Questions and Answers on the Establishment of Site-Specific Freshwater Criteria using the Copper Biotic Ligand Model
EPA Region 3
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EPA Region 3 is providing these recommendations to the EPA Region 3 states for use when developing sampling plans for calculating a site-specific freshwater copper criterion using the biotic ligand model (BLM). These recommendations are based on existing EPA guidance and do not contain or constitute any new EPA policy. EPA recommends that the state submit the study plan for a site-specific criterion to EPA for comment prior to implementation. Region 3 has consolidated existing guidance on the copper BLM into this document to assist the Region 3 states in ongoing efforts to implement the copper BLM. This guidance may be updated as EPA evaluates the nationwide implementation of the copper BLM.

The Biotic Ligand Model (BLM) is a metal bioavailability model that uses receiving water body characteristics to develop site-specific water quality criteria. The BLM utilizes the best available science and serves as the basis for the current national recommended criteria. Unlike the prior copper criteria, the BLM is not based on hardness. The BLM is used to derive the criteria rather than as a post-derivation adjustment as was the case with the hardness-based criteria. This allows the BLM-based criteria to be customized to the particular water body under consideration and thus ensure the protection of the aquatic life use. BLM-based criteria can be more stringent than the current hardness-based copper criteria and in certain cases the current hardness-based copper criteria may be overly stringent for particular water bodies. Further information on the BLM-based copper criteria, including information on obtaining a copy of the BLM, is available at https://www.epa.gov/wqc/aquatic-life-criteria-copper.

Monitoring

Q: How frequently should monitoring to establish a BLM-based criterion at a site with an NPDES discharge occur?

A: Criteria must be scientifically defensible and protective of the applicable designated use. It is important that the temporal and spatial variability of the BLM input parameters at a site have been adequately captured to ensure that the criteria are adequately protective of the most bioavailable conditions at a site spatially and temporally (including seasonal and annual variability). This can be done through monthly sampling for 24 months (or 12 months if that time is sufficient to capture the variability at the site, as described below), or by applying appropriate statistical tools to monitoring data.

The number of samples needed to characterize site variability depends on several characteristics of the site. The water quality characteristics that determine the bioavailability of copper can vary widely in both space and time, changing with biological activity, flow, geology, human activities, watershed landscape, and other features of the water body. For the state to ensure that the criteria are adequately protective of the most bioavailable conditions at the site through time, the state should

apply appropriate methods to evaluate how a site's water quality conditions are expected to vary temporally, and ensure that adequate monitoring is in place to capture the variability across the site and through time.

To ensure the criteria will be protective during the times when copper is most bioavailable the following sampling plan is recommended. EPA recommends that the state initially require collection of at least 24 months of monthly sampling data for the 10 BLM parameters in order to account for both intra- and inter-annual variability of BLM input parameters to ensure that times when copper is most bioavailable are included in the calculation. For the purpose of setting the discharger's next permit limit, if the observed variability during the first 12 months of sampling follows expected and explainable seasonal and other patterns (as demonstrated by statistical methods), then the state may be able to use the first 12 months of outputs to derive a criterion maximum concentration (CMC) and a criterion continuous concentration (CCC) (see "Calculating the BLM"). Collection of an additional 12 months of data would then help to confirm the state has captured inter-annual variability. If after the first 12 months, the collected ambient water quality data appears highly variable and the calculated bioavailability is unpredictable, it may be harder to justify issuing a permit without collecting another 12 months of data. Following this recommendation would result in 24 "data sets" of the 10 required BLM parameters, or 12 if the variability of the site is captured, which should be used to calculate 24 (or 12) instantaneous water quality criteria for dissolved copper using the BLM. The state can use these instantaneous criteria to derive a single numeric site-specific criterion (see "Calculating the BLM").

If the state does not collect 24 (or 12) months of data, the state should use appropriate analytical methods or statistical tools, such as a Monte Carlo simulation or another analytical tool, to determine if the monitoring methods are sufficient to capture the temporal trends, and the resultant calculated criteria are adequate to represent the most bioavailable conditions over time at the site. EPA suggests that states develop Quality Assurance Project Plans (QAPPs) for sampling protocols, in order to assure that representative data are collected. Further information on QAPPs may be found at http://www.epa.gov/quality/qapps.html.

Q: What parameters should be measured?

A: Collect data for the ten parameters used in the BLM:

1. dissolved organic carbon (DOC),
2. pH,
3. temperature,
4. alkalinity,
5. calcium,
6. magnesium,
7. sodium,
8. potassium,
9. sulfate, and

10. chloride.

EPA strongly recommends that at a minimum, the state or whomever the state deems responsible test for pH and DOC at each sampling event, since these two parameters most strongly influence copper toxicity, and can vary widely seasonally and annually. Additionally, because pH can vary widely diurnally, it is important that the state consider the diurnal variation in pH when sampling for this parameter. EPA also recommends that the state record temperature at each sampling event, since this is a commonly measured parameter. If the state does not have data for all 10 parameters for each sampling event, missing parameters, except pH and temperature, can be estimated using EPA's "Draft Technical Support Document: Recommended Estimates for Missing Water Quality Parameters for Application in EPA's Biotic Ligand Model". This document provides conservative ecoregional estimates at the tenth percentile.

EPA suggests that states develop Quality Assurance Project Plans (QAPPs) for sampling protocols, in order to assure that representative data are collected, and sufficiently sensitive methods of data analysis are used. Further information on QAPPs may be found at http://www.epa.gov/quality/qapps.html. EPA strongly recommends that a study plan be developed and submitted prior to sampling. The plan should also include analytical methods to be used.

Q: Where should monitoring occur?

A: Sampling should occur outside the chronic mixing zone, at a location that is representative of ambient water conditions reflecting complete mixing. Metals are generally persistent, so calculating criteria at or near an NPDES discharge (e.g., at the edge of a mixing zone) could result in a criterion that is not protective of areas that are outside the mixing zone. If the boundaries of the mixing zone cannot be determined, or if downstream sampling is not possible, samples could be taken upstream of the influence of the effluent discharge.

Just as the number of samples at each sampling site depends on the site characteristics, the number of sampling locations within a site, too, is dependent on those characteristics. States should ensure that enough sampling locations are used to adequately characterize the spatial variability of the site. Because BLM input parameters may vary spatially within a water segment or water body, multiple sampling locations may be appropriate. The unique characteristics of each site should be considered, including variability in BLM input parameters. It is important to accurately define the boundaries of the site to which a BLM-derived criterion will apply prior to monitoring. It is also important to have sufficient ambient data to accurately reflect the spatial and temporal variability of the site. The more ambient data that are collected, the more accurately the water chemistry at the site can be characterized, which will result in more accurate criteria development. Appropriate sampling locations should be based on the physical and chemical variability of the water. As the size of a site increases, the spatial and temporal variability is likely to increase and, thus, more sampling locations, and

greater sampling frequency, are necessary to adequately account for the spatial and temporal variability.

The collection of data outside of the chronic mixing zone both upstream and outside of the influence of the effluent discharge, and downstream of the discharge would best characterize the spatial variability of the site. EPA recommends that data be collected at several downstream sampling locations to accurately characterize the water body and those areas where the aquatic life will be more sensitive to the toxic effects of copper. In general, sampling locations should not be overly influenced by the presence or absence of effluent discharges unless these discharges result in ambient copper being made more bioavailable, and thus toxic, to aquatic life. EPA also notes that any input (e.g., tributary, NPDES discharge, etc.) or output (e.g., water withdrawals, etc.) within a site's boundaries should be carefully considered to determine its effect on ambient copper availability, and whether greater frequency and/or more sampling locations will be needed. Data collection should reflect site-specific characteristics and consider special circumstances that may affect copper toxicity throughout the expected range of receiving water conditions.

Calculating the BLM

Q: How is a single numeric site-specific criterion calculated from multiple BLM-derived instantaneous criteria?

A: The BLM calculates an instantaneous copper criterion value for each set of input parameters (e.g., each "data set"). EPA recommends that states review the variability of a given site's BLM outputs over time (e.g. monthly) and determine, based on the variability, a WQS derivation method that will be most protective of the designated uses for aquatic life throughout the year and under a variety of circumstances (e.g., seasonal conditions, high and low flows). Options include:

a) Take the lowest output (a particularly good option if you have <12 samples).
b) Take a low percentile of the outputs:
   This is appropriate if the BLM-derived copper criteria vary significantly for reasons that cannot be easily explained (e.g., are not seasonal), then a lower percentile value may be best to ensure that the water body is sufficiently protected and the criterion is not exceeded more than the state standard allows.
c) Use another statistical method to identify a function of the outputs that would be protective.
d) If the outputs are very similar, take a geometric mean:
   If the water quality parameters and BLM-derived copper criteria are relatively constant over a range of seasonal and flow conditions, (i.e., there is little variation in the input parameters and instantaneous criteria), then using the geometric mean of all instantaneous criteria may be appropriate. A geometric mean is a measure of central

tendency and is less likely to be affected by outliers than an arithmetic mean.

e) Seasonal geometric means:

If a water body exhibits significant seasonal variations in the BLM input parameters and BLM-derived instantaneous copper criteria, then it may be best to develop seasonal criteria using seasonal geometric means. In such water bodies, averaging on an annual basis could result in a criterion value that is potentially underprotective during parts of the year (e.g., fall and winter).

f) If there are significant spatial differences in the instantaneous BLM-derived criteria for a water segment, then dividing the segment into smaller sections may be appropriate.

References

- United State Environmental Protection Agency (EPA). Training Materials on Copper BLM: Data Requirements. Office of Science and Technology, Washington, D.C. https://www.epa.gov/sites/production/files/2015-11/documents/copper-data-requirements-training.pdf
- United State Environmental Protection Agency (EPA). Training Materials on Copper BLM: Implementation. Office of Science and Technology, Washington, D.C. https://www.epa.gov/sites/production/files/2015-11/documents/copper-implementation-training.pdf
- United State Environmental Protection Agency (EPA). February 2007. Aquatic Life Ambient Freshwater Quality Criteria – Copper 2007 Revision. Office of Water, Washington, D.C. EPA-822-F-07-001.
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- United State Environmental Protection Agency (EPA). March 2016. Draft Technical Support Document: Recommended Estimates for Missing Water Quality Parameters for Application in EPA's Biotic Ligand Model. Office of Water, Washington, D.C. EPA-820-R-15-106.
- Quality Assurance Project Plans http://www.epa.gov/quality/qapps.html
- United State Environmental Protection Agency (EPA). June 14, 2016. Re: Proposed federal rulemaking for freshwater aquatic life criteria and recommendations for data collection and criteria implementation. Region 10, Office of Seattle, Washington.