

POLLUTE

Version 8

Example 19: Multiphase Diffusion Test



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Description

In this example a multiphase diffusion test performed by Buss et al. (1995) is modelled. This test involved the migration of toluene from a 'constant' source through a 0.1 cm thick HDPE geomembrane, a 18.2 cm thick airspace and into a 12.3 cm water reservoir (assumed to be well mixed). Based on Buss et al. the geomembrane diffusion coefficient was $6 \times 10^{-8} \text{ cm}^2/\text{s}$ and the phase coefficient was 43.8. From Schwarzenbach et al. (1993), the diffusion coefficient and phase coefficient for toluene in air are $0.088 \text{ cm}^2/\text{s}$ and 0.27 respectively. Based on these parameters the test is modelled for 600 hours and the calculated and observed concentrations in the receptor are provided at the end of this example.

Data Entry

Open the Examples project and open Case 19.

General Tab

General Information

Model Title: Case 19: Multiphase Diffusion Test

Maximum Depth: 30.6 cm

Darcy Velocity: 0 m/a

Laplace Transform Parameters

TAU: 7 N: 20 SIG: 0 RNU: 2

Run Parameters

Output Units

Time Units: hr Depth Units: cm Concentration Units: mg/L

☒ All Depths ☐ Specified Depths

☒ Concentrations at Specified Times ☐ Maximum Concentrations

+ Add X Delete

Time	Units
1	hr
20	hr
40	hr
70	hr
100	hr
150	hr
200	hr
250	hr
300	hr
350	hr
400	hr
450	hr
500	hr
550	hr
600	hr

The general data for this example can be specified on the General tab. If the Passive Sink has been

selected yet, the Darcy velocity will be ignored. The run parameters for this example can be specified at the bottom of this tab. In this example the times to calculate the concentration are 1, 20, 40, 70, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, and 600 hours.

Layers Tab

Run Auto On Off Save Save As General Layers Boundaries Special Features Subsurface Model + Add ✕ Delete 📄 Copy 📄 Paste ↓ Move Down ↑ Move Up												
Name	Sublayers	Thickness	Thickness Units	Dry Density	Density Units	Porosity	Hydrodynamic Dispersion Coefficient	Dispersion Units	Distribution Coefficient	Distribution Units	Fractures	Symbol
Geomembrane	1	0.1	cm	2.7	kg/m ³	1	0.000216	cm ² /hr	0	m ³ /kg	None	
Air Space	4	18.2	cm	2.7	kg/m ³	1	316.8	cm ² /hr	0	m ³ /kg	None	

The layer data for this example consists of two layers: a geomembrane and an air space. The data for these layers can be specified on the Layers tab.

Boundaries Tab

Run Auto On Off Save Save As General Layers Boundaries Special Features Subsurface Model Click to run the model	
Top Boundary	Bottom Boundary
☐ Zero Flux ☒ Constant Concentration ☐ Finite Mass	☐ Zero Flux ☐ Constant Concentration ☒ Fixed Outflow Velocity ☐ Infinite Thickness
Concentration 500 mg/L	Landfill Length: 1 cm Landfill Width: 1 cm Base Thickness: 12.3 cm Base Porosity: 1 Base Outflow Velocity: 0 m/a Base Symbol

The boundary conditions for this example are a constant concentration top boundary and a fixed outflow bottom boundary. These boundaries can be specified on the Boundaries tab.

Special Features

The passive sink data for this model can be entered on the Special Features tab.

Passive Sink

Passive Sink

Inflow Rate: ☒ No ☐ Yes

Phase Change: ☐ No ☒ Yes

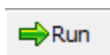
Interval Type: ☒ Depth Intervals ☐ Layers

+ Add - Delete

Top Depth	Top Depth Units	Bottom Depth	Bottom Depth Units	Darcy Velocity	Darcy Velocity Units	Rate of Removal	Rate of Removal Units	Phase Parameter
0	cm	0.1	cm	0	m/a	0	m/a	43.8
0.1	cm	18.3	cm	0	m/a	0	m/a	0.27

The passive sink data is used to specify the Phase parameter and the horizontal and vertical Darcy velocities. In this example there are two depth intervals for the passive sink.

Model Execution



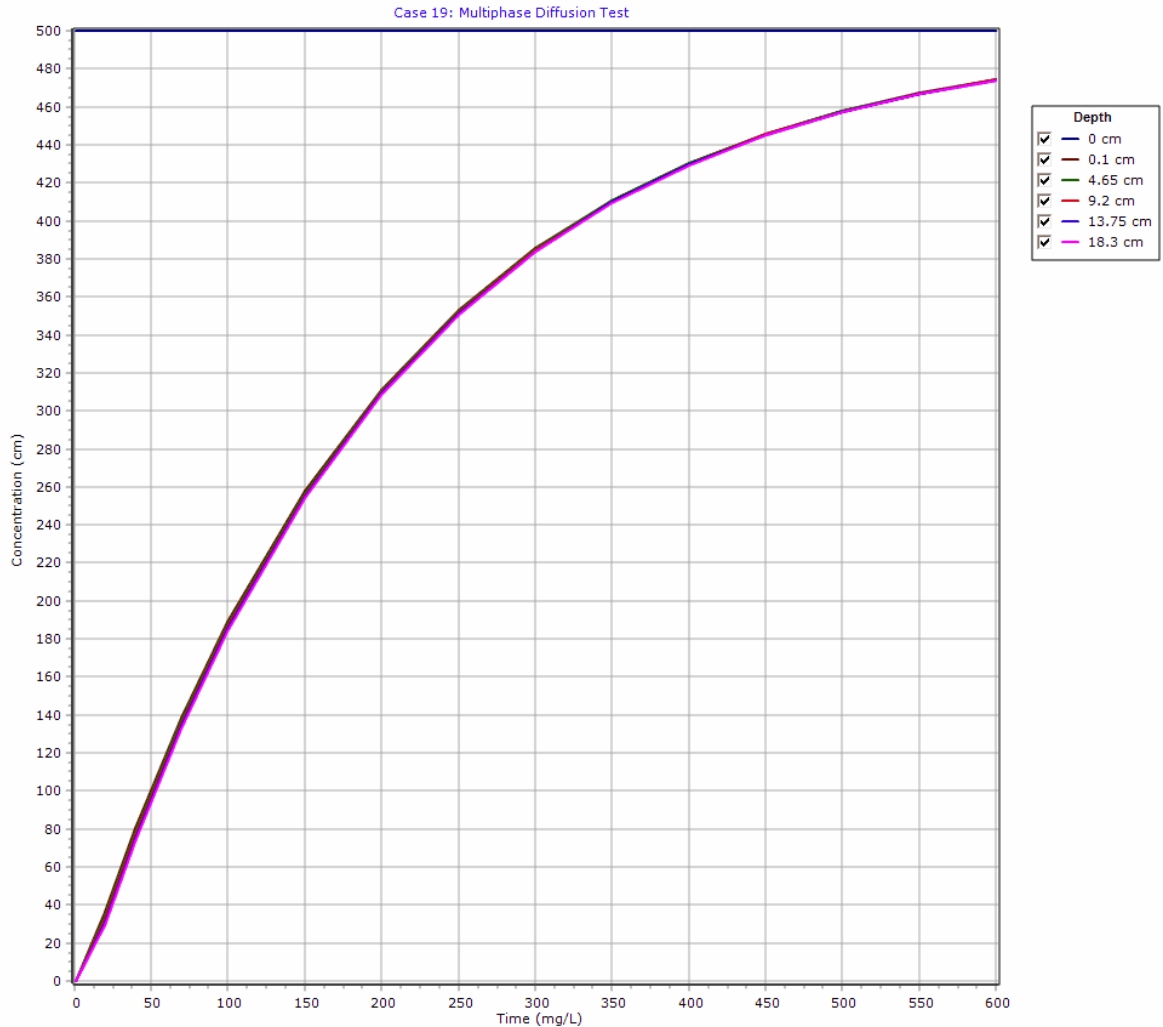
To run the model and calculate the concentrations press the Run button on the toolbar.

Model Output

After the model has been executed, the output for the model will be displayed.

Concentration vs Time

The Concentration vs Time chart can be displayed by selecting the Depth vs Concentration item for the Chart Type.



Output Listing

To display the output as a text listing that will show the calculated concentrations as numbers, click on the List tab.

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Case 19: Multiphase Diffusion Test

THE PASSIVE SINK OPTION HAS BEEN USED. NOTE THE USER IS RESPONSIBLE FOR ENSURING THAT VELOCITY CHANGES ARE CONSISTENT WITH THE PASSIVE SINK.

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distribution Coefficient	Dry Density
Geomembrane	0.1 cm	1	0.000216 cm ² /hr	1	0 m ³ /kg	2.7 kg/m ³
Air Space	18.2 cm	4	316.8 cm ² /hr	1	0 m ³ /kg	2.7 kg/m ³

Boundary Conditions

Constant Concentration

Source Concentration = 500 mg/L

Fixed Outflow Bottom Boundary

Landfill Length = 1 cm

Landfill Width = 1 cm

Base Thickness = 12.3 cm

Base Porosity = 1

Base Outflow Velocity = 0 m/a

Velocity and Sink Profile

Time Period	Minimum Depth	Maximum Depth	Vertical Velocity	Horizontal Outflow	Phase Parameter
01	0 cm	0.1 cm	0 m/a	0 m/a	43.8
	0.1 cm	18.3 cm	0 m/a	0 m/a	0.27

Laplace Transform Parameters

TAU = 7 N = 20 SIG = 0 RNU = 2

Calculated Concentrations at Selected Times and Depths

Time hr	Depth cm	Concentration mg/L
1	0.000E+00	5.000E+02
	1.000E-01	1.771E-04
	4.650E+00	7.045E-05
	9.200E+00	2.687E-05
	1.375E+01	9.110E-06
	1.830E+01	6.369E-07
20	0.000E+00	5.000E+02
	1.000E-01	3.622E+01
	4.650E+00	3.420E+01
	9.200E+00	3.234E+01
	1.375E+01	3.062E+01
	1.830E+01	2.906E+01

40	0.000E+00	5.000E+02
	1.000E-01	8.022E+01
	4.650E+00	7.834E+01
	9.200E+00	7.660E+01
	1.375E+01	7.500E+01
	1.830E+01	7.354E+01
70	0.000E+00	5.000E+02
	1.000E-01	1.387E+02
	4.650E+00	1.370E+02
	9.200E+00	1.355E+02
	1.375E+01	1.342E+02
	1.830E+01	1.329E+02
100	0.000E+00	5.000E+02
	1.000E-01	1.890E+02
	4.650E+00	1.876E+02
	9.200E+00	1.863E+02
	1.375E+01	1.851E+02
	1.830E+01	1.840E+02
150	0.000E+00	5.000E+02
	1.000E-01	2.577E+02
	4.650E+00	2.566E+02
	9.200E+00	2.556E+02
	1.375E+01	2.547E+02
	1.830E+01	2.539E+02
200	0.000E+00	5.000E+02
	1.000E-01	3.113E+02
	4.650E+00	3.104E+02
	9.200E+00	3.097E+02
	1.375E+01	3.089E+02
	1.830E+01	3.083E+02
250	0.000E+00	5.000E+02
	1.000E-01	3.530E+02
	4.650E+00	3.523E+02
	9.200E+00	3.517E+02
	1.375E+01	3.512E+02
	1.830E+01	3.507E+02
300	0.000E+00	5.000E+02
	1.000E-01	3.855E+02
	4.650E+00	3.850E+02
	9.200E+00	3.845E+02
	1.375E+01	3.841E+02
	1.830E+01	3.837E+02
350	0.000E+00	5.000E+02
	1.000E-01	4.108E+02
	4.650E+00	4.104E+02
	9.200E+00	4.100E+02
	1.375E+01	4.097E+02
	1.830E+01	4.094E+02
400	0.000E+00	5.000E+02
	1.000E-01	4.305E+02
	4.650E+00	4.302E+02

	9.200E+00	4.299E+02
	1.375E+01	4.297E+02
	1.830E+01	4.294E+02
450	0.000E+00	5.000E+02
	1.000E-01	4.459E+02
	4.650E+00	4.456E+02
	9.200E+00	4.454E+02
	1.375E+01	4.452E+02
	1.830E+01	4.450E+02
500	0.000E+00	5.000E+02
	1.000E-01	4.578E+02
	4.650E+00	4.577E+02
	9.200E+00	4.575E+02
	1.375E+01	4.573E+02
	1.830E+01	4.572E+02
550	0.000E+00	5.000E+02
	1.000E-01	4.672E+02
	4.650E+00	4.670E+02
	9.200E+00	4.669E+02
	1.375E+01	4.668E+02
	1.830E+01	4.666E+02
600	0.000E+00	5.000E+02
	1.000E-01	4.744E+02
	4.650E+00	4.743E+02
	9.200E+00	4.742E+02
	1.375E+01	4.741E+02
	1.830E+01	4.740E+02

NOTICE

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