State of Oregon Department of Environmental Quality

Implementation of the Freshwater Aquatic Life Water Quality Standards for Copper

Introduction

The biotic ligand model for copper is the U.S. Environmental Protection Agency's current recommendation for determining freshwater aquatic life criteria for copper. This model determines site-specific criteria that account for changes in bioavailability, and thus toxicity, of copper to aquatic life due to differences in water chemistry. The copper biotic ligand model uses 10 water quality parameters to calculate acute and chronic instantaneous water quality criteria (IWQCs) that represent copper toxicity at a given location and time. The parameters used to calculate an IWQC need to be collected together at the same location.

Biotic Ligand Model Software

The following model software program is used to derive site-specific criteria based on the water chemistry of a site, which affects the bioavailability and toxicity of copper to aquatic life.

The currently recommended version of the software is version 2.2.3. You may download the software from the following link: http://www.deq.state.or.us/wq/standards/docs/BLM223.zip

Procedures to calculate instantaneous criteria values

Calculation of an instantaneous criteria value (Instantaneous Water Quality Criteria, IWQC) requires the input of the following water quality parameters, measured concurrently. All input parameters are measured as the dissolved form. Samples passing a 0.45µm filter are considered dissolved for these purposes.

PARAMETERS
Temperature (°C)
pH (Standard Units)
DOC (mg/L)
Calcium (mg/L)
Magnesium (mg/L)
Sodium (mg/L)
Potassium (mg/L)
Sulfate (mg/L)
Chloride (mg/L)
Alkalinity (mg/L $CaCO_3$ equivalent)

General Procedure for Calculating Instantaneous Water Quality Criteria (IWQC)

Refer to the procedures and/or the process flow chart shown below for the general procedure for verifying a sample of the input parameters to calculate an IWQC.

1. If the humic acid fraction of DOC has been measured, enter the value for HA in percent. If not specified, use a default value of 10.

2. If organic carbon has been measured for the sample:
    a. If measured as DOC, enter this value.
    b. If measured as TOC, apply a correction factor of 0.83 to estimate the concentration as DOC. Enter this value.
    c. If neither DOC nor TOC was measured, apply a regional default value from the tables provided below.

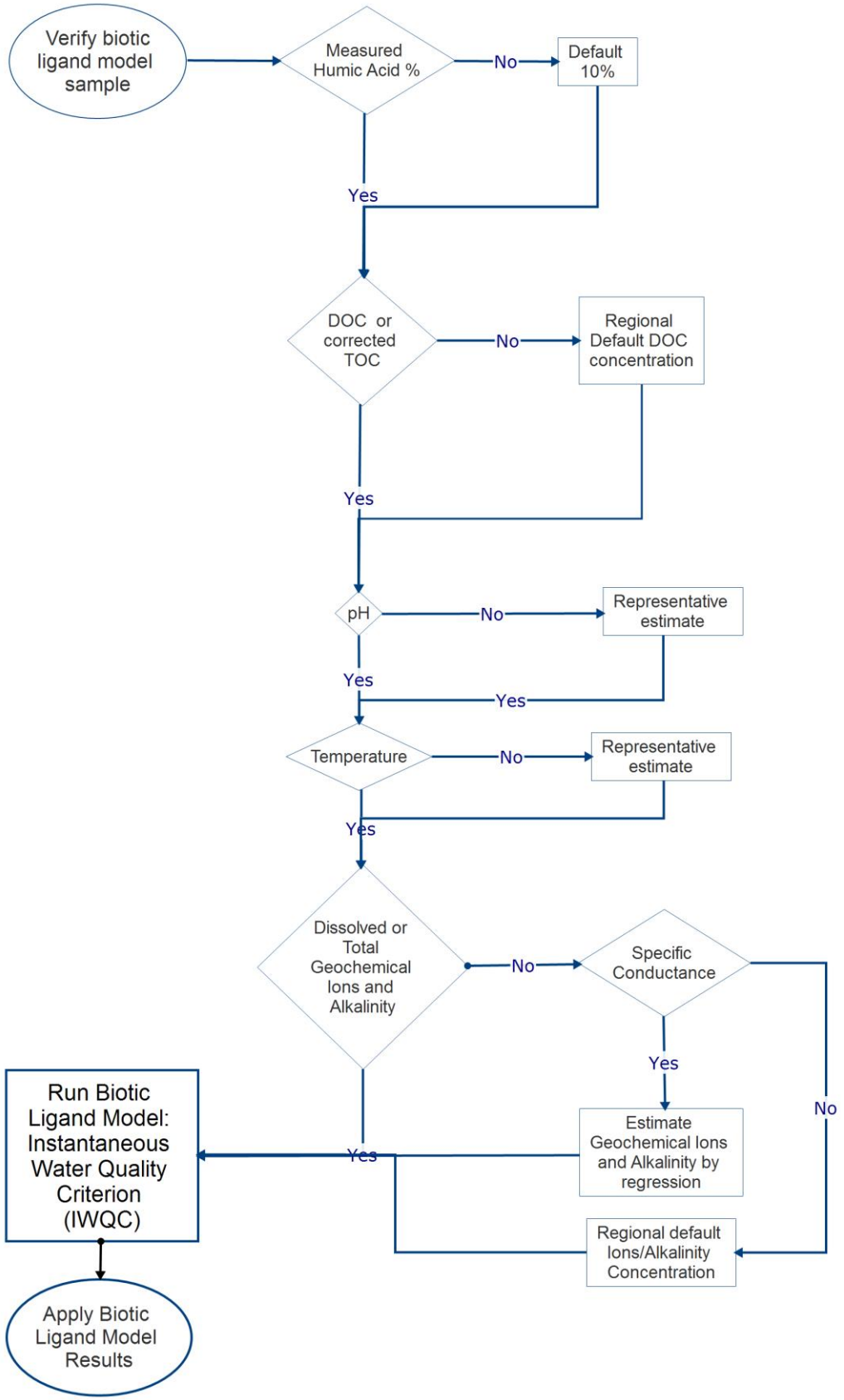
3. Determine the availability of pH and temperature measurements.
    a. If pH has been measured, enter this value.
    b. If pH has not been measured, apply a representative value based on pH data collected at other times at the site, or from a nearby representative monitoring location.
    c. If temperature has been measured, enter this value.
    d. If temperature data are not available, apply the monthly geometric mean temperature for the site if available, or from a nearby representative monitoring location.

4. Determine the availability of measurements of the geochemical ions and alkalinity.
    a. The geochemical ions include Calcium, Magnesium, Sodium, Potassium, Sulfate, Chloride, and Sulfide.
    b. Dissolved Inorganic Carbon (DIC) can be substituted for alkalinity if DIC has been measured. Please refer to the model software manual for changing the mode to calculate criteria using DIC measurements instead of alkalinity.
    c. If any geochemical ions or alkalinity have been measured as dissolved concentration, enter these values.
    d. If any geochemical ions or alkalinity have been measured as total concentration, enter this value, it may be substituted if the dissolved concentration was not measured.
    e. If sulfide (S^-) has not been measured, use a default value of $1x10^{-6}$ mg/L.
    f. If a geochemical ion or alkalinity value has not been measured, estimate the value using the **specific conductance estimation equations** provided below.
    g. If specific conductance data are also not available for the sample, apply the appropriate value from the table of **regional default input values** provided below.

5. Follow the instructions in the documentation provided with the model to run each version of the software to obtain an acute and chronic instantaneous criterion values (IWQC) value for each set of parameter measurements prepared using this procedure.

    The default input values are provided in the next section.

Process outline of the general procedure to verify biotic ligand model sample data



Default input parameter values

Specific conductance estimation equations

Parameter	Equation
Alkalinity	$Alk. = \exp^{(0.88 \cdot [\ln(SpC)] - 0.41)}$
Calcium	$Ca = \exp^{(0.96 \cdot [\ln(SpC)] - 2.29)}$
Chloride	$Cl = \exp^{(1.15 \cdot [\ln(SpC)] - 3.82)}$
Magnesium	$Mg = \exp^{(0.91 \cdot [\ln(SpC)] - 3.09)}$
Potassium	$K = \exp^{(0.84 \cdot [\ln(SpC)] - 3.74)}$
Sodium	$Na = \exp^{(0.86 \cdot [\ln(SpC)] - 2.22)}$
Sulfate	$SO_4 = \exp^{(1.45 \cdot [\ln(SpC)] - 5.59}$

Where, "SpC" is a measurement of specific conductance in µmhos/cm, "ln" is the natural logarithm, and "exp" is a mathematical constant that is the base of the natural logarithm (≈ 2.71828).

Regional default input values

PARAMETERS	Cascades	Coastal	Columbia River	Eastern	Willamette Valley
DOC (mg/L)	0.51	0.83	1.41	1.35	1.25
Calcium (mg/L)	2.6	4.2	15.9	5.5	6.3
Magnesium (mg/L)	0.88	1.48	4.06	2.36	2.20
Sodium (mg/L)	1.9	4.3	3.7	4.4	4.2
Potassium (mg/L)	0.39	0.46	0.93	1.43	0.70
Sulfate (mg/L)	0.25	1.90	9.88	1.31	2.02
Chloride (mg/L)	0.59	3.14	1.64	0.82	3.60
Alkalinity (mg/L)	13	29	55	48	30

Regional default input values are based on the 20th percentile of concentration for the Cascades, Coastal, Willamette Valley Regions and Columbia River main stem, and the 15th percentile of concentration for the Eastern Region. See Attachment D, the Copper Rulemaking Issue Paper, for more information: http://www.deq.state.or.us/eqc/docs/2016/110216/ItemG.pdf

Regional Map for copper biotic ligand model default values