Update to BioWin 6.2

May 12, 2022

A patch was released in May 2022, taking the full version to **6.2.7.3043**. The patch updates several default model and element parameters with respect to the Membrane Aerated Bioreactor (MABR) unit and improves the modeling of short-circuiting that may occur when continuously-fed sequencing batch reactors (SBR) are in settling mode.

Membrane Aerated Bioreactor

A number of default model and element parameter changes were made based on discussions with MABR technology vendors. These are as follows:

- All parameters on the **Project > Parameters > Aeration/Mass Transfer... MABR Membrane effective diffusivities** tab have been reduced by two orders of magnitude. That is, parameters that previously were of the order 10^{-9} are now of the order 10^{-11}.

- To better mimic behavior of these systems, MABR units now default to using **local biofilm parameters** on the **Model options** tab, with the following changes to default parameter values:
    - **Biofilm general** tab: Thin film limit [local value of 0.1 mm]; Thick film limit [local value of 0.6 mm]; Assumed Film thickness for tank volume correction (temp independent) [local value of 0.7 mm]
    - **Maximum biofilm concentrations (mg/L)** tab: All parameter values increased by a factor of three
    - **Effective diffusivities (m^2/s)** tab: All Arrhenius coefficients have been changed to 1.0393 from 1.029

- On the **Dimensions** tab of the MABR element, the **Displaced volume/cassette** parameter now has a default value of 1 m^3/cassette (35.315 ft^3/cassette) and the **Membrane thickness** parameter now has a default value of 0.020 mm.

- On the **Operation** tab of the MABR element, the **Inlet pressure** parameter now has a default value of 145 kPa (21 psi) and the **Outlet pressure** parameter now has a default value of 125 kPa (18.1 psi).

- On the **Model options** tab, the **Boundary layer thickness** parameter now has a default value of 200 micrometers.

The patch also includes three new output variables for the MABR. These are:

1. **Apparent ammonia removal rate**; this parameter is simply the net change in ammonia mass rate across the MABR element.

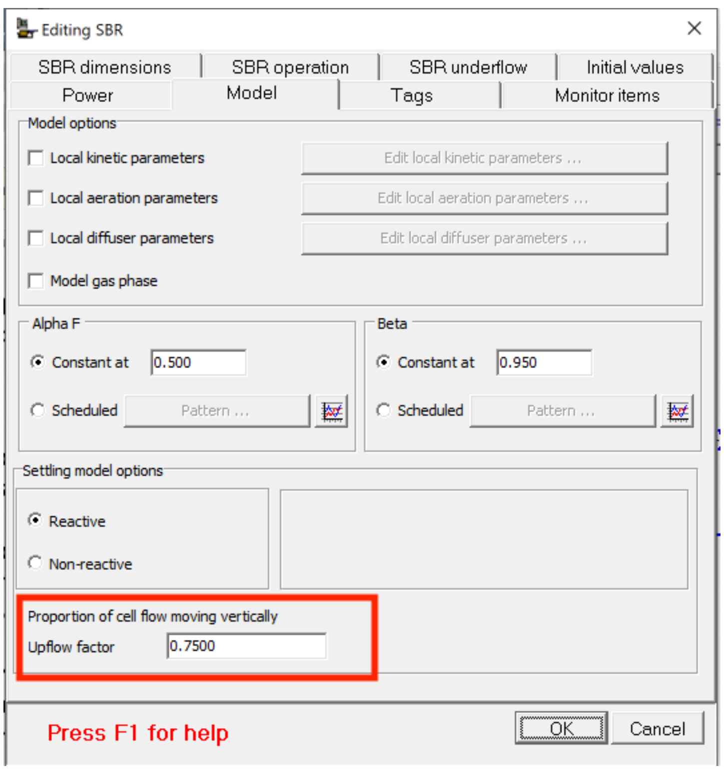
2. **Apparent ammonia removal rate / m²**; this parameter is simply the net change in ammonia mass rate across the MABR element divided by the total membrane surface area of the MABR.

3. **Net AOB (sloughed) / ammonia removed**; this parameter calculates the ratio of the mass rate of ammonia oxidizing biomass (AOB) leaving the biofilm to the net change in ammonia mass rate across the MABR element.

The first two of these three new output variables are shown on the MABR element fly-by pane in the main BioWin window and also are available in Album charts and tables. The third new output variable only is available in Album charts and tables.

Sequencing Batch Reactor

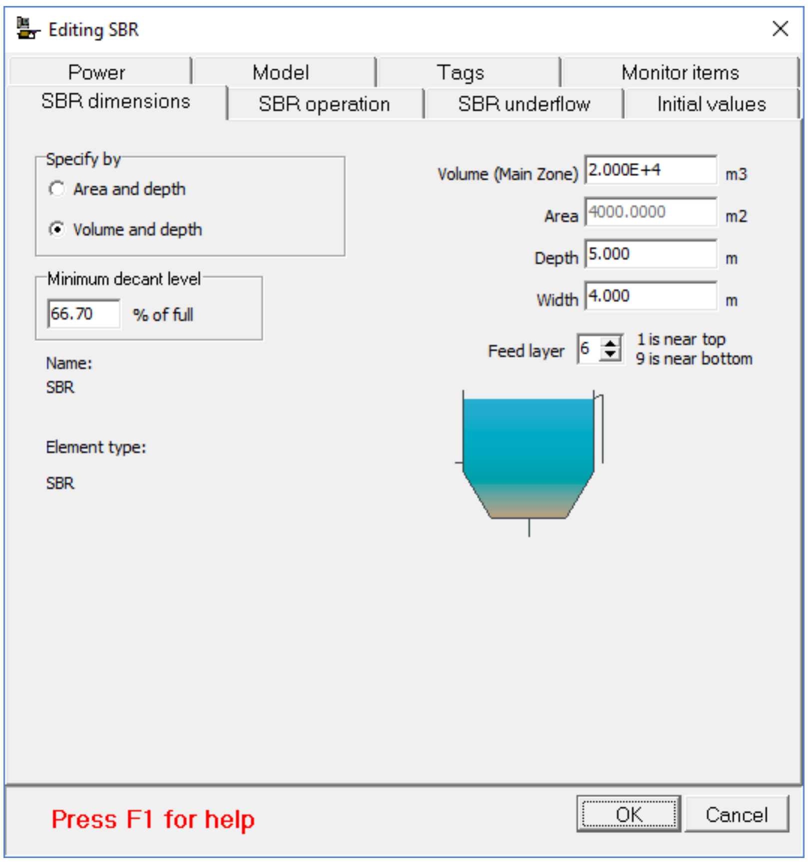
This patch also included a **new parameter** related to the modeling of short-circuiting in sequencing batch reactors (SBRs) during the settling phase. The parameter is called the **Upflow factor** and has a **default value of 0.75**:



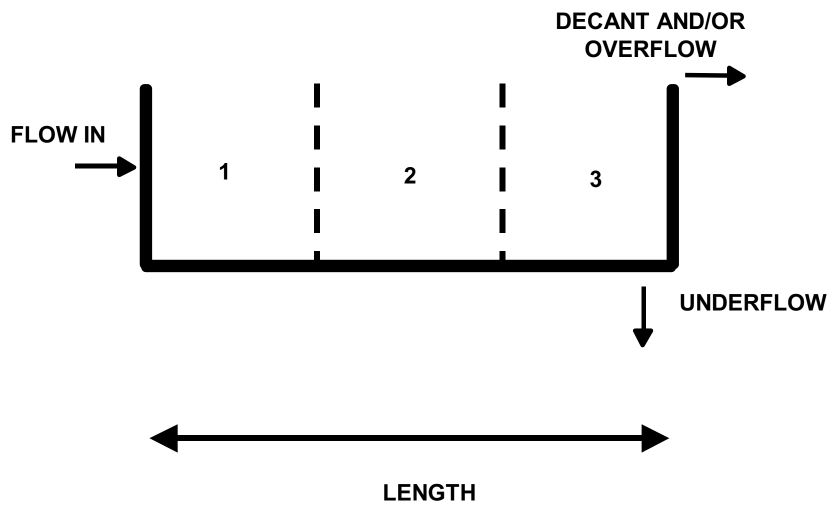
To understand how this parameter is used, some discussion of SBR dimensions is necessary. There are two methods for entering the dimensions: by **Area and depth**, or by **Volume and depth**. The method is specified by clicking on the appropriate radio button.

- If the user selects **Area and depth**, the SBR area and depth must be entered in the Area and Depth text edit boxes.
- If the user selects **Volume and depth**, the SBR volume and depth must be entered in the Volume and Depth text edit boxes.

Regardless of the method you choose, the user should also specify a **Width** for the SBR. Units are shown to the right of the edit boxes.



BioWin uses the **Width** parameter to calculate the **length** of the SBR and as part of the velocity gradient calculation. When settling commences the length is then divided into three equal-length zones. Flow enters the first zone at the level specified by the **Feed layer**. Underflow leaves the SBR at the bottom of the third zone, and decant and/or overflow leaves the SBR at the top of the third zone. The figure below illustrates these concepts.



FLOW DISTRIBUTION IN A SINGLE-TANK SBR

For example, imagine the full depth is 5 m and the length is 15 m. When settling starts, this is what happens:

- The horizontal length of the SBR is divided into three equal-length subsections (each 5 m in this case).
- The vertical direction is divided into 10 equal-depth layers. [Note: as the level goes down during decanting - with no feed - the number of layers stays at 10, and the depth of each layer decreases]. That is, think of each length section as being 10 layers stacked on top of each other (and there are 3 sections).
- Each of the three sections is treated as a vertical settler. That is, the SBR (during settling) is 3 side-by-side settlers, with a total of 30 cells (each completely mixed i.e. of uniform composition).

Consider the dimensions of each of the 30 cells:

- The horizontal area of each cell is Width * (Length/3) = W * 5 m here.
- The end area of each cell is Width * (Liquid Depth/10) = W * 0.5 m (0.5 m when it is full). [Note: in this case the ratio of cell horizontal to side area is 5 : 0.5 = 10 : 1 (if tank is full - but ratio increases when tank level drops)].

BioWin must solve a flow balance to determine how flow moves through the 30-cell matrix towards the upper right cell when decant commences and/or when flow enters (e.g. with continuous flow SBRs). For a typical cell, there can be:

- Flow out of the top surface;
- Flow out the right side;
- Flow in through the bottom surface; and

- Flow in through the left surface.

Exceptions (boundary conditions) to this include:

- The cell of the first zone where flow enters;
- The cells adjacent to the floor and walls;
- The cells at the very top of each zone;
- The bottom cell of the last zone where underflow may be withdrawn; and
- The top cell of the last zone where decant may be withdrawn.

The top and bottom surface area of a cell is [W * L/3]; the left- and right-side surface area of a cell is [W * D/10]. The ratio of the top area to the side area is [(3/10) * (D/L)]. Earlier versions of BioWin (**6.2.5.2788** and lower) assumed that the flows leaving a cell from the top and the side were in proportion to the top and side area of the cell. For typical SBR decant zone dimensions, the fraction of the flow leaving via the top surface of a cell was between 0.90 and 0.95 of the total flow. Experience has shown that such a large factor could result in a degree of short-circuiting of flow up the first settling zone, and then across the top layer of cells to the decant. This assumption did not result in a reasonable distribution of flow to the decant. Therefore, an **Upflow fraction** has been included in this update to allow the user to specify the fraction of flow leaving through the top surface of the cell. The **Upflow fraction** will determine the "pathway" the flow takes through the main zone.

The exercise of adjusting the **Upflow fraction** and seeing the potential impact on the flow pathway can be visualized using Microsoft Excel to mimic a unit flow balance and assigning colors to represent the predominant flow path (blue) and "dead" volume (red). For example, the image below shows the flow regime with flow entering the bottom right-most cell and an **Upflow fraction** of 0.75:

	0.0751	0.2440	1.0000
	0.1001	0.2253	0.7560
	0.1335	0.2670	0.6997
	0.1780	0.3115	0.6329
	0.2373	0.3560	0.5551
	0.3164	0.3955	0.4661
	0.4219	0.4219	0.3672
	0.5625	0.4219	0.2617
	0.7500	0.3750	0.1563
1	1.0000	0.2500	0.0625

The **Upflow fraction** parameter can be used to approximate short-circuiting of soluble components (e.g. ammonia) that may occur in SBRs that receive influent flow during the settling period. It has a relatively minimal impact in SBRs that operate in batch-feed mode. Low values of this parameter can be used to model short-circuiting along the bottom of the SBR and up the side of the tank at the end where decant is removed. For example, the image below shows the flow regime with the **Upflow fraction** set to 0.15:

	0.0000	0.0000	1.0000
	0.0000	0.0000	1.0000
	0.0000	0.0000	1.0000
	0.0000	0.0001	1.0000
	0.0001	0.0004	0.9999
	0.0005	0.0022	0.9996
	0.0034	0.0115	0.9978
	0.0225	0.0574	0.9880
	0.1500	0.2550	0.9393
1	1.0000	0.8500	0.7225

High values of this parameter can be used to model short-circuiting up the wall at the front of the SBR where influent is introduced and along the top of the liquid surface. For example, the image below shows the flow regime with the **Upflow fraction** set to 0.95:

	0.6302	0.9139	1.0000
	0.6634	0.2985	0.0861
	0.6983	0.2793	0.0712
	0.7351	0.2573	0.0572
	0.7738	0.2321	0.0444
	0.8145	0.2036	0.0328
	0.8574	0.1715	0.0226
	0.9025	0.1354	0.0140
	0.9500	0.0950	0.0073
1	1.0000	0.0500	0.0025

Minor Bug Fix

A minor issue was identified where the plug-flow channel element used the previous flow rate for its velocity gradient calculation for the first steady state simulation after a flow change. This issue has been addressed in this patch.