BLM-MONTE USER'S GUIDE

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Introduction

Metal bioavailability and toxicity have long been recognized to be a function of water chemistry (e.g., Sunda and Guillard, 1976; Sunda and Hansen, 1979). Formation of inorganic and organic metal complexes and sorption on particle surfaces has been shown to reduce metal toxicity. As a result, metal toxicity can be highly variable and dependent on ambient water chemistry when expressed as total or dissolved metal concentration. In contrast, the effects of water chemistry on metal toxicity can often be reduced or eliminated when metal toxicity is related to free metal ion concentrations (Sunda and Guillard, 1976). Allen and Hansen (1996) have shown the relationship between metal speciation and toxicity and have used this relationship to predict the range of effects site-specific water quality characteristics can have on copper toxicity.

The Biotic Ligand Model (BLM) was developed to incorporate metal speciation and the protective effects of competing cations into predictions of metal bioavailability and toxicity (DiToro et al., 1999). The BLM is based on a conceptual model similar to the gill site interaction model proposed by Pagenkopf (1983). The BLM incorporates a version of CHESS (Santore and Driscoll, 1995) that has recently been modified to include the chemical and electrostatic interactions described in WHAM (Tipping, 1994). Metal toxicity is simulated as the accumulation of metal at a biologically sensitive receptor, the “biotic ligand”, which represents the site of action of acute metal toxicity. However, inorganic and organic ligands can also bind metal thereby reducing accumulation at the biotic ligand. By incorporating the biotic ligand into a chemical equilibrium framework that includes aqueous metal complexes, the relation between free metal ion concentrations and toxicity is an inherent feature of the model

The BLM framework also incorporates the competitive effects of other cations that interact with the biotic ligand to mitigate toxicity. For example, at a fixed free ion concentration, as hardness increases, the increased Ca^{2+} competes with the free metal for binding sites at the fish gill. A higher free metal concentration is therefore required to achieve the same toxic effect in the presence of elevated Ca^{2+} concentration. The BLM uses this competitive mechanism to simulate the reduction in metal toxicity due to elevated hardness concentrations. It has been shown that the BLM can effectively account for reduction in metal toxicity due to elevated levels of hardness cations (Meyer et al., 1999).

The BLM has been developed using published information on metal toxicity and biotic ligand accumulation as a function of water chemistry. The most comprehensive data compiled to date for use with the BLM is for copper toxicity to fathead minnows (*Pimephales promelas*). The “biotic ligand” or site of acute copper toxicity for fathead minnow has been identified as Na ion uptake channels in the gill membrane (Playle et al., 1993a). Copper accumulation on the gill has been associated with respiratory distress and decreased blood plasma Na concentrations due to interference with these sites (Playle et al., 1992). The adsorption of copper on gill surfaces in the BLM has been calibrated to measurements of copper accumulation on the gill over a wide range of water quality conditions (Playle et al., 1992 and 1993b). Additionally, MacRae (1994) established a dose response relationship necessary to determine the biotic ligand LC50 in rainbow trout. In the BLM, metal toxicity is defined as the amount of metal necessary to result in accumulation at the biotic ligand equal to the biotic ligand LC50. While others have developed models capable of predicting metal bioaccumulation on the gill in short term exposures (Playle et al., 1993a, 1993b), the BLM is the first that includes a scheme for predicting toxicity.

In summary, the BLM can be used to calculate the chemical speciation of a dissolved metal including complexation with inorganic, organic, and the biotic ligand. The biotic ligand represents a discrete receptor or site of action on an organism where accumulation of metal leads to acute toxicity. The BLM, therefore, can be used to predict the amount of metal accumulation at this site for a variety of chemical conditions and metal concentrations.

According to the conceptual framework of the BLM, accumulation of metal at the biotic ligand at or above a critical threshold concentration leads to acute toxicity. Since the BLM includes inorganic and organic metal speciation, and competitive adsorption at the biotic ligand, the amount of dissolved metal required to reach this threshold will vary, depending on the water chemistry. In addition to calculating chemical speciation, the BLM can also predict the concentration of metal that would cause acute toxicity (HydroQual, 2001).

With this implementation of the biotic ligand model (BLM-Monte, DiToro et al, 2000), the BLM and a Monte Carlo procedure (Monte) have been combined within a probabilistic dilution framework and implemented as a series of steps executed within an Excel spreadsheet. A classical case of a wastewater effluent discharging into a single reach of a stream is examined, with copper being the pollutant of concern. The BLM is used to estimate the toxicity of copper towards a given aquatic organism in the stream reach downstream of the discharge. Based on the estimated frequency of occurrence of toxicity towards that particular organism, the effluent copper concentration can be adjusted by the user in order to attain a certain frequency of occurrence of toxicity. For example, if the initial calculations with BLM-Monte show a frequency of 10 occurrences of toxicity in 100 samples (or 100 days) and if the desired frequency of occurrence of toxicity is only 1 in 100 days, the user may reduce the effluent copper concentration in order to obtain the desired toxicity occurrence frequency. The remainder of this document describes the data requirements of BLM-Monte, the computer resources needed to run this application and a step-by-step guide on using BLM-Monte.

Data Requirements of BLM-Monte

The BLM predicts metal toxicity for a particular site based on the ambient water chemistry. Therefore the user is expected to provide summary data describing the physical and chemistry characteristics of the receiving water and the effluent. The necessary parameters are flow-rate, TSS, pH, total copper, dissolved organic carbon, major cations (Ca, Mg, Na, and K), major anions (SO_4, Cl), alkalinity and sulfide. All the parameters except for pH and alkalinity are considered to be conservative. The probabilistic values of each of these parameters for effluent and upstream receiving water is determined by the Monte Carlo procedure and used to determine the water quality characteristics downstream of the discharge using a simple mass balance calculation assuming complete and instantaneous mixing of the effluent with receiving water. For the non-conservative parameters - pH and alkalinity, the user is expected to specify the values for the mixed water downstream of the discharge.

Some of the inputs have an important effect on determining metal toxicity, while other inputs have only minor effects on toxicity predictions. The user should be aware of the relative importance of each of the inputs to decide whether adequate information is available for a meaningful application of BLM-Monte. The following guidelines may be helpful in that assessment.

Flow-rate

Effluent and upstream flow-rate information is used in the mass balance calculations after the Monte Carlo procedure to determine mass loadings of each of the conservative parameters and ultimately to determine the concentrations of those parameters in the water downstream of the discharge. Therefore, flow-rate is an important parameter that can influence the calculated water quality downstream of the discharge and subsequently predictions of toxicity and should be considered to be an essential input to BLM-Monte.

Total Copper

Total copper concentrations in the effluent and the receiving water are required in order to make an assessment of the toxicity of the effluent discharge and should therefore be a well-characterized parameter.

TSS

Since the toxic form of copper is modeled as a fraction of dissolved copper, total suspended solids concentration in the water downstream of the discharge is used by BLM-Monte to determine the dissolved fraction of the total copper present in the water. The partitioning of copper between the dissolved and particulate phases is estimated using the USEPA’s metals translator (USEPA, 1996). The equations used are as described below:

$$K_p = K_{PO} \times TSS^a$$
$$C_d = (1 + K_p \times TSS)^{-1} \times C_T$$

where K_p = Partition coefficient in L/mg
K_{PO} = 1.04 for streams
TSS = total suspended solids in mg/L
a = -0.7436 for streams
C_d = Dissolved copper concentration
C_T = Total copper concentration

pH

Accurate pH values are important to BLM results for most metals. The chemical speciation of many metals, such as copper, is directly affected by pH. However, pH is also important in determining the metal complexation capacity of dissolved organic matter. It is also important in determining the speciation of inorganic carbon, which relates to the formation metal carbonate complexes. For these reasons, pH is considered a required chemical input.

DOC

Dissolved organic matter can likewise play a critical role in determining metal speciation and bioavailability. The presence of dissolved organic matter is specified as a dissolved organic carbon concentration (DOC) in mg/L and is considered a required input for BLM-Monte. For water with low DOC it is important to make sure that analytical detection limits are sufficiently low.

Major Cations

The cations Ca, Mg, Na, and K are all necessary inputs to BLM-Monte. Ca and Na can directly compete with the metal at biotic ligand sites and these cations will, therefore, have a direct effect on predictions of metal toxicity. For some organisms, Mg may play a critical role as well. These cations, therefore, should be considered required inputs to BLM-Monte. On the other hand, K currently has no known direct effect on metal toxicity in the BLM and can be estimated if measurements do not exist.

Major Anions

The anions SO_4 and Cl are all necessary inputs to BLM-Monte (although bicarbonate is also an important anion, it is discussed separately below). Even though SO_4 and Cl do have any appreciable direct effects on the speciation of copper, they are important for determining charge balance and ionic strength. The chemistry of metals and of natural organic matter is dependent to varying degrees on ionic strength and so SO_4 and Cl have some importance as a BLM input. However, if measurements are not available the input can be estimated.

Alkalinity

BLM-Monte uses alkalinity and pH information to calculate the dissolved inorganic carbon (DIC) in the water. DIC species in the BLM include carbonate (CO_3), bicarbonate (HCO_3), and carbonic acid (H_2CO_3). Bicarbonate is usually the most important DIC species in natural waters since it is the dominant species between the pH of 6.3 and 10.3. Alkalinity is a critical input to the BLM because of the formation of metal-carbonate complexes. Alkalinity should be measured on filtered samples to eliminate potential contribution from suspended $CaCO_3$.

Sulfide

Although it has traditionally been assumed that sulfide concentrations are negligible in aerated waters, recent evidence suggests that appreciable sulfide concentrations persist in both marine and freshwaters. Waters impacted by wastewater treatment plant effluents in particular can have elevated sulfide concentrations. Sulfide has a strong affinity for many metals and is therefore an important consideration in determining metal speciation and bioavailability. Therefore, if it is present, measured sulfide should be considered a required input, especially when sulfide concentrations are similar to the predicted effect levels for a given metal and organism.

Estimating Concentrations

As noted in the guidelines above, it may be appropriate to estimate the concentrations for some of the input parameters. Whenever it is necessary to estimate a concentration the user should make an effort to use data sources from waters as similar as possible to the desired water body. As a last resort, the following table may provide reasonable estimates.

Table 1: Estimates of water quality inputs for the BLM (from Morel and Hering, 1993).

Input Parameter	*Freshwater (mmol/L)*	*Seawater (mmol/L)*
Ca	0.33	10.2
Mg	0.15	53.2
Na	0.23	468
K	0.03	10.2
SO_4	0.069	28.2
Cl	0.16	545
HCO_3*	0.86	2.38

*NOTE: Alkalinity is approximately equal to HCO_3 for pH ranging from 7.6 to 9.0

Installing BLM-Monte

BLM-Monte is designed for use on the IBM compatible PC family of microcomputers running Microsoft Windows. The memory requirements of BLM-Monte are modest and should not interfere with other resident programs. Since BLM-Monte requires Microsoft Excel running under Windows, it is assumed that both Windows 95/98/2000/NT and Excel (95 or later) have been installed. Visual Basic for applications must have also been installed along with Excel. BLM-Monte must be run from the user's hard drive.

BLM-Monte is distributed as a compressed file called 'BLM-Monte.zip'. Installation can be accomplished by simply copying the file to a directory on the hard disk. The user must first use a program such as WinZip to extract the contents of this file. Open the zip file and extract the contents to the desired directory, making sure the program will preserve directory names. If using WinZip, this task is accomplished by clicking on the 'Actions' menu followed by selecting 'Extract'. On the dialog box that opens, set the 'Extract to:' field to point to the desired directory on the user's hard drive and make sure the box entitled 'Use Folder Names' is checked. Then click on 'Extract'. A file folder named 'BLM Monte' is created in the selected directory and the appropriate files are copied to that folder. The user may wish to verify that the following files and directories have now been created:

In the user-specified directory:	*Description*
BLM Monte	Directory

In the directory 'BLM Monte':	*Description*
models	Directory
model.xls	Microsoft Excel Worksheet
BLM-Monte Users Guide.pdf	Users guide for BLM-Monte
Terms and Conditions.pdf	The terms and conditions for the use of BLM-Monte

In the directory '\BLM Monte\models'	*Description*
blm_ap08.exe	BLM executable
CuOH.dat	BLM Parameter File
Water21.dbs	Thermodynamic database
monte.exe	Monte Carlo executable

If desired, the BLM Monte directory can be moved to any other location on the user's hard drive. However, the relative locations of the file 'model.xls' and the directory 'models' should be maintained as in the original distribution, i.e. the directory 'models' should be located within the directory containing the file 'model.xls'.

Terms and Conditions of Use

Before using BLM-Monte, the user is advised to refer to the terms and conditions of use of this program, described in the document 'Terms and Conditions.pdf' included with the distribution of BLM-Monte. Use of BLM-Monte implies the user's acceptance of the terms and conditions described in the document 'Terms and Conditions.pdf'.

Running BLM-Monte

To launch BLM-Monte, start Excel and load the file 'model.xls'. Excel may show a warning message indicating the presence of macros in this file. These macros are essential to the function of the BLM-Monte and hence the macros need to be enabled. This spreadsheet contains a series of pages with each step in the execution of the BLM-Monte organized sequentially on different pages.

Worksheet 'Model'

The first page (moving from left to right) is called 'Model' (Figure 1). This page contains information describing the physico-chemical characteristics of the effluent and receiving water. A list of the water quality parameters that must be defined is shown in Table 2. User definable fields are highlighted in blue in the Excel spreadsheet. Statistical measures (the type of distribution i.e. normal or lognormal, the median for parameters with log-normal distributions and mean for parameters with normal distribution, coefficient of variation of the parameters, and cross-correlations between the different parameters) of upstream water and effluent characteristics are specified as inputs to the Monte Carlo procedure which then generates a user-specified number of observations. Due to certain numerical limitations in the Monte Carlo procedure, the user should specify a minimum of about 10 observations to be generated by Monte Carlo. A simple mass balance dilution calculation based on the Monte Carlo generated upstream and effluent flows and concentration is performed to calculate the water quality downstream of the discharge.

After specifying these parameters, the user can now run the Monte Carlo program by clicking the button 'GO' next to the label 'Run Monte Carlo'. A MS-DOS window will show up briefly on the screen and disappear after the Monte Carlo program finishes execution. Further, a brief message box will show up describing the number of parameters and the number of observations simulated for each parameter. Click 'OK' to proceed to the next page.

Table 2: Water quality parameters specified in the 'Model' **page of BLM-Monte**

Parameter	***Description***	***Units***
Q U/S	Upstream Flow	m^3/s
TSS U/S	Upstream Total Suspended Solids	mg/L
Cu U/S	Upstream Copper	?g/L
DOC U/S	Upstream Dissolved Organic Carbon	mg/L
Ca U/S	Upstream Calcium	mg/L
Mg U/S	Upstream Magnesium	mg/L
Na U/S	Upstream Sodium	mg/L
K U/S	Upstream Potassium	mg/L
SO4 U/S	Upstream Sulfate	mg/L
Cl U/S	Upstream Chloride	mg/L
Q Effluent	Effluent Flow	m^3/s
TSS Effluent	Effluent Total Suspended Solids	mg/L
Cu Effluent	Effluent Copper	?g/L
DOC Effluent	Effluent Dissolved Organic Carbon	mg/L
Ca Effluent	Effluent Calcium	mg/L
Mg Effluent	Effluent Magnesium	mg/L
Na Effluent	Effluent Sodium	mg/L
K Effluent	Effluent Potassium	mg/L
SO4 Effluent	Effluent Sulfate	mg/L
Cl Effluent	Effluent Chloride	mg/L
pH Mix	Downstream (mixed) pH	
Alk Mix	Downstream (mixed) Alkalinity	mg $CaCO_3$ / L

Worksheet 'Temporals'

This page contains a graphical representation of the probabilistic results generated by MONTE. For each water quality parameter, a temporal plot is shown for upstream, effluent, and the downstream mixture (Figure 2). The user may wish to review this output and verify that the graphical depictions correspond to the median (or mean) and variance for each of the specified parameters. Otherwise, there is no user action that is required on this page. Click on the worksheet labeled 'BLMInfo' to go to the next page.

Worksheet 'BLMInfo'

This page organizes the additional input information required to run the BLM (Figure 3). There are only three values (highlighted in blue) that needs user input on this page - the humic acid content of DOC, the downstream water temperature, and the critical threshold copper concentration on the biotic ligand that leads to acute toxicity (LA50).

The BLM uses a description of organic matter chemistry developed for the WHAM (ver 1.0), which characterizes metal complexation with both humic and fulvic organic matter sources. It is necessary, therefore, to specify the distribution of humic and fulvic acids in the organic matter present in a given water. Unfortunately, natural organic matter composition is not routinely characterized and information on humic and fulvic acid content is not likely to be available. In the absence of chemical characterization, a value of 10% humic acid content is recommended for most natural waters. The variability of the dissolved organic matter content in diverse water sources is a topic of current study by BLM investigators. The average downstream water temperature in degrees Celsius should also be specified.

As mentioned in the introduction to this document, the BLM considers toxicity to occur for any particular organism when the accumulation of copper on the biotic ligand exceeds a certain lethal threshold level. This value is referred to as the Lethal Accumulation at 50% mortality (LA50), specified in units of nmol/g_{wet} weight of the biotic ligand. This is an empirical parameter and is typically calculated for different organisms on the basis of laboratory toxicity testing data. In the BLM, it is this parameter that accounts for the species sensitivity of different organisms to a metal. In other words, a relatively insensitive organism such as Fathead minnow will have a higher LA50 than a more sensitive organism such as *Ceriodaphnia dubia*. Based on the current version of the BLM (blm_ap08.exe, build 10/09/2001, CuOH model), LA50s for some of the organisms have been calculated based on test data and are listed in the page 'BLMInfo' for reference. It is also envisioned that as more toxicity test data becomes available and as the model undergoes further refinement, these values will change. Therefore, the user is advised to refer to the BLM-Monte homepage, at http://www.hydroqual.com/blm for additional updates on the use of LA50s.

The user will need to decide what organism the BLM should predict toxicity for, and enter in the corresponding LA50 value in the position next to the column labeled 'Organism LA50 (nmol/g_{wet})*'. BLM-Monte should now be ready to run the BLM with the user defined parameters and the output from the Monte Carlo program. Click the button 'GO' next to the label 'Run BLM'. An MS-DOS window will show up which will show the progress of the BLM simulation in terms of the number of observations processed at any point. This window will disappear once the program completes execution and the program will proceed to the next page, which displays the BLM results along with some of the important chemical parameters influencing the toxicity of copper.

Worksheet 'PlotBLM'

A summary of the relevant BLM results is displayed as a series of temporal graphs on this page (Figure 4) and arranged in two columns. The first column is a summary of the water quality parameters that have the biggest impact on determining copper toxicity. These parameters include pH, hardness, DOC and alkalinity. The second column includes information about copper toxicity as predicted by the BLM. The first graph shows the predicted copper LC50 for the organism selected by the user. The variation in the predicted LC50 values can be traced to variations in water quality parameters displayed in the first column of figures.

The middle graph in the second column is the time-series graph of downstream copper concentrations as calculated by Monte Carlo and fractionated as dissolved and total copper. Partitioning of copper to suspended solids is calculated using the USEPA translator for metals (USEPA, 1996).

Dissolved copper concentrations are compared to BLM predicted LC50s in the next graph (last from the top) and displayed as Toxic Units (TU). The toxic unit for a particular observation is calculated as the ratio of the instream dissolved copper concentration downstream of the discharge to the BLM predicted LC50 for that particular observation. A toxic unit value greater than 1 is indicative of the toxicity of the downstream water towards the user selected organism, presumably due to the copper in the effluent. The frequency of exceedances, if they occur, can be estimated from information presented on the next page. Click on the worksheet labeled 'ProbPlot' to go to the next page.

Worksheet 'ProbPlot'

The two graphs on this page (Figure 5) show probability distributions of dissolved copper concentrations in the effluent, and the resulting toxic units in the water downstream of the discharge (solid lines in black). The frequency of occurrence of toxic unit values greater than 1, can be estimated by determining the fraction of observations with toxic units greater than 1.

This information is especially useful for conducting "what if" scenarios to determine the level of copper removal required from the effluent before release to the receiving water so that the occurrence of toxicity in the water downstream of the discharge is only at a frequency desirable to the user. As with other pages, user definable fields are highlighted in blue. For example, the user can input the copper concentration in the effluent before treatment in the appropriate field on the right hand side of this page. The level of removal necessary to yield the median copper concentration in the post-treatment effluent is calculated.

Next, the user can suggest an alternative post-treatment copper concentration in the effluent. This value may be higher or lower than the existing condition value depending on whether the current level of treatment meets the user's criteria of an acceptable level of ecological risk described in terms of the frequency of occurrence of toxicity. If this criterion is currently being exceeded, then a lower effluent copper concentration should be input. By clicking the button 'GO' next to the label 'Run Alternative Condition', the effects of this additional treatment can be studied. When the projections for the alternative condition are completed, a message box will be shown informing the user of the completion. A new line (broken lines in red) will appear on both probability plots showing the changes that result from the modified effluent treatment. The modified post-treatment effluent copper concentration can be adjusted again until an acceptable frequency of toxicity exceedance is attained.

Hidden Worksheets

In addition to the main worksheets where user input/review is required, the input and output generated by the Monte Carlo and the BLM programs are also contained within the 'model.xls' file. However, the worksheets containing this information is hidden from view in the original distribution of BLM-Monte. These worksheets are described below and can be made visible in case the user desires so.

Worksheet *'MonteOut'*

For ease of use, this sheet is hidden from the user and can be displayed, if desired, by choosing 'Format --> Sheet --> Unhide --> MonteOut' in the top menu bar within Excel. This page should now contain all of the output from the Monte Carlo program. No user action needs to be taken on this page. These same results are summarized graphically on the worksheet 'Temporals'.

Worksheet *'BLMInput'*

For ease of use, this sheet is hidden from the user and can be displayed, if desired, by choosing 'Format --> Sheet --> Unhide --> BLMInput' in the top menu bar within Excel. The input data for the BLM prepared from the Monte Carlo output and the user specified BLM parameters on the worksheet 'BLMInfo' should be displayed here. The user may wish to review that these inputs are the same as the Monte Carlo output displayed on the worksheet 'Temporals'. Otherwise, there is no user action required on this page.

Worksheet *'BLMOut'*

For ease of use, this sheet is hidden from the user and can be displayed, if desired, by choosing 'Format --> Sheet --> Unhide --> BLMOut' in the top menu bar within Excel. The BLM output data is displayed here and no user action is required on this page.

Contact

For questions or problems relating to the application of BLM-Monte to copper toxicity, and all other questions or problems including bug reports, please contact:

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Figure 1: An excerpt from the page 'Model' showing input fields and program buttons.

Monte Carlo Inputs:

Run Monte Carlo GO

MODEL INPUT PARAMETERS:

# of output values	25
iseed	2345

Distribution Type : 1 = log normal; 0=normal; 2= user

UNITS: Flow [m^3/s); Copper (µg/L); all other water quality parameters [mg/L]

Parameters	Distn. Type	Median	Coeff. Varn.	TSS U/S Corr. Coeff.	Cu U/S Corr. Coeff.	DOC U/S Corr. Coeff.	Ca U/S Corr. Coeff.	Mg U/S Corr. Coeff.	Na U/S Corr. Coeff.	K U/S Corr. Coeff.	SO_4 U/S Corr. Coeff.	Cl U/S Corr. Coeff.
Q U/S	1	2	0.5	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
TSS U/S	1	6	0.74	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cu U/S	1	4	0.3	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
DOC U/S	1	4	0.45	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Ca U/S	1	88	0.6	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Mg U/S	1	24	0.8	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Na U/S	1	99	0.51	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
K U/S	1	3	0.47	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
SO_4 U/S	1	112	0.94	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cl U/S	1	33	0.12	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Q Effluent	1	10	0.51	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
TSS Effluent	1	12	0.75	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cu Effluent	1	25	1.5	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
DOC Effluent	1	9	0.5	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Ca Effluent	1	49	0.5	0.002	0.002	0.002	0.002	0.002	0.002	0.002		
Mg Effluent	1	29	0.3	0.002	0.002	0.002	0.002	0.002	0.002			
Na Effluent	1	162	0.3	0.002	0.002	0.002	0.002	0.002				
K Effluent	1	13.8	0.3	0.002	0.002	0.002	0.002					
SO_4 Effluent	1	140	0.3	0.002	0.002	0.002						
Cl Effluent	1	183	0.3	0.002	0.002							
pH Mix	0	7.3	0.05	0.002								
Alkalinity Mix	1	50	0.14									

Figure 2:   Time-Series plots from page 'Temporals'

Time Series Plots of Data output from MONTE

UPSTREAM TEMPORAL PLOTS | **EFFLUENT TEMPORAL PLOTS** | **DOWNSTREAM TEMPORAL PLOTS**

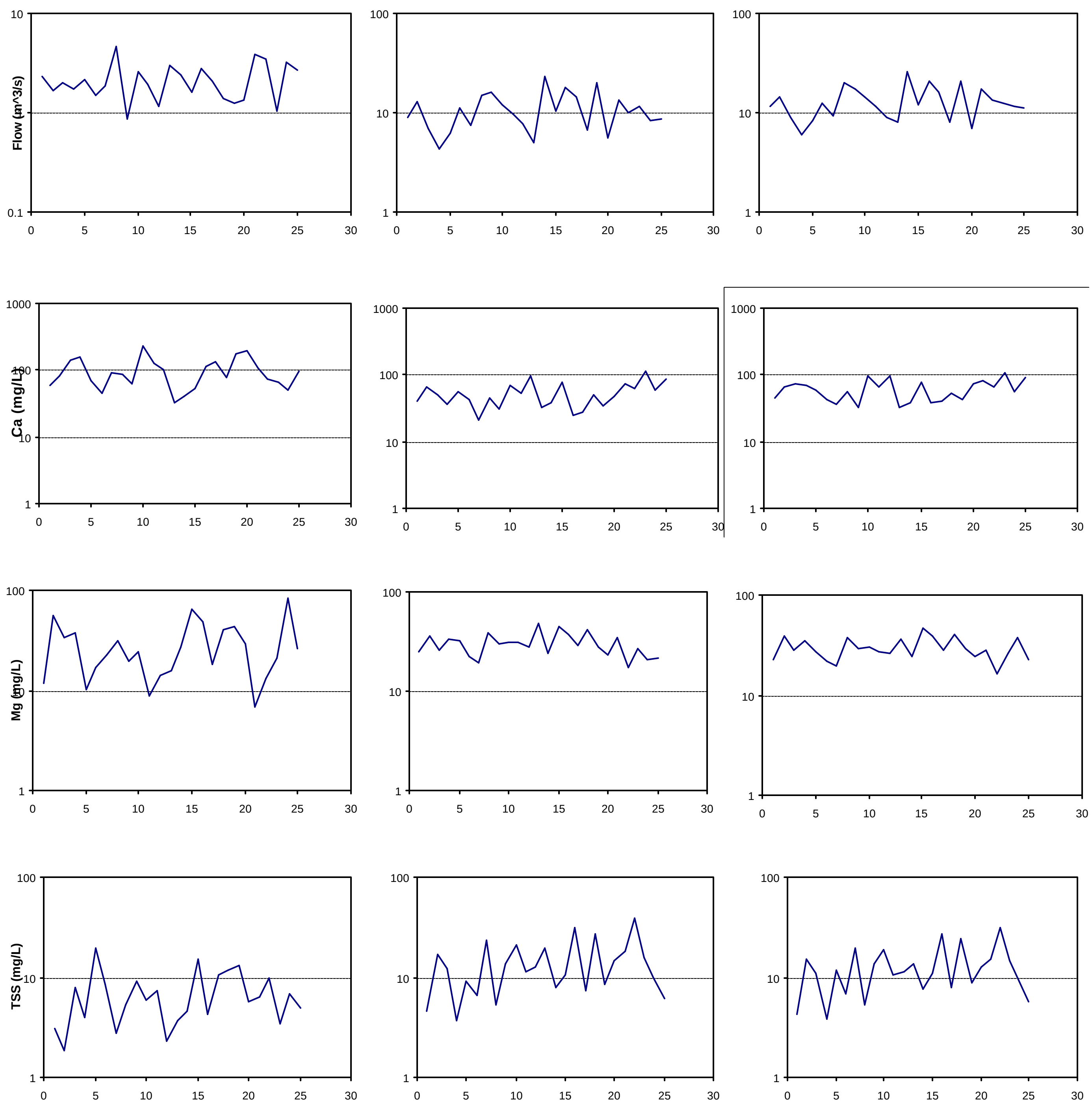

Figure 3: An excerpt from the page 'BLMInfo' showing input fields and program buttons.

BLM Inputs:

Run BLM **Go**

MODEL INPUT PARAMETERS:

Humic Acid content of DOC (%)	**10**
Temp (°C)	**15**
Organism LA50 (nmol/g_{wet})*	**0.035**

* Recommended LA50s :

Organism	*LA50 (nmol/g_{wet})*
Fathead minnow	7.32
Daphnia magna	0.069
Ceriodaphnia dubia	0.077

Click here for updates on LA50s

Figure 4: BLM Results and Site Water Chemistry from page 'PlotBLM'

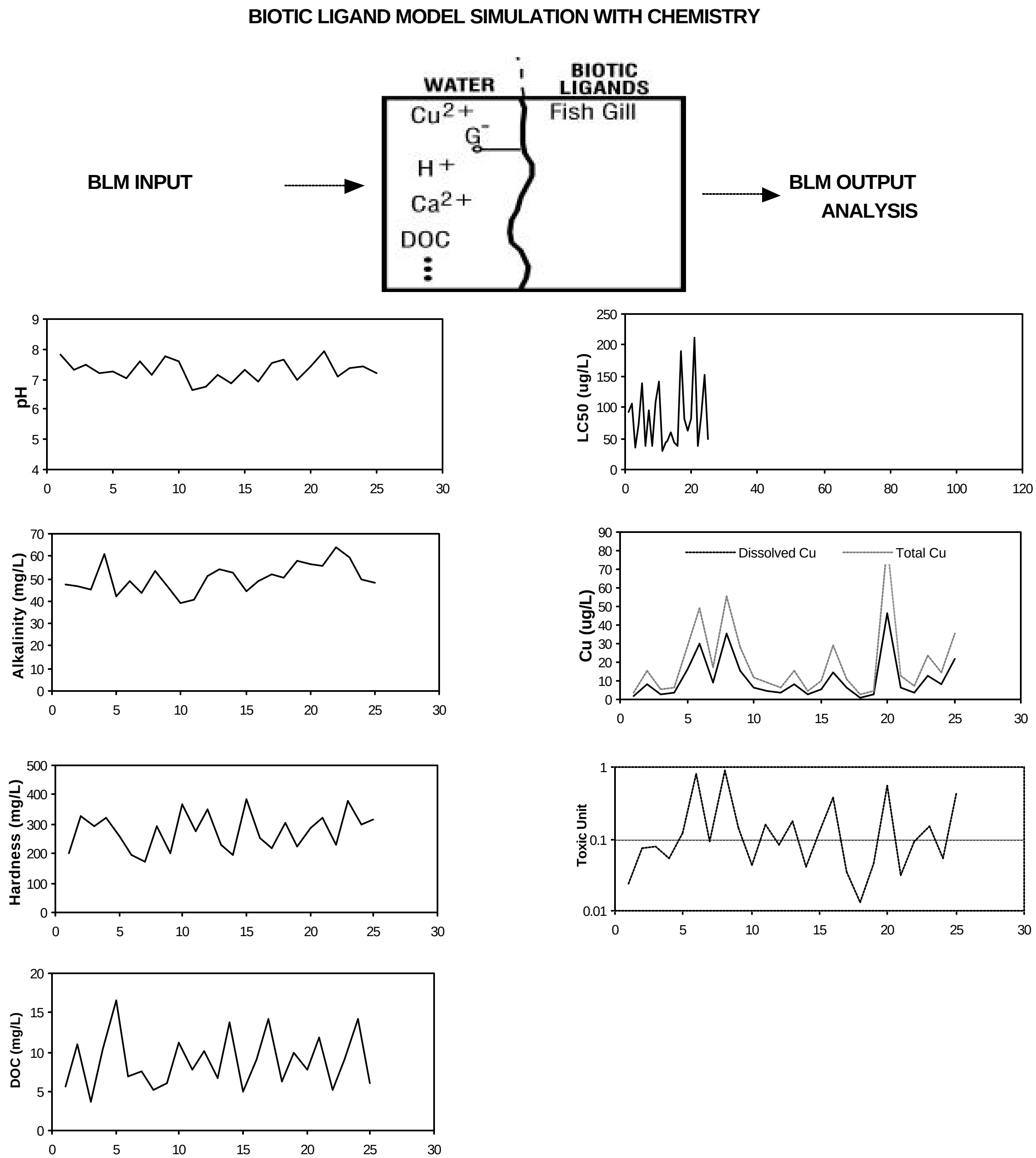

Figure 5: An excerpt from the page 'ProbPlot' showing input fields and program buttons.