



Introduction to I1DISP

- River Examples
- Lake Examples



River Examples

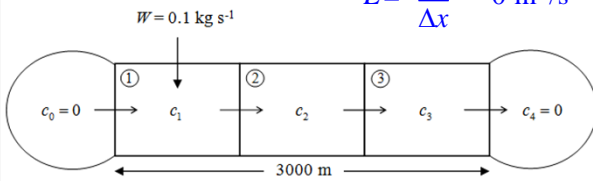
Examples 3.1 – 3.3

Example 3.1 - Summary



$$\begin{aligned}
 A &= 20 \text{ m}^2 & L &= 3000 \text{ m} & u &= 0.1 \text{ m/s} \\
 E &= 0.0 \text{ m}^2/\text{s} & \Delta x &= 1000 \text{ m} & W &= 0.1 \text{ kg/s} \\
 k &= 10^{-4} \text{ s}^{-1} & Q &= uA = 2 \text{ m}^3/\text{s}
 \end{aligned}$$

$$\bar{E} = \frac{E \cdot A}{\Delta x} = 0 \text{ m}^3/\text{s}$$



Example 3.1 – Analytical Solution

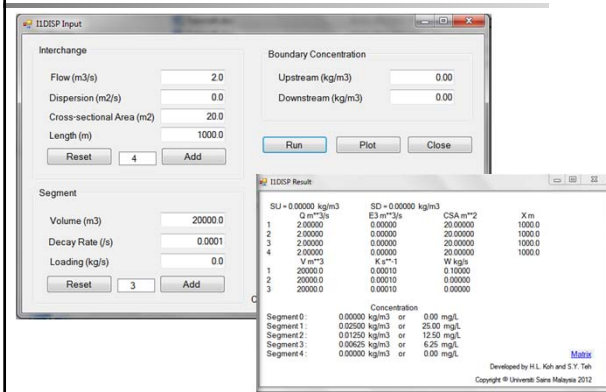


$$c_1 = 0.025 \text{ kg/m}^3 = 25 \text{ mg/L}$$

$$c_2 = 0.0125 \text{ kg/m}^3 = 12.5 \text{ mg/L}$$

$$c_3 = 0.00625 \text{ kg/m}^3 = 6.25 \text{ mg/L}$$

Example 3.1 – I1DISP Solution

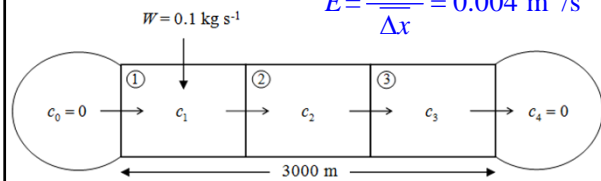


Example 3.2 - Summary



$$\begin{aligned}
 A &= 20 \text{ m}^2 & L &= 3000 \text{ m} & u &= 0.1 \text{ m/s} \\
 E &= 0.2 \text{ m}^2/\text{s} & \Delta x &= 1000 \text{ m} & W &= 0.1 \text{ kg/s} \\
 k &= 10^{-4} \text{ s}^{-1} & Q &= uA = 2 \text{ m}^3/\text{s}
 \end{aligned}$$

$$\bar{E} = \frac{E \cdot A}{\Delta x} = 0.004 \text{ m}^3/\text{s}$$



Example 3.2 – Analytical Solution

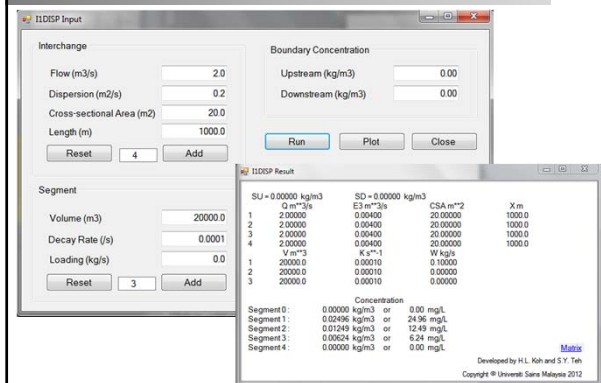


$$c_1 = 0.02496 \text{ kg/m}^3 \quad \text{or} \quad c_1 = 24.96 \text{ mg/L}$$

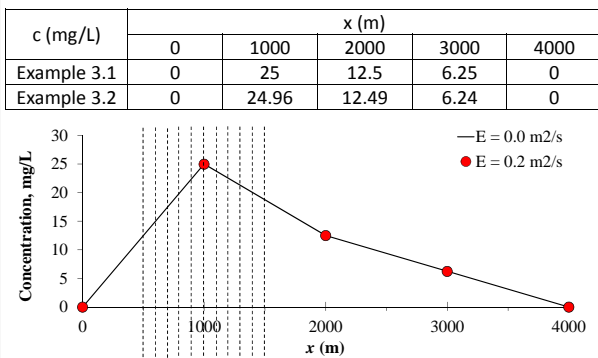
$$c_2 = 0.01249 \text{ kg/m}^3 \quad \text{or} \quad c_2 = 12.49 \text{ mg/L}$$

$$c_3 = 0.00624 \text{ kg/m}^3 \quad \text{or} \quad c_3 = 6.24 \text{ mg/L}$$

Example 3.2 – I1DISP Solution



Examples 3.1 & 3.2: Comparison



Example 3.3 - Summary

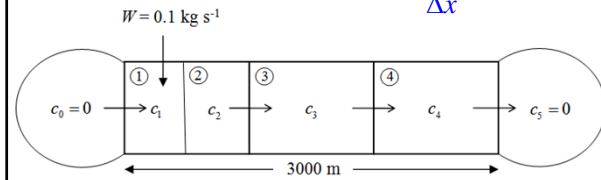


$$A = 20 \text{ m}^2 \quad L = 3000 \text{ m} \quad u = 0.1 \text{ m/s}$$

$$E = 0.0 \text{ m}^2/\text{s} \quad \Delta x = 1000 \text{ m} \quad W = 0.1 \text{ kg/s}$$

$$k = 10^{-4} \text{ s}^{-1} \quad Q = uA = 2 \text{ m}^3/\text{s}$$

$$\bar{E} = \frac{E \cdot A}{\Delta x} = 0 \text{ m}^3/\text{s}$$



Example 3.3 – Analytical Solution



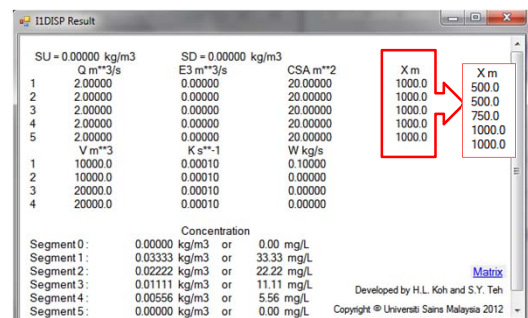
$$c_1 = 0.033 \text{ kg/m}^3 \quad \text{or} \quad c_1 = 33 \text{ mg/L}$$

$$c_2 = 0.022 \text{ kg/m}^3 \quad \text{or} \quad c_2 = 22 \text{ mg/L}$$

$$c_3 = 0.011 \text{ kg/m}^3 \quad \text{or} \quad c_3 = 11 \text{ mg/L}$$

$$c_4 = 0.0056 \text{ kg/m}^3 \quad \text{or} \quad c_3 = 5.6 \text{ mg/L}$$

Example 3.3 – I1DISP Solution



Lake Examples

Example 1

A lake has the following characteristics:

- Volume = 50,000 m³
- Mean depth = 2 m
- Inflow = outflow = 7500 m³ d⁻¹

The lake receives the input of a pollutant from three sources: a factory discharge of 50 kg d⁻¹, a flux from atmosphere of 0.6 g m⁻² d⁻¹, and the inflow stream that has a concentration of 10 mg L⁻¹. If the pollutant decays at the rate of 0.25 d⁻¹, determine the steady-state concentration.

Example 1 – Analytical Solution

Factory discharge, $W_1 = 50 \text{ kg/d}$

Atmospheric flux, $W_2 = 0.6 \text{ g m}^{-2} \text{ d}^{-1} \times \frac{50000}{2} \text{ m}^2 = 15000 \text{ g/d} = 15 \text{ kg/d}$

Inflow input $W_3 = 10 \text{ mg/L} \times 7500 \text{ m}^3/\text{d} = 0.01 \text{ kg/m}^3 \times 7500 \text{ m}^3/\text{d} = 75 \text{ kg/d}$

Loading, $\bar{W} = 50 + 15 + 75 = 140 \text{ kg/d}$

Assimilation factor, $a = Q + \gamma V = (7500 + 0.25 \times 5 \times 10^4) \text{ m}^3 \text{ d}^{-1} = 2 \times 10^4 \text{ m}^3 \text{ d}^{-1}$

Steady-state concentration, $C = \frac{\bar{W}}{a} = \frac{140}{2 \times 10^4} \left(\frac{\text{kg}}{\text{d}} \times \frac{\text{d}}{\text{m}^3} \right) = 0.007 \text{ kg/m}^3 = 7 \text{ mg/L}$

Example 1 – I1DISP Solution

The screenshot shows the I1DISP software interface. The 'Interchange' tab is active, displaying input parameters: Flow (m3/s) = 0.0868, Dispersion (m2/s) = 0.0, Cross-sectional Area (m2) = 20.0, Length (m) = 1000.0, and Segment 1 with Volume (m3) = 50000.0, Decay Rate (/s) = 0.00002289, and Loading (kg/s) = 0.00162. The 'Boundary Concentration' tab shows Upstream (kg/m3) = 0.00 and Downstream (kg/m3) = 0.00. The 'I1DISP Result' window shows the calculated concentration for Segment 1 as 0.00700 kg/m3 or 7.00 mg/L.

Example 2

A pond with a single inflow stream has the following characteristics:

- Mean depth = 3 m ; Surface area = $2 \times 10^5 \text{ m}^2$;
- Residence time = 2 weeks ; Inflow BOD = 4 mg L⁻¹

A subdivision housing 1000 people will discharge raw sewage into this system. Each individual contributes about 150 gal capita⁻¹ d⁻¹ of wastewater and 0.25 lb capita⁻¹ d⁻¹ of BOD. If the BOD decays at a rate of 0.1 d⁻¹ and settles at a rate of 0.1 m d⁻¹, Determine the steady-state concentration for the lake with and without the subdivision.

Example 2

Determine the steady-state concentration for the lake with and without the subdivision.

Steady-state concentration for the lake without subdivision,

$$C = \frac{Q_{in} C_{in}}{a}$$

Steady-state concentration for the lake with subdivision,

$$C = \frac{Q_{in} C_{in} + \mu}{a}$$

Example 2 – Without Subdivision



Steady-state concentration for the lake without subdivision,

$$C = \frac{Q_{in} C_{in}}{a} \quad \text{Inflow BOD} = 4 \text{ mg L}^{-1} \Rightarrow C_{in} = 0.004 \text{ kg/m}^3$$

Pond residence time, $\tau_w = V/Q$

$$Q_{in} = 0.429 \times 10^5 \text{ m}^3/\text{d}$$

$$\Rightarrow 2 \text{ week} = \frac{2 \times 10^5 \times 3 \text{ m}^3}{Q} \Rightarrow Q = 3 \times 10^5 \text{ m}^3/\text{week} = 0.429 \times 10^5 \text{ m}^3/\text{d}$$

Decay, $k = 0.1 \text{ d}^{-1}$ Settling velocity, $v = 0.1 \text{ m}^{-1} \text{d}^{-1}$

Surface area, $A_s = 2 \times 10^5 \text{ m}^2$

Assimilation factor, $a = Q + kV + vA_s$

$$= 0.429 \times 10^5 + 0.1 \times (6 \times 10^5) + 0.1 \times (2 \times 10^5) \text{ m}^3/\text{d}$$

$$= (0.429 + 0.6 + 0.2) \times 10^5$$

$$a = 1.229 \times 10^5 \text{ m}^3/\text{d}$$

Example 2 – Without Subdivision



Steady-state concentration for the lake without subdivision,

$$C = \frac{Q_{in} C_{in}}{a} \quad Q_{in} = 0.429 \times 10^5 \text{ m}^3/\text{d}$$

$$C_{in} = 0.004 \text{ kg/m}^3$$

$$a = 1.229 \times 10^5 \text{ m}^3/\text{d}$$

$$\therefore C = \frac{Q_{in} C_{in}}{a} = 1.4 \times 10^{-3} \text{ kg/m}^3 = 1.4 \text{ mg/L}$$

Example 2 – With Subdivision



Steady-state concentration for the lake with subdivision,

$$C = \frac{Q_{in} C_{in} + \mu}{a}$$

Wastewater BOD loading

$$Q_{in} = 0.429 \times 10^5 \text{ m}^3/\text{d}$$

$$C_{in} = 0.004 \text{ kg/m}^3$$

$$a = 1.229 \times 10^5 \text{ m}^3/\text{d}$$

$$= 0.25 \left(\frac{\text{lb}}{\text{capita d}} \right) \times 1000 \text{ capita}$$

$$= 2.5 \times 10^2 \text{ lb/d}$$

$$\approx 113.6 \text{ kg/d}$$

$$\therefore C = \frac{Q_{in} C_{in} + \mu}{a} = 2.32 \times 10^{-3} \text{ kg/m}^3 = 2.32 \text{ mg/L}$$

Example 2 – I1DISP Without Sub



I1DISP Input

Interchange

Flow (m³/s): 0.5
Dispersion (m²/s): 0.0
Cross-sectional Area (m²): 20.0
Length (m): 1000.0
Reset: 2 Add

Boundary Concentration

Upstream (kg/m³): 0.004
Downstream (kg/m³): 0.00
Run Plot Close

I1DISP Result

Segment	Volume (m ³)	Decay Rate (/s)	Loading (kg/s)	SU = 0.00400 kg/m ³	SD = 0.00000 kg/m ³	E3 m ³ /s	CSA m ²	X m
1	600000.0	0.00000154	0.00	0.50000	0.00000	20.00000	20.00000	1000.0
2	600000.0	0.00000154	0.00	0.50000	0.00000	20.00000	20.00000	1000.0

Concentration

Segment 0: 0.00400 kg/m³ or 4.00 mg/L
Segment 1: 0.00140 kg/m³ or 1.40 mg/L
Segment 2: 0.00000 kg/m³ or 0.00 mg/L

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Example 2 – I1DISP With Sub



I1DISP Input

Interchange

Flow (m³/s): 0.5
Dispersion (m²/s): 0.0
Cross-sectional Area (m²): 20.0
Length (m): 1000.0
Reset: 2 Add

Boundary Concentration

Upstream (kg/m³): 0.004
Downstream (kg/m³): 0.00
Run Plot Close

I1DISP Result

Segment	Volume (m ³)	Decay Rate (/s)	Loading (kg/s)	SU = 0.00400 kg/m ³	SD = 0.00000 kg/m ³	E3 m ³ /s	CSA m ²	X m
1	600000.0	0.00000154	0.00131	0.50000	0.00000	20.00000	20.00000	1000.0
2	600000.0	0.00000154	0.00131	0.50000	0.00000	20.00000	20.00000	1000.0

Concentration

Segment 0: 0.00400 kg/m³ or 4.00 mg/L
Segment 1: 0.00232 kg/m³ or 2.32 mg/L
Segment 2: 0.00000 kg/m³ or 0.00 mg/L

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Thank you

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