category	<i>Cladophora</i>	Widespread, but particularly abundant in enriched conditions.
Green	As above, but forms distinct mats/carpets on upper surface of stones in rivers and individual filaments do not exceed 3 cm in length	<i>Aegagropila</i>	Absent from heavily enriched rivers
Green	Rough when rubbed between fingers, but no branches visible	Various candidates including	Broad ecological range

Colour	Appearance and texture	Likely identity	Habit
	when viewed through handlens.	<i>Oedogonium</i> and <i>Bulbochaete</i> . Difficult to differentiate without microscope	
Green	Mostly vertical (sometimes prostrate) filaments forming dark green felt-like mats or cushions up to 20 cm across.	<i>Vaucheria</i>	Broad ecological range but especially prolific in enriched conditions.
Olive-green	Sparsely branched filaments with a coarse, wiry feel with thickened nodes at intervals. The whole plant is streamlined in appearance and can grow up to 40 cm long.	<i>Lemanea</i>	Prefers relatively unpolluted conditions. Found in the fastest flowing sections, and most abundant in late winter/early spring. Also tolerant of heavy metals.
Olive-green to brown	Very slippery to the touch (like frog spawn); a beaded-structure should be apparent when viewed with a hand lens.	<i>Batrachospermum</i> and relatives	Mostly associated with good conditions, although exceptions do occur.
Blue-green, green, brown	Mat, closely adpressed to surface	Cyanobacterial filaments (e.g. <i>Microcoleus autumnalis</i>)	Several species occurring across a range of conditons
Pink / red	Short filaments forming tufts or mats on surfaces. Branching present but not visible with naked eye	<i>Audouinella</i> / <i>Chantransia</i>	<i>Chantransia</i> are simple filamentous stages of other red algae such as <i>Lemanea</i> . Most cannot be identified reliably

Colour	Appearance and texture	Likely identity	Habit
			even with a microscope.
Brown	Very delicate filaments that disintegrate very easily when touched. No branching visible when viewed with a hand lens.	<i>Melosira varians</i>	Mostly associated with enriched conditions, especially after long periods of warm weather and low flow.

Illustrations of mats, flocs, films and filaments



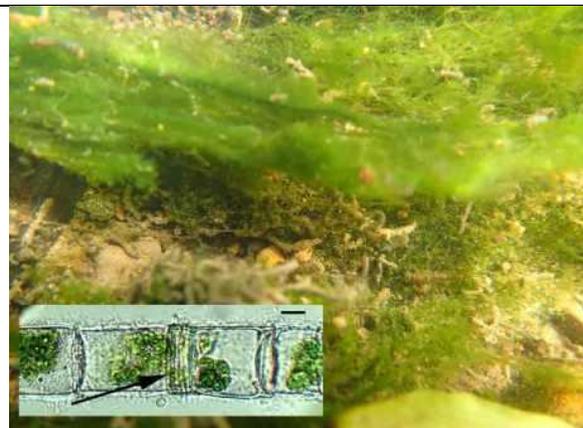
Stigeoclonium tenue



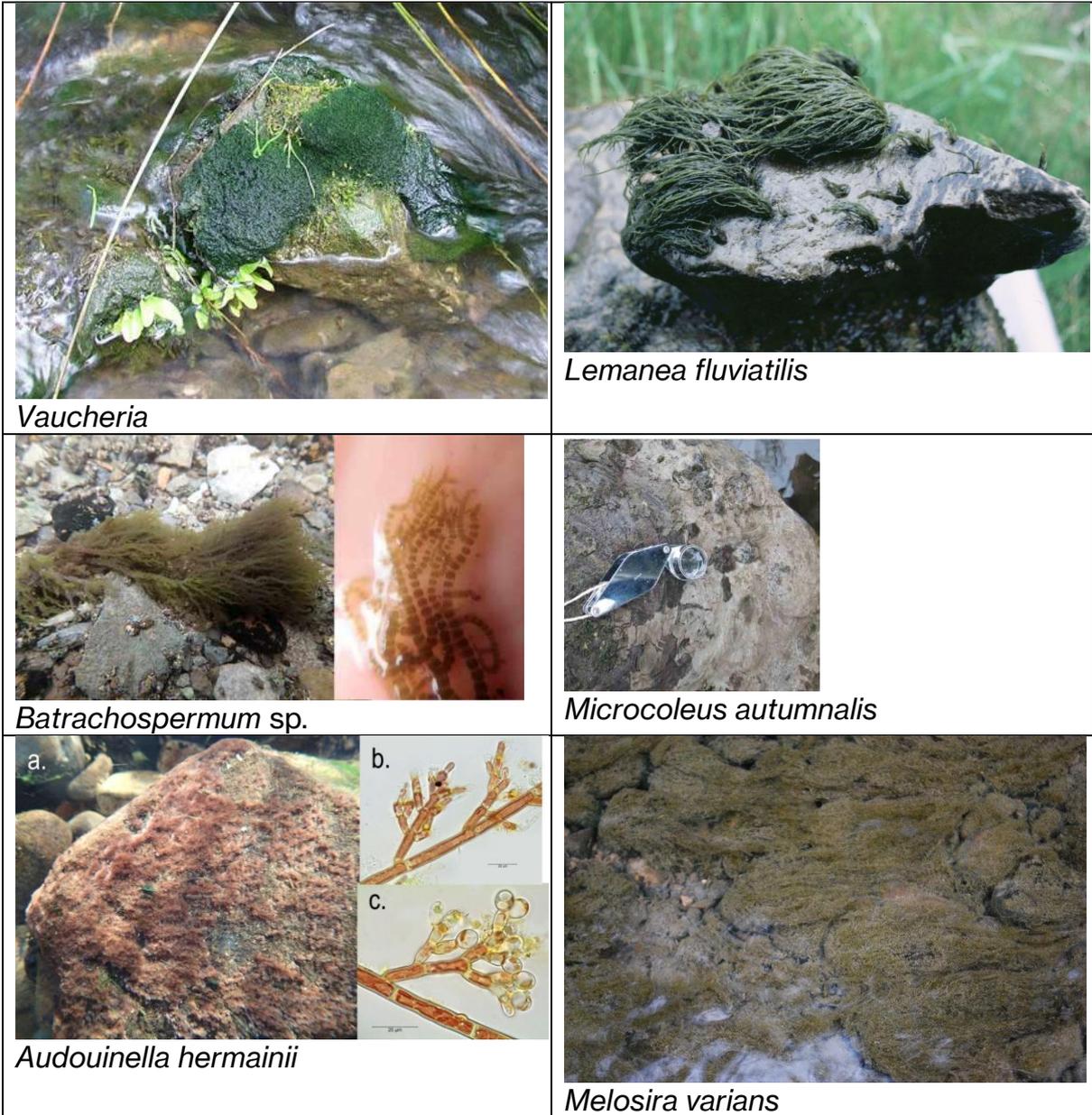
Cladophora glomerata



Aegagropila limnei



Oedogonium sp



Step 2d: learning more about other growth forms

Colour	Appearance and texture	Likely identity	Habit
Green	Forms thick mats which, on close inspection with the naked eye or hand-lens, is a fine mesh of green filaments	<i>Hydrodictyon</i>	Mostly lowland areas, where it can form extensive growths, particularly in late summer.

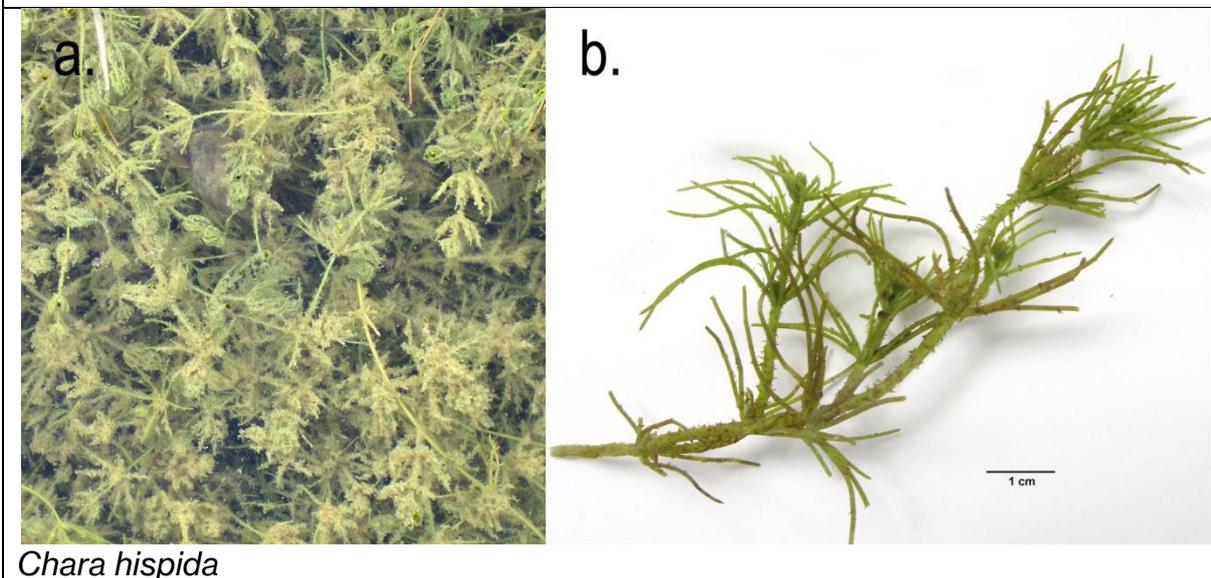
Colour	Appearance and texture	Likely identity	Habit
Green	Narrow tubular thalli, often branched	<i>Ulva</i>	Lowland enriched rivers; most abundant in late summer
Green	Central stem from which whorls of “branchlets” arise. Outer cortex of some forms is calcified and/or have spines, making the plant rough to the touch. Other genera are softer to the touch. Often smells garlicky or musty	Characeae	Generally associated with relatively clean water.

Illustrations of other growth forms





Ulva flexuosa



Chara hispida

Additional observations

Make sure you have completed all the fields in the survey form. Note that there is also space for you to add any observations of your own that you think may be useful for interpreting the results.

Calculating RAPPER-CS

Once you have recorded all the types of algae that are present, and assessed their abundance, use Tables 3 and 4 to estimate the health of your stream. Note that we are mostly interested in whether sensitive taxa are present, whereas it is the abundance of tolerant taxa, rather than just their presence, that is most important. The complete list of indicators is:

Table 3. Summary of algae categories and their indications

Growth form	Colour / texture (likely identity)	Indication
Colonies	Green (1) (<i>Chaetophora</i>)	Sensitive
Colonies	Green (2) (<i>Tetraspora</i>)	Sensitive
Colonies	Brown/brown-black leathery (<i>Nostoc</i>)	Sensitive
Colonies	Brown, not leathery (<i>Rivulariaceae/Tolypothrix</i>)	Sensitive
Colonies	Brown/yellow-brown (1) <i>Didymosphenia</i>	Sensitive
Colonies	Brown/yellow brown (2) other diatoms	Sensitive
Crust	Green (<i>Gongrosira</i>)	Sensitive
Crust	Red (1) (<i>Hildenbrandia</i>)	Uncertain
Crust	Red (2) (<i>Haematococcus</i>)	Uncertain
Crust	Brown black	Uncertain
MFFF	Green, rough, branched (<i>Cladophora</i>)	Tolerant
MFFF	Green, upright filaments, felty-texture (<i>Vaucheria</i>)	Tolerant
MFFF	Brown, very delicate (<i>Melosira</i>)	Tolerant
MFFF	Green, slimy	Sensitive
MFFF	Olive green, coarse, wiry with nodules (<i>Lemanea</i> etc)	Sensitive
MFFF	Olive-green to brown, slippery (<i>Batrachospermum</i>)	Sensitive
MFFF	Pink red short tufts or turf (<i>Audouinella / Chantransia</i>)	Sensitive
MFFF	Green, rough, short filaments, mats or carpets (<i>Aegagropila</i>)	Uncertain
MFFF	Green, rough, no obvious branches	Uncertain
MFFF	Blue, green, brown mats (Cyanobacteria)	Uncertain
Other	Green, net-like (<i>Hydrodictyon</i>)	Tolerant
Other	Green, narrow tubular thalli (<i>Ulva</i>)	Tolerant

Table 3 (cont.)

Growth form	Colour / texture (likely identity)	Indication
Other	Green, stalk with whorls of branchlets (Characeae)	Sensitive

(MFFF = Mats, flocs, films, filaments)

We should not rely on a single taxon to determine the health of a stream. Overall, the balance of organisms should point either towards a healthy or an unhealthy stream but there will still be some mismatches, both “false positives” or “false negatives”. This is exacerbated when we have limited capacity to identify the organisms, so it is important that we accept this uncertainty and look for additional evidence in order to reach a firm conclusion.

Be aware, too, that both sensitive and tolerant taxa can thrive when invertebrates are affected by other pressures (e.g. acidification, toxic metals). Long periods of warm dry weather can also encourage algae to grow even if pollution levels are quite low.

Table 4. The revised interpretation framework for RAPPER.

Algae		Thickness			
Sensitive	Tolerant	1	2	3	4
Present	0 - 5%				
Present	≥ 5, < 25%				
Present	≥ 25%				
Absent	0 - 5%				
Absent	≥ 5, < 25%				
Absent	≥ 25%				

Risk of “eutrophication”

Low	Maybe	High
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If more than one taxa is recorded for each group, combine the cover values by adding together the mid-points of their individual cover categories. These are:

Category	Cover range	Mid-point*
1	< 5%	1.25
2	5 – 25%	13.03
3	> 25%	56.25

* Note that mid-points were calculated on square-root transformed data

The outcomes designated as “maybe at risk” fall into two groups:

mixed messages: (evidence points in two directions with both sensitive and tolerant taxa);

Algae		Thickness			
Sensitive	Tolerant	1	2	3	4
Present	0 - 5%	Blue	Blue	Blue	Blue
Present	≥ 5, < 25%	Blue	Green	Green	Green
Present	≥ 25%	Green	Green	Orange	Orange
Absent	0 - 5%	Green	Green	Green	Green
Absent	≥ 5, < 25%	Green	Green	Orange	Orange
Absent	≥ 25%	Green	Orange	Orange	Orange

not enough evidence: sensitive taxa are not present and tolerant taxa are absent or sparse). Maybe algae are unable to thrive due to shading, or have been scoured away by a recent spate).

Algae		Thickness			
Sensitive	Tolerant	1	2	3	4
Present	0 - 5%	Blue	Blue	Blue	Blue
Present	≥ 5, < 25%	Blue	Green	Green	Green
Present	≥ 25%	Green	Green	Orange	Orange
Absent	0 - 5%	Green	Green	Green	Green
Absent	≥ 5, < 25%	Green	Green	Orange	Orange
Absent	≥ 25%	Green	Orange	Orange	Orange

Worked example (1): a lowland site in summer.

The following algae were found:

Category	Cover	Thickness
<i>Melosira varians</i>	2	3
<i>Vaucheria</i>	1	3
<i>Cladophora glomerata</i>	2	4

No sensitive taxa were recorded. To calculate the overall cover of the tolerant taxa, we sum the three taxa as follows: 13.03 + 1.25 + 13.03 = 27.3, which equates to cover category = 3

The average thickness is 3.3 which, rounded down, is equivalent to thickness = 3.

Together, the absence of sensitive taxa, cover = > 25% and thickness = 3 equate to this site being classified as “at risk”

Worked example (2) Lake District river, downstream of lake, late summer

The following algae were found:

Category	Cover	Thickness
Slimy greens	3	3
Brown colonies	1	

The algal growths here are extensive and thick enough for this site too to be classified as “at risk”. This is because, though usually associated with high quality streams, mass growths of “slimy greens” still have the potential to influence other stream processes. In this case, other information indicates that this is unlikely to be due to nutrients but that a long period of warm weather and low flow may be responsible.

Additional evidence

A single visit to a reach gives us some information about the condition of a stream but this understanding could be improved if it were combined with other evidence. This might include:

- **Further visits to the location.** Further visits to the same location help to understand whether a flush of green algae is a transient phenomenon or is persistent. Several types of stream algae have a burst of growth in late winter and early spring, so a visit in early summer is a good plan to see whether these growths have dissipated or not. Similarly, warm dry periods in summer can lead to extensive algal growth even in relatively healthy streams, so a visit in autumn may reveal some dramatic changes.

In all cases, the most reliable baseline for a stream is drawn from your own accumulated experience of that stream. Repeated visits will give you some insight into expected patterns of seasonal variation, and deviations from this pattern should alert you to changes in the catchment.

Leave at least a month between visits; two or three monthly intervals are recommended for regular monitoring.

- **Visits to nearby locations.** Another question to ask if a stretch of a stream appears to be unhealthy is whether other stretches of the stream also show similar symptoms or whether this is a very local phenomenon. If it is confined to a limited area, then this might prompt a search for causes (e.g. a farmyard or wastewater discharge). You will need to use your knowledge of the locality to decide where else to survey. If you suspect a discharge, search for new locations upstream of this. Pay particular attention to changes in land use and the presence of settlements. Make sure that any extra sites have similar types of substratum and bankside shade to your original site.

It is also worthwhile looking at reaches in nearby catchments. Assuming that land use and settlement patterns are similar, then similar patterns of algal growth will point to a regional, rather than a local, effect.

- **Analysis of invertebrates present in the stream.** Riverfly sampling across the UK – either basic RMI or extended Riverfly can be useful to monitor alongside RAPPER. The Extended Riverfly produces a water quality score and a silt/flow score which can help determining if other pressures are evident in the river. In Ireland, the Small Stream Impact Score (Ireland) combines an assessment of algal cover with information gained from invertebrate “kick” samples to give a more nuanced insight into the condition of a stream.
- **Analysis of the chemistry of the stream.** Basic water quality tests carried out alongside the RAPPER surveys will be useful in identifying whether there are any basic water quality issues. Water quality parameters that are relatively easy to measure in the field include, phosphate, nitrate, ammonia, conductivity, pH, turbidity/total dissolved solids. The equipment and methods chosen will depend on what is available and what level of training is required. The Catchment Systems Thinking Cooperative has reviewed and audited several water quality methods and made recommendations on which ones to use – <https://castco.org/knowledge-base/overview-water-chemistry-monitoring/> Freshwater Watch nutrient test kits can also be used.