Lake Phytoplankton Bloom Metrics – Discussion Paper

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Summary

Cyanobacterial blooms are probably the most widely recognized ecological responses to eutrophication, of great interest to the public, water managers and policy makers. They are one of few WFD elements to have explicit consequence for ecosystem services (access to safe, clean water for drinking and recreation). To not develop a bloom metric is a great opportunity missed for making ecological science relevant with the general public and policy makers. Cyanobacterial bloom metrics based on actual abundance, rather than % abundance, are relevant to water users and have been shown in WISER to have a robust relationship with pressure. For these reasons I would propose that GIGs very seriously consider adopting a phytoplankton metric based on cyanobacteria – as long as it can be shown to be robust and not too uncertain.

Introduction

Annex V of the WFD outlines "frequency and intensity of algal blooms" as a component of the lake phytoplankton BQE, alongside phytoplankton composition and abundance (chlorophyll a). Annex V indicates that blooms may occur at good, and even high, status, but more specifically states that at moderate status "persistent blooms may occur during summer".

The metric should incorporate some measure of both bloom intensity (spot measures of magnitude/abundance) and how frequently they occur (or potentially could occur) over a particular specified time period (e.g. within a 3 monthly summer sample or over 6 year WFD reporting period).

Only 2 Member States have reported a bloom metric: Germany (max chlorophyll a) and Belgium-W (NL? cyanobacteria abundance thresholds??).

There is no consistent agreement on a definition of a bloom and there has been much discussion of difficulties associated with an adequate monitoring frequency and redundancy with composition or chlorophyll metrics. For example, Portielje et al. (200X) proposed a definition of a bloom ["a luxurious growth of algae leading to biomasses at or above the maximum value to be expected at reference conditions"] and suggested using a threshold chlorophyll value (e.g. 3 x G/M) that should not be exceeded "very often". They, however, showed that there was redundancy with the chlorophyll metric and also highlighted issues of adequate sampling frequency. More recently the NGIG has decided that cyanobacteria have been used to define boundaries for both the chlorophyll and composition metrics, so a cyanobacterial bloom metric is unnecessary.

WISER (Deliverable 3.1-2) does not propose a definition of a bloom. Instead it outlines three characteristics of a summer bloom:

- High phytoplankton abundance
- Uneven community – dominance by one or two species
- Abundance of nuisance species e.g. potentially toxic cyanobacteria

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WISER has now proposed two potential bloom metrics for GIGs to consider for IC purposes:

1. community evenness (incorporating critical abundance threshold)
2. cyanobacterial abundance (actual biovolume – not % abundance)

Evenness is a component composition metric in 3 proposed MS assessment schemes (EE, LV, NO)
% cyanobacteria is a component composition metric in 12 proposed MS assessment schemes (FI, NO, SE, UK, CY, GR, IT, PT, ES, BE, LT, PL)

This paper discusses whether cyanobacteria (actual or %) can be considered as a bloom metric.

Can cyanobacteria be considered as a bloom metric?

The term "bloom" has been associated with surface scums of cyanobacteria for hundreds of years. More recently ecologists have also used this term to refer to spring and autumn increases in diatoms – but the Annex V text explicitly refers to persistent blooms in summer and almost certainly had in mind potentially toxic blooms of cyanobacteria. It is cyanobacterial blooms that are widely recognized as a health threat by the public, water managers and politicians across Europe and has led to international WHO guidelines on acceptable thresholds in drinking water and recreation.

The over-arching aim of the WFD is to provide "good quality surface water as needed for sustainable, balanced and equitable water use". As European policy evolves to focus on monitoring ecosystem services, metrics that can be quantitatively related to access to safe, clean water will be needed.

For these reasons, the WFD gives us a great opportunity to deliver relevant ecological science and develop a cyanobacteria metric whose importance is widely understood by both public and policy makers – much more so than any composition metric, which may be more robust and less uncertain (because they have been explicitly calibrated to be so), but which are much more abstract and less representative of socio-economic values.

Is it robust?

The WISER analysis shows that there are highly significant relationships between actual abundance of cyanobacteria with pressure (TP). % cyanobacteria has been shown to have a much weaker relationship (UK analysis only).

Additionally, their abundance in reference lakes is significantly lower than in non-reference lakes in all 3 GIGs examined (N, CB & Med). [Further analysis on reference lakes still not completed]

Further analysis will be carried out on uncertainty as part of the WISER field exercise

If % cyanobacteria is adopted by MS as a bloom metric they would need to combine this with a critical bloom density measure, as with evenness (e.g. >G/M chl), otherwise sites with very low phytoplankton abundance but high % cyanobacteria could fail (certainly possible in HA lakes).

Can frequency by measured adequately?

Many MS only monitor phytoplankton composition once or twice a year – too limited to assess frequency within a single summer season. The WFD talks about persistence during summer, but this does not, however, rule out basing the assessment on the frequency of blooms between years. [In fact the monitoring frequency of the WFD – 1 or 2 times per year makes this a necessity]. If, for example, sampling is always carried out in July or August (when blooms are most likely to be present), a lake which routinely fails a cyanobacteria metric every year is clearly a lake in bad status affecting the sustainable use of water. Further work on uncertainty in general, but temporal uncertainty in particular, is definitely required, but it is clear a bloom metric should only be applied to summer sampling (Jul-Sep).

What about redundancy with other metrics?

Using Max Chlorophyll as a bloom metric is certainly highly redundant with mean chlorophyll metric and provides little “added value”.

Cyanobacteria metrics are likely to correlate with composition metrics – although this may be greatest in N GIG where a clearer switch from chrysophytes/diatoms to cyanobacteria occurs with increasing pressure. In HA lakes in CB GIG, the likelihood of a high PTI/MFGI due to cyanobacteria could be present in relatively low impacted lakes. High composition index scores could also be obtained in HA lakes with communities dominated by colonial greens and other "high-Index" algae (classic Lund, 1950 paper). This problem could be balanced with a cyanobacteria bloom metric – if low actual cyanobacteria abundance would strengthen the likelihood of a pass (when combined with chl too), if high actual cyanobacterial abundance strengthens the likelihood of a fail.

It is the strong relevancy of cyanobacteria that makes it too important to discard as a metric just because it has some redundancy with composition metrics. The fact that it has been used to define composition metric boundaries goes someway to making these more relevant, but it would be better to have them more explicit.

Recommendation

Cyanobacteria bloom metric should not be discarded unless the WISER uncertainty analyses shows that it is too variable within a lake that it greatly weakens the BQE assessment based on chlorophyll and composition.

I would also recommend that MS consider adopting a cyanobacteria metric based on actual abundance, rather than % abundance. It is a much more robust metric and relates more explicitly to WHO guidelines on water use. To get %, it is necessary to estimate the biovolume of all algae in a sample. To get actual cyanobacterial abundance, a counter only needs to measure cyanobacteria.

Further more, as remote-sensing and in-situ fluoroprobes become more widespread, the frequency and spatial variability questions become less relevant and a cyanobacteria metric potentially becomes a low-cost metric