Understanding the Comp1FlowDecayPlus Model

A Flow carries an inflow concentration, Cin, into a one compartment model with a given Volume. Cin is constantly and instantaneously well mixed becoming C, the concentration in the compartment. C empties out of the compartment and is designated Cout. G is a clearance rate.

For a constant concentration of inflowing material the analytic solution is given.

The Comp1FlowDecay model combines the Comp1Decay model with the Comp1Flow model. The governing ordinary differential equation is given as

$$dC/dt=(F/V)\cdot(C_{\text{in}}-C)-(G/V)\cdot G$$

with initial condition

$$C(0)=C_0 \ .$$

For C_{in} constant, the analytic solution is

$$C_{analytic}=((F\cdot C_{\text{in}})-(F\cdot(C_{\text{in}}-C_0)-G\cdot C_0)\cdot\exp(-(F+G)\cdot t/V))/(F+G) \ .$$

Figures and Explanations

Figure 1: Washout: Fig1 parameter set

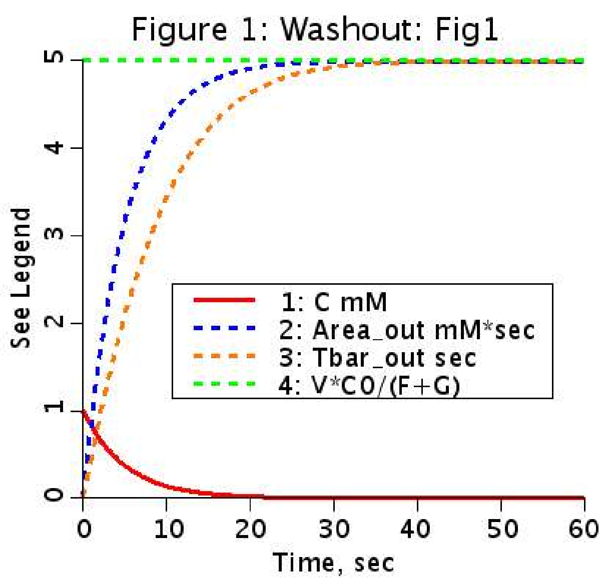


Figure 1 is a combined plot of Cout (red solid), Area_out (dashed blue), Tbar_out (dashed orange), and analytic calculation of Area_out (dashed green) as a function of time.
The parameters for this run are

C0 = 1 mM (concentration in the compartment at time = 0),
F   = 0.01 ml/sec (flow),
V   = 0.05 ml (volume),
G   = 0 ml/sec (clearance rate) and
Cin = 0 (the inflowing concentration).

The mean transit time through the chamber is V/F = 5 seconds which equals the transit time of the outflow concentration since the transit time of the inflow concentration is zero. This means that the solution should fall to 1/e of its original value in 5 seconds. Using the text button, we find
that C(t=5 seconds) = .36787944 mM which is correct to all 8 digits.

The area of the outflow concentration approaches 5 mM*sec (4.999693 mM*sec) confirming that

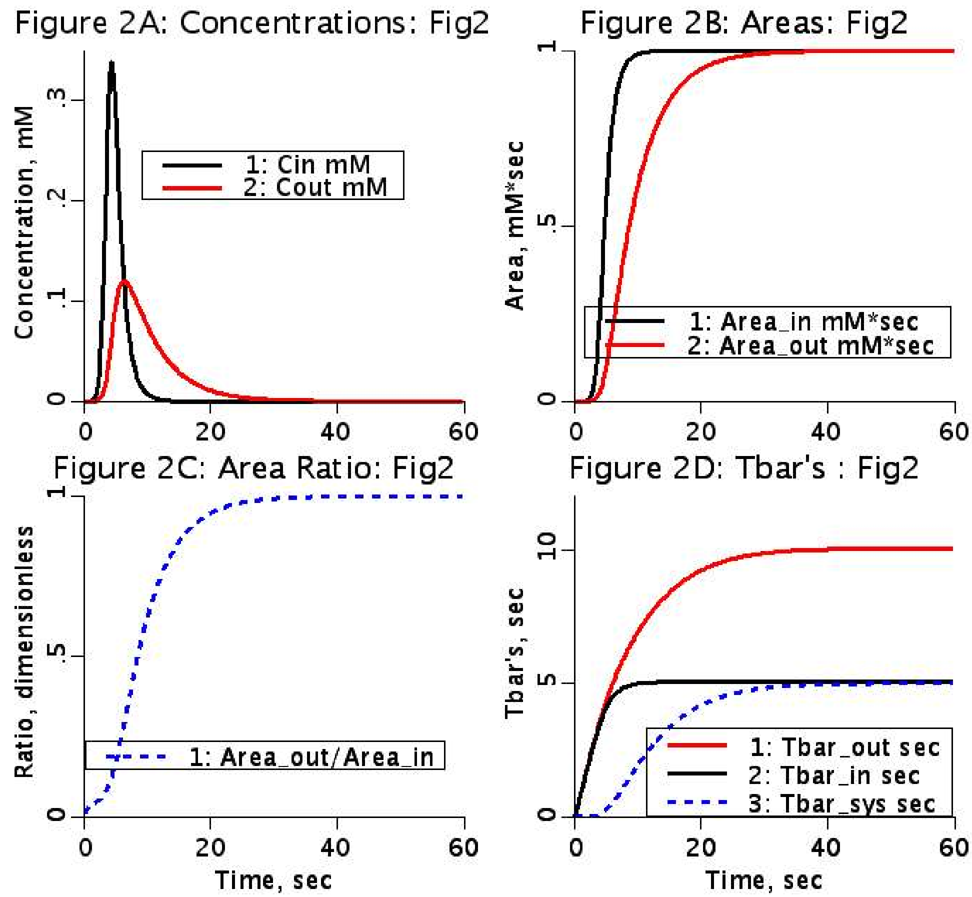
$$Area_{out} = \int_0^{\infty} C(t)\,dt = \frac{V \cdot C_0}{F}$$, when G=0.

Verify that when G>0,

$$Area_{out} = \int_0^{\infty} C(t)\,dt = \frac{V \cdot C_0}{F+G}$$

by setting C0=2 and G=0.03. The answer should be Area_out = 2.5 mM*sec.

Figure 2A: Concentrations: Fig2 parameter set
Figure 2B: Areas: Fig2 parameter set
Figure 2C: Area Ratio: Fig2 parameter set
Figure 2D: Tbar's: Fig2 parameter set



Load the Fig2 parameter set and run the model. The following parameters have been set:

C0 = 0.0 mM (initial concentration at time = 0.)
F = 0.01 ml/sec (flow),
V = 0.05 ml (volume),
G = 0 ml/sec (clearance rate) and
Cin = The Lagged Normal input function use the function generator, fgen_1. (the inflowing concentration).

Al plots are functions of time.

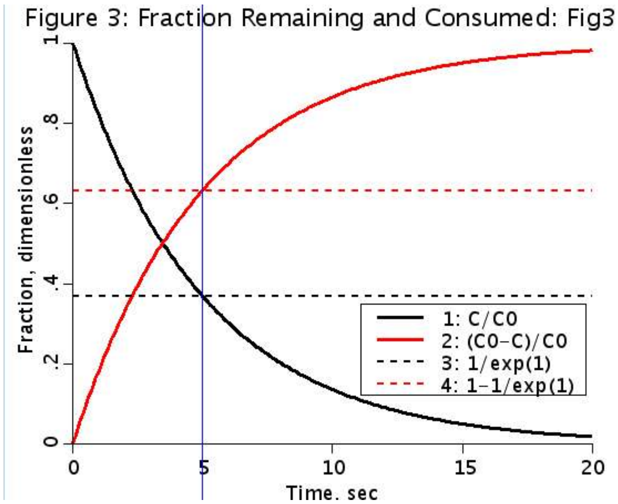
Figure 2A shows Cin and the more dispersed Cout.

Figure 2B shows the corresponding areas from integration. It is seen that both approach the same value.

Figure 2C shows the ratio of Area_out divided by Area_in. It shows that the ration approaches 1 demonstrating that the integrated inflow concentration must equal the integrated outflow concentration in the absence of decay (clearance).

Figure 2D shows the transit times of Cin, Cout, and the system. The transit time of the system approaches V/F = 5 seconds.

Figure 3: Fraction Remaining and Consumed: Fig3 parameter set

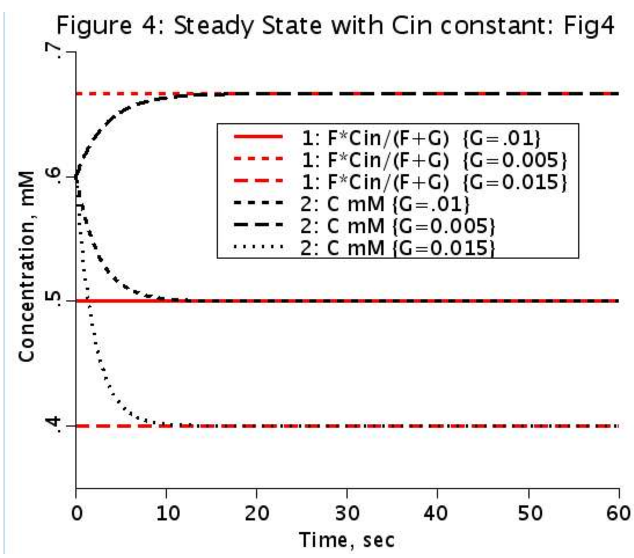


The **black solid line** is the fraction consumed (or cleared). The **red solid line** is the fraction remaining.

Load the Fig3 parameter set and run the model. The following parameters have been set:
C0 = 1.0 mM (initial concentration at time = 0.)
F = 0.00 ml/sec (flow),
V = 0.05 ml (volume),
G = 0.01 ml/sec (clearance rate) and
Cin = 0.0 mM.
The time to reach C=C0/e is 5 seconds as before, and the fraction of C consumed is C0*(1-1/e).

Figure 4: Steady State with Cin constant: Fig4 parameter set

C0=0.6 mM, F = 0.01 ml/sec, G=0.01 ml/sec, V=0.05, Cin = 1.0 mM (constant).



The concentration of C(t) levels off at 0.5 mM. This is because the clearance rate equals the flow so that half is consumed during the time that C is in the compartment.

Run loops with G=0.01, 0.005, and 0.015 ml/sec. The results are

G ml/sec	C(t=60) mM
0.005	0.666
0.010	0.500
0.015	0.400

The steady state solution for the equation

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dC(t)/dt = (F/V)*(Cin-C(t))-(G/V)*C(t)
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when Cin is constant is

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C(t) = F*Cin/(F+G).
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This value does not depend on C0. Clicking on the show button for Curve 1, Figure 4, will reveal the expected value for this calculation.