The BioWin Advantage

Volume 1
Number 4

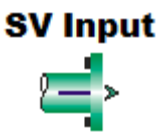
April 2010

In this edition of The BioWin Advantage we will be touching on a few of the most popular questions that are asked by our users. These include:

- Adding alkalinity sources in a process flowsheet
- Simulating coarse bubble aeration systems
- Pointers on using the BOD influent element

Questions

Question #1 - How Do I Simulate Alkalinity Addition?



Over the years, many users have asked us "how can I simulate the addition of a supplemental alkalinity stream to a process?" Related issues are how best to add an acid, how to add a nutrient stream, etc. Rather than use a "normal" BioWin input, the easiest way to do this is with the State Variable Influent element. Let's discuss a few examples in the following sections.

Lime (Calcium Hydroxide)

Calcium has an atomic weight of 40.078, so a 1M lime solution has a calcium content of 1 x 40,078 = 40,078 mgCa/L (a 3M solution would have 3 x 40,078 = 120,234 mgCa/L for example). Calcium is one of the BioWin state variables. So to specify lime, one can simply use a State Variable influent element and adjust the concentration of the calcium state variable. If you open the lime input in the **Chemicals31.bwc** example that accompanies this newsletter, you will see that the only concentration value is the 40,078 mg/L of calcium. All that is required in this case is the calcium concentration. BioWin will calculate the pH, and the composition of the lime solution - BioWin essentially adds the hydroxide anions required to balance out the calcium.

Featured Article

Most Popular BioWin User Questions

Quick Links

EnviroSim has moved!

McMaster Innovation Park
175 Longwood Road S
Suite 114A
Hamilton, ON L8P-0A1
Canada

P: +1 (905) 481-2607
F: +1 (905) 481-2610

Quick Links

News from EnviroSim
Click here to find out the latest EnviroSim News...conferences, training, and more!

Discussion Forum
See what other users are talking about and doing with BioWin...

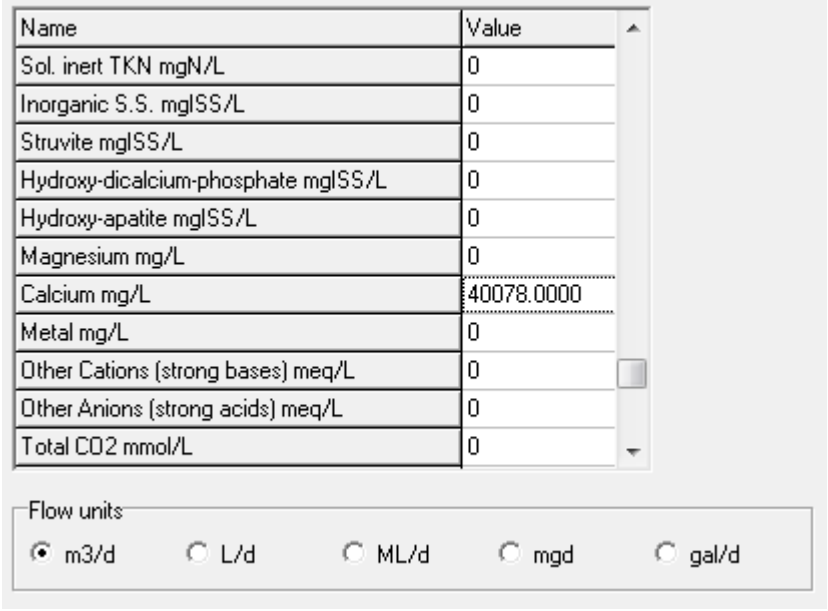
BioWin Papers
Looking for the title of that BioWin presentation you attended at a recent conference? We list them all here...

Contact Us

www.envirosim.com
info@envirosim.com

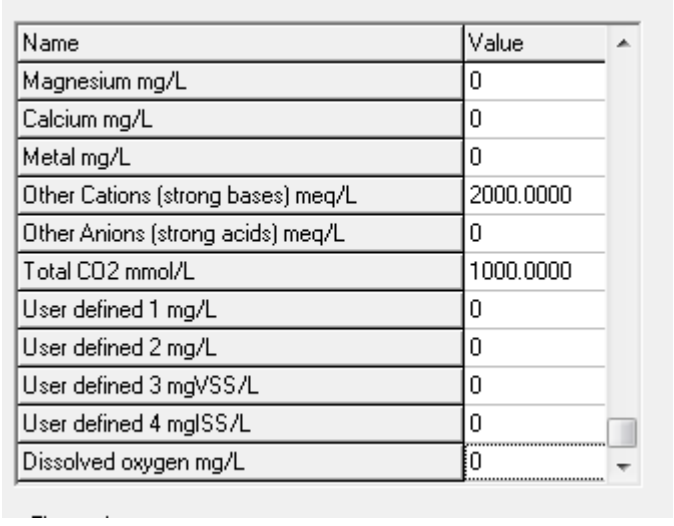
P: +1 (905) 481-2607
F: +1 (905) 481-2610

Join Our Mailing List!



Name	Value
Sol. inert TKN mgN/L	0
Inorganic S.S. mgISS/L	0
Struvite mgISS/L	0
Hydroxy-dicalcium-phosphate mgISS/L	0
Hydroxy-apatite mgISS/L	0
Magnesium mg/L	0
Calcium mg/L	40078.0000
Metal mg/L	0
Other Cations (strong bases) meq/L	0
Other Anions (strong acids) meq/L	0
Total CO2 mmol/L	0

Soda Ash (Sodium Carbonate)
For soda ash (Na2CO3), the two items to be entered in the State Variable influent are the "Other Cations" and CO2. For your solution, you need to calculate the concentration in millimoles per litre. Once you have the number of millimoles, you will enter double this value in the Other Cations field to represent the sodium concentration and this value in the CO2 field (when you enter the CO2 concentration, BioWin will adjust the carbonate system accordingly). So, for a 3 M solution we would enter 6,000 meq/L for Other Cations (the equivalent concentration is the same as the molar concentration because the sodium charge is plus 1 - watch your units if working with multivalent ions) and 3,000 mmol/L for the CO2 concentration. A 1 M solution (shown below) would require 2,000 meq/L for the Other Cations and 1,000 mmol/L for the CO2.



Name	Value
Magnesium mg/L	0
Calcium mg/L	0
Metal mg/L	0
Other Cations (strong bases) meq/L	2000.0000
Other Anions (strong acids) meq/L	0
Total CO2 mmol/L	1000.0000
User defined 1 mg/L	0
User defined 2 mg/L	0
User defined 3 mgVSS/L	0
User defined 4 mgISS/L	0
Dissolved oxygen mg/L	0

Sodium Hydroxide
For this chemical (NaOH), you only need to enter a value for the **Other Cations**. Once again, you need to calculate the concentration in millimoles per litre of your solution. Once you have the number of millimoles, you will enter this value in the **Other Cations** field to represent the sodium concentration. So for a 1 M solution we would enter 1,000 meq/L for the **Other Cations** (once again, the equivalent concentration is the same as the molar concentration because the sodium charge is plus 1). As in the Lime case above, BioWin will calculate the pH, and the composition of the sodium hydroxide solution - BioWin essentially adds the hydroxide anions required to balance out the sodium.

Other Solutions
EnviroSim has generated a number of State Variable Influent streams that

represent a variety of chemical input streams that you can use as starting points to save yourself time. Attached with this newsletter is a BioWin file called **Chemicals31.bwc**. Most of these examples follow the approach outlined in the three examples discussed above.

What about "real" solutions? Say for example we talked to a vendor and they said that they have 50% (by weight) caustic soda (NaOH) solution. How would we set that up in BioWin?

Say the density of the solution at 20 deg C is 1.5253 kg/L (this figure was taken from Perry's Chemical Engineer's Handbook, but typically the vendor will have this information). So one litre of the solution weighs 1.5253 kg, and since it is 50% by weight then the weight of NaOH is 0.76265 kg or 762,650 mg. The concentration of NaOH is then 762,650 mg/L.

The molar weight of NaOH is 40 mg/mmol, so to convert the "mass concentration" to a "molar concentration", we take (762,650 mg/L)/(40 mg/mmol) and get 19,066 mmol/L. So using the ideas discussed above what we'd enter in BioWin is 19,066 meq/L in the **Other Cations** field.

In summary, BioWin makes things easier for us!

Question #2 - How Do I Simulate Coarse Bubble Aeration?

Another common question we receive is "**can I use BioWin to simulate coarse bubble aeration?**" The answer is **Yes!**

The BioWin aeration model settings "as shipped" are set up to directly mimic a fine bubble system. However, the mass transfer model in BioWin has been formulated to be flexible so that it can also be adjusted to simulate coarse bubble responses.

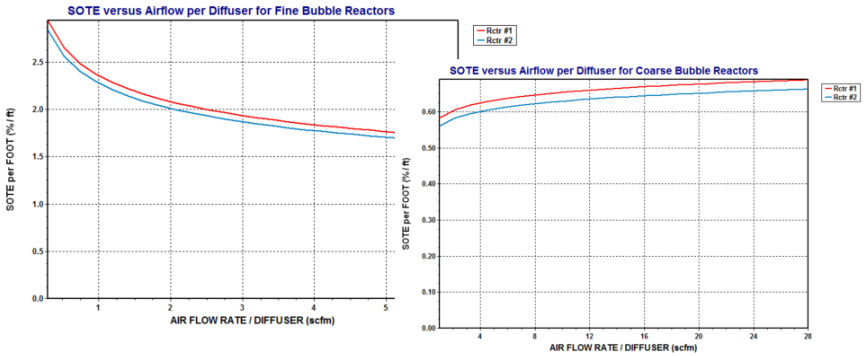
Attached with this newsletter is a BioWin file called **Aeration - Fine vs Coarse - US.bwc**. If you open that file and double click on the coarse bubble bioreactors, go to the Operation tab, and click the model parameters button, you will note several changes have been made to the coarse bubble reactor aeration and diffuser parameters:

- On the **Aeration tab**, alpha values are higher (0.7 to 0.9 range is typical for coarse bubble systems)
- On the **Aeration tab**, the off-gas composition has been changed slightly (higher oxygen, lower CO2) to reflect the decreased transfer one might see in coarse bubble systems
- On the **Diffuser tab**,the aeration parameters K1, K2, and Y have been changed quite a bit. One thing to note here is that K1 is very low (nearly zero). What this does is essentially remove diffuser density from the oxygen transfer equations. So in regards to transfer efficiency, it doesn't matter too much what you put in for your diffuser area and density for a coarse bubble system - which helps because this fine-pore terminology doesn't really apply to coarse bubble systems.

The main thing we are trying to do when modelling coarse bubble systems is match the expected performance in terms of SOTE. If you look in the album of the attached example file, you will see the SOTE curves for the coarse bubble have two main features: (1) the SOTE values are lower in comparison to the fine bubble SOTE curves; and (2) the shape is much flatter and tends to increase slightly with increasing airflow (as opposed to the fine bubble SOTE response that shows decreasing efficiency with increasing air flow).

The parameters in the example file should serve as a good starting point to achieve the objective of matching coarse bubble performance. Find out what the manufacturers suggest for SOTE range and you can adjust the aeration parameters accordingly. Note that if you're happy with the general "pattern" of the SOTE curve for the coarse bubble system (i.e. slight increase with increasing air flow), you can shift the curves up and down by increasing or decreasing the K2 parameter. For example, open the album and note the range of SOTEs for the Coarse Bubble #1 reactor (the red line ranging between about 0.6 and 0.7). Now change K2 from 0.38 to 0.58, and go back into the album; you will see that the red line now ranges between higher values. The K2 parameter essentially translates the curves up and down vertically.

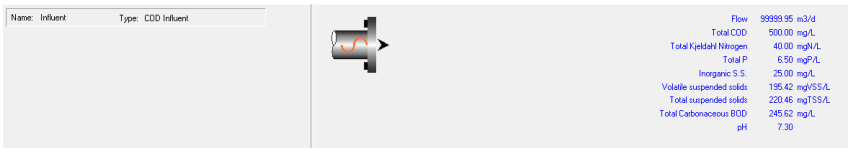
NOTE: by default, Membrane Bioreactor elements have their aeration and diffuser parameters set to similar values to simulate the coarse bubble systems typically found in these systems for membrane scouring purposes.



Question #3 - Why Did BioWin Change a Wastewater Fraction in My BOD Influent?

The third and final common query we receive is "**why did BioWin change a value on the wastewater characteristics tab?**"

With a COD-based input, what you specify for data are "total" concentrations of COD, TKN, TP, and ISS. BioWin takes these totals and breaks them down into state variables (e.g. soluble readily biodegradable COD, unbiodegradable particulate COD; that is, the variables that BioWin tracks via mass balances throughout the entire process flowsheet) based on the wastewater fractions that are specified for the input. Also, based on these state variables, BioWin simulates certain influent parameters. For example, if you hover over a COD-based influent on the drawing board you will see that there is information displayed in the "fly by" section of the main drawing board for things like TSS, VSS, and BOD. That is, based on the biodegradable COD components, BioWin simulates what the BOD will be.

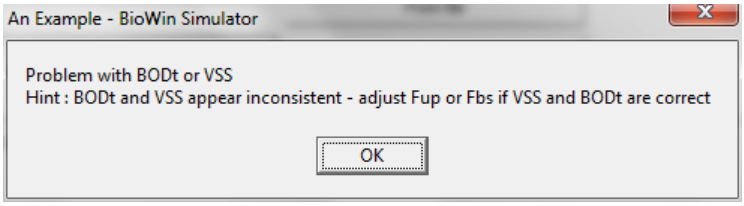


Based on the particulate components (both biodegradable and unbiodegradable), BioWin calculates a VSS and then adds the inorganic suspended solids to that to get a TSS.

The default wastewater fractions for BioWin are for a typical North American raw wastewater (based on EnviroSim's experience running many wastewater characterization studies). That is, for a given input COD and the default fraction set, BioWin will simulate a BOD that results in a COD:BOD ratio of about 2.1, a TSS:BOD of about 0.9-1.0, etc. Adjusting certain of the wastewater fractions will impact certain of the simulated influent parameters. For example, increasing FUP (the unbiodegradable particulate fraction) will decrease BOD and increase VSS.

In the case of a BOD-based influent, the user inputs a BOD, VSS, and TSS (instead of BioWin simulating them as is the case in a COD influent), and for the given wastewater fraction set, BioWin calculates the COD that the influent must have in order to "accommodate" the user-input BOD and VSS. In order to do this, BioWin must adjust the wastewater fractions. To simplify this process, BioWin only may change the FXSP (non-colloidal slowly biodegradable COD) fraction. If you try to change this fraction, BioWin will ignore your input.

If you notice that BioWin is needing to adjust FXSP to a value that is substantially different from the default value of 0.75, then this possibly is an indication that other fractions (e.g. FUP [unbiodegradable particulate COD]) need to be adjusted. For example, if you make a change to the FUP fraction, say OK, and then go back in and look at the wastewater fractions tab, you'll see that BioWin has readjusted FXSP.
A related issue is the following warning from BioWin:



Users often encounter this message when they try and enter a wastewater that is perhaps somewhat "atypical" into a BOD-based influent. For example, the above alarm was generated when an attempt was made to enter the following influent characteristics:

ATTRIBUTE	VALUE
BOD	245 mg/L
TSS	315 mg/L
VSS	270 mg/L
TKN	40 mg/L
TP	10 mg/L

In this case, note that the solids content of the wastewater is relatively high compared to the BOD. What happens in this case is:

1. BioWin attempts to adjust FXSP to a higher value to accommodate the high VSS.
2. BioWin "runs out of room"; that is, even if FXSP is set to its maximum value, there is not enough particulate material in the influent element to agree with the user-defined VSS.
3. BioWin warns the user and prompts for a change to either FUP or FBS.

This is where some knowledge of wastewater characteristics is helpful. Because we are trying to accommodate an influent with high VSS, the logical place to start is to increase FUP. For example, in this case, BioWin won't stop warning us until we input an FUP of 0.16. When we do that, we can see that BioWin is no longer "hitting the limit" on its adjustment of FXSP.

Parameters

Name	Default	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.16000	0.16000
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.15000	0.15000
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.75000	**0.99560**
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.05000	0.05000
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.13000	**0.16000**
Fna - Ammonia [gNH3-N/gTKN]	0.66000	0.66000
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.50000	0.50000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.02000	0.02000
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.03500	0.03500
Fpo4 - Phosphate [gPO4-P/gTP]	0.50000	0.50000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.01100	0.01100
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZaob - Ammonia oxidizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZnob - Nitrite oxidizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4

Note, however, that BioWin is still assigning almost all of the slowly biodegradable COD to the particulate phase - that is, with an FXSP of close to one, there will be very little colloidal material in the influent. If we wanted BioWin to adjust FXSP down to a more reasonable value, then we would need to increase FUP:

Parameters

Name	Default	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.16000	0.16000
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.15000	0.15000
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.75000	**0.87641**
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.05000	0.05000
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.13000	**0.25000**
Fna - Ammonia [gNH3-N/gTKN]	0.66000	0.66000
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.50000	0.50000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.02000	0.02000
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.03500	0.03500
Fpo4 - Phosphate [gPO4-P/gTP]	0.50000	0.50000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.01100	0.01100
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZaob - Ammonia oxidizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZnob - Nitrite oxidizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	1.0000E-4	1.0000E-4

Note, however, that we have to increase FUP to a value that would be considered as on the upper end of "typical" for a raw municipal wastewater so that BioWin can bring FXSP down to a more reasonable value. This is where our experience and judgement as process engineers becomes important!

In Conclusion

In this edition of the **BioWin Advantage**, we've covered a few of the "greatest hits" as far as Technical Support questions go! In future editions, we'll continue to look at a variety of topics with the goal of increasing your productivity with BioWin.

Please feel free to contact us at **info@envirosim.com** (Subject: The BioWin Advantage) with your comments on this article or suggestions for future article.

Thank you and good modeling

The EnviroSim Team