‘Sewage fungus’
A field and microscopic guide

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Introduction

• Mainly heterotrophic micro-organisms
• Sensitive indicators of organic pollution
• Matrix of filamentous bacteria, fungi and/or stalked protozoa
• Can be present either as an almost pure monoculture of one species or as a mixed growth of several species
• Growth form varies due to species type and severity of organic pollution
• Species present can indicate type of organic pollution
• Colour varies widely from white to brown or pink
• Can be used to identify organic pollution sources several kilometres away
• Assessment below substrate particularly useful as lack of competition with autotrophic organisms
• Microscopic examination required to confirm identification
References


Main sewage fungus taxa and growth forms

The taxa below are the main sewage fungus organisms found in freshwaters and typical growth forms. One or more taxa can be present in sewage fungus outbreaks and microscopic examination is required to confirm identification. Further information on growth forms, environmental conditions and key identification features can be found on pages 12 to 25.

**Sphaerotilus natans**
Filamentous bacterium
Slimy fronds

**Zoogloeal bacterium**
Ill defined taxonomically
Jelly-like gelatinous mass

**Beggiaatoa alba**
Filamentous bacterium
Thin white film
Main sewage fungus taxa and growth forms

**Fusarium aquaeductuum**
Filamentous fungus
Imparts pink or red colouration

**Geotrichum candidum**
Filamentous fungus
Soft texture loosely following contours of stones

**Leptomitus lacteus**
Filamentous fungus
Overlapping cotton wool-like streamers

**Carchesium polypinum**
*Stalked protozoan*
*Short 2-3mm tufts*
Assessment methodology

Record cover and density above and below substrate as follows:

**Cover**
- None
- Local - <30%
- Widespread - 30 – 60%
- Extensive - >60%

**Density**
- Trace - Present but only just detectable
- Thin - Obvious presence but substrate not obscured
- Thick - Thick enough to fully obscure substrate
- Massive - Occupies a significant proportion of the water column

**Recording**
It is also useful to record associated parameters on the recording sheet shown on page 10. All parameters follow BIOSYS methods. Take photographs to show cover, density and growth form. The standard issue Pentax Optio WG series camera is particularly useful, as it can take close up underwater photographs. Photographs can also be used as exhibits in witness statements.

**Samples for analysis**
Take representative samples of sewage fungus in a small amount of water. A 30ml plastic polypropylene vial (shown right) with a conical base is ideal for samples. Write sample site details on side of vial with a permanent pen. If immediate analysis is not possible keep samples refrigerated.
Examples of sewage fungus densities

**Trace**
Present but only just detectable

**Thin**
Obvious presence but substrate not obscured

**Thick**
Thick enough to fully obscure substrate

**Massive**
Occupies a significant proportion of the water column
# Sewage fungus recording sheet

<table>
<thead>
<tr>
<th>Field</th>
<th>Options</th>
</tr>
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<tbody>
<tr>
<td>Water Body:</td>
<td>Site ID: Date: Time:</td>
</tr>
<tr>
<td>Site Name:</td>
<td>NGR (GPS):</td>
</tr>
<tr>
<td>Photos: Yes / No</td>
<td>Sampler:</td>
</tr>
<tr>
<td>TURBIDITY: Tick box</td>
<td>SEWAGE LITTER: Tick box</td>
</tr>
<tr>
<td>ODOUR: Tick box</td>
<td>GENERAL COMMENTS:</td>
</tr>
<tr>
<td>CLEAR: Water not visibly turbid</td>
<td>NONE: No discernible odour</td>
</tr>
<tr>
<td>SLIGHT: Visible turbidity but no effect on</td>
<td>SLIGHT: Odour detectable within the channel</td>
</tr>
<tr>
<td>light penetration</td>
<td>LOCAL: &lt;30% of possible area</td>
</tr>
<tr>
<td>MODERATE: Significant effect on</td>
<td>MODERATE: Odour obvious within the channel or</td>
</tr>
<tr>
<td>light penetration</td>
<td>noticeable away from it</td>
</tr>
<tr>
<td>HIGH: Visibility limited to 10cm depth</td>
<td>WIDESPREAD: 30 - 60% of the possible area</td>
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<tr>
<td>OVERLAYING SILT COVER: Tick box for cover and density</td>
<td>GROSS: &gt;60% of possible area</td>
</tr>
<tr>
<td>LOCAL: Occasional patches: &lt;30% of area</td>
<td>TRACING: Just detectable by eye</td>
</tr>
<tr>
<td>THIN: Obvious presence but fine details of</td>
<td>LOCAL: Occasional patches: &lt;30% of area</td>
</tr>
<tr>
<td>substrate not obscured</td>
<td>THIN: Obvious presence but fine details of substrate</td>
</tr>
<tr>
<td>WIDESPREAD: 30 - 60% of area</td>
<td>WIDESPREAD: 30 - 60% of area</td>
</tr>
<tr>
<td>THICK: Coats stones and obscures fine</td>
<td>THICK: Coats stones and obscures fine details of</td>
</tr>
<tr>
<td>details of substrate</td>
<td>substrate</td>
</tr>
<tr>
<td>EXTENSIVE: &gt;60%</td>
<td>MASSIVE: Fills interstices between gravel sized</td>
</tr>
<tr>
<td>particles</td>
<td>particles</td>
</tr>
<tr>
<td>SEWAGE FUNGUS ABOVE STONES: Tick box for</td>
<td>SEWAGE FUNGUS BELOW STONES: Tick box for presence</td>
</tr>
<tr>
<td>presence and density</td>
<td>and density</td>
</tr>
<tr>
<td>LOCAL: Occasional patches: &lt;30% of area</td>
<td>TRACING: Present but only just detectable</td>
</tr>
<tr>
<td>THIN: Obvious presence but substrate not</td>
<td>LOCAL: Occasional patches: &lt;30% of area</td>
</tr>
<tr>
<td>obscured</td>
<td>THIN: Obvious presence but substrate not obscured</td>
</tr>
<tr>
<td>WIDESPREAD: 30 - 60% of area</td>
<td>WIDESPREAD: 30 - 60% of area</td>
</tr>
<tr>
<td>THICK: Thick enough to fully obscure the</td>
<td>THICK: Thick enough to fully obscure the substrate</td>
</tr>
<tr>
<td>substrate</td>
<td></td>
</tr>
<tr>
<td>EXTENSIVE: &gt;60%</td>
<td>MASSIVE: Occupies a significant proportion of the</td>
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<tr>
<td></td>
<td>water column</td>
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<td>SEWAGE FUNGUS BELOW STONES: Field comments</td>
</tr>
<tr>
<td>SEWAGE FUNGUS BELOW STONES: Lab analysis</td>
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**Lab use only:**

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<th>Options</th>
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<td>Analyst:</td>
<td>Laboratory: Date: Time:</td>
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<td>SEWAGE FUNGUS BELOW STONES: Lab analysis</td>
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</table>
Main sewage fungus taxa
Sphaerotilus natans

- Filamentous bacterium
- Requires aerobic conditions
- Requires flowing water
- Prefers pH between 6.8-9.0
- Growth form variable from short tufts to slimy fronds
- Tolerates a wide range of organic conditions
**Sphaerotilus natans**

- Filamentous bacterium
- Unbranched filaments with rod shaped cells
- 1-2 µm wide filaments
- Characteristic beaded appearance especially at ends of filaments
- Cells within a closely fitting sheath
- Sheath varies in thickness and can obscure beaded appearance
- False branching can be present
- In lower organic conditions false branching common and thin sheath typical
- In higher organic conditions false branching weakly developed or absent and thick sheath typical
- Zigzag growth may indicate an intermittent discharge
Beggiatoa alba

- Filamentous bacterium
- Forms a thin white film on surface of substrate
- Prefers low dissolved oxygen
- Prevalent in high organic conditions
- Oxidises hydrogen sulphide
- Characteristic of slow flowing waters
- Can be found as a mono-culture in faster flowing waters where it forms very long fine filaments
- Tolerant of saline conditions
Beggiatoa alba

- Filamentous bacterium
- Unbranched filaments with rod shaped cells
- 3-4 µm wide filaments
- Motile filaments
- Sulphur granules stored within cells increasing in number with age
Zoogloea1 bacteria

- Not well defined taxonomically
- Jelly-like forming thick gelatinous mass
- Restricted to slow flowing waters
- Prevalent in high organic conditions
Zoogloea bacteria

- Not well defined taxonomically
- Cells embedded in a gelatinous matrix
- Forms lobed and unlobed spherical masses

Unlobed spherical mass

Lobed spherical masses

Cells
Fusarium aquaeductuum

- Filamentous fungus
- Requires high dissolved oxygen
- Prefers acid pH
- Imparts pink or red colouration to growth
- Rarely dominant
Fusarium aquaeductuum

- Filamentous fungus
- Septate branched filaments
- 5 µm wide filaments
- Boat-shaped spores freely produced
Geotrichum candidum

- Filamentous fungus
- Grey to brown in colour
- Soft texture
- Growth loosely follows contours of stones
- Able to oxidise lactic acid
- Growth supported by ammonia, asparagine and urea
- Often associated with dairy products, silage and pickling wastes
- Prevalent in high organic conditions
Geotrichum candidum

- Filamentous fungus
- Septate branched filaments
- 5-10 µm wide filaments
- Dichotomous branching
- Brick-shaped arthrospores may be present

Septa
Dichotomous branching
**Leptomitus lacteus**

- Filamentous fungus
- Forms long characteristic streamers with overlapping cotton-wool like growths
- Requires high dissolved oxygen
- Prefers moderate to fast flow
- Prefers acid pH
**Leptomitus lacteus**

- Filamentous fungus
- Non-septate coarse branching filaments
- 8-15 µm wide filaments
- Characteristic constrictions at intervals with spherical cellulin plugs
- Cellulin plugs block the constrictions and prevent cytoplasm flowing away from the growing apices of the filaments
Carchesium polypinum

- Stalked protozoan
- Bacteria feeder
- Growth form of short tufts of 2-3 mm
- Prevalent in low organic conditions and recovery zones
**Carchesium polypinum**

- Stalked protozoan
- Inverted bell-shaped zooids at ends of stalks
- Branched stalks
- Zooids can become separated from stalks, especially in degraded samples
- Stalks can contract independent of each other
- Stalks contract spirally
- Stalk with discontinuous myoneme
- Sinuous myoneme
- Zooids 100-125 µm long
- Zooid peristomial lip bulges out
- Zooid with C-shaped macronucleus
- Zooid with smooth surface
Other sewage fungus taxa
Flexibacter spp.

- Filamentous bacterium
- Unbranched filaments
- Motile with whole filament bending and flexing
- No sulphur granules in cells
- Rarely dominant
Thiothrix II

- Gammaproteobacteria
- Uses low molecular carbon sources (short-chain fatty acids and alcohols) as well as reduced sulphur compounds
- Does not grow in anoxic conditions
- Found associated with cows bedded on waste gypsum in West Wales
Thiothrix II

- Straight or bowed filaments
- 1 um wide filaments
- False branching and rosette formation
- Sulphur granules evident
- No obvious septa
- Not motile
- Filaments do not taper
Achyla spp.

- Filamentous phycomycete fungus
- Similar to *Leptomitus* but wider filaments and no spherical cellulin plugs
- Tends to grow near source of silage effluent with which it is closely associated
Flavobacterium spp.

- Filamentous bacterium
- Unbranched filaments
- 0.5-1 µm wide filaments lying parallel to each other
- Filaments lying close together separated by 10-12µm
- Individual cells 0.5-1 µm wide by 10-50µm long
- Occasionally forming pink or yellow growths
- Requires organic nitrogen source for growth
- Rarely dominant
Taxa commonly mistaken for sewage fungus
Didymosphenia spp.

- Stalked diatom
- Generally occurs as off-white cohesive lumps or mats
- Prefers cool oligotrophic waters
- Not slimy
- Feels spongy and scratchy, like cotton wool
- Does not indicate pollution
- Obvious ‘coke-bottle’ shaped diatom cells embedded in a mass of extracellular stalks
Leptothrix ochracea

- Filamentous iron bacterium
- 2-3 µm wide filaments
- Grows in slow flowing waters high in ferrous iron and low in organic matter
- Requires ferrous (iron) salts, oxygen and carbon dioxide for growth
- Growth of bacterium results in accumulation and sedimentation of orange-brown ferric hydroxide in sheath surrounding filament
- Sheath has smooth surface
- Growth results in many empty sheaths