Problems for an Instantaneous Release of a Pollutant to a Stream

1. An aqueous solution of Endosulfan (alpha) containing 1.5 kg is accidentally released into a small stream. The streams dimensions are 20 meters wide, 0.8 meters deep, and has an average velocity of 2 meters/s. The stream channel drops 25 meters over a distance of 10 km. Endosulfan decays by first-order kinetics with a half-life of 9.1 days.

a) Assuming that the solution immediately mixes with the stream water, determine the distribution of Endosulfan at 5 min, 30 min, 1 hour, and 3 hours as a function of distance from the release point.
b) Determine the concentration at a distance of 8000 meters and at a time of 1 hour.
c) The stream is located in a state with a drinking water standard of 0.005 mg/L. Estimate when water at a distance of 25000 km will be below this level.

2. Determine the affect of the longitudinal coefficient, E, on the downstream concentration of Endosulfan. Do this by using the data in problem 1, but reducing the E by half, and then by one-fourth. Do lower E values result in a higher or lower concentration of Endosulfan?

3. A medical supply of ^{131}I (500 mCi) is being transported to a hospital. On its way, an automotive accident results in the release of the iodine into a small stream. The stream channel has a average width of 3 m and an average depth of 0.25 m. The average water flow in the stream is 0.40 m^3/s and the stream channel drops 1 meter in elevation over a distance of 10 km.

a) Assuming that the ^{131}I is evenly distributed across the stream channel, estimate the distribution of ^{131}I as a function of distance downstream (using a maximum distance of 30 km) at 1, 3, 6, and 12 hours.
b) Estimate the ^{131}I activity (concentration) at a distance of 12 km at 6 hours after the release. (^{131}I has a half-life of 8.04 days.)

4. A tanker containing 5000 kg of 2,4-dinitrophenol (DNP) wastewater spills into a large river and immediately mixes with the stream water. The stream's dimensions are 100 meters wide, 25 meters deep, and has an average velocity of 0.75 meters/s. The stream channel drops 0.5 meters over a distance of 10 km. DNP decays by first-order kinetics with a half-life of approximately 17.5 days.

a) Determine the distribution of DNP at 6, 24, 48, and 96 hours as a function of distance from the release point.
b) Determine the concentration at a distance of 130 kilometers and at a time of 48 hours.

5. Problem 4 quotes a first-order decay rate of 17.5 days. Another investigation estimates the decay rate at 2.8 days.

(a) What are the effects of using the slower decay rate on the concentration of DNP in the 6, 24, 48, and 96 hour concentration plots? Also, recalculate the concentration at a distance of 130 kilometers and 48 hours.

(b) What are the effects of reducing the decay rate to zero. Recalculate the concentration at a distance of 130 kilometers and 48 hours.