Additional Problems

1. Lake Superior contains 10% of the Earth's freshwater. Lake Superior has a surface area of 8.21×10^{10} m^2, an average depth of 145 m, and an average water residence time of 112 years. Although Lake Superior is considered a pristine lake it is subject to atmospheric inputs of pollutants. Suppose that a pollutant enters the lake at a rate of 100kg/day, but decays with a half-life of 1.04 years. Assume that the input starts today ($C_o = 0$) and continues for 50 years. (a) Prepare two plot of pollutant concentration versus time (from 0 to 15 years) assuming that the major removal mechanism is washout in the St. Mary's River (the effluent river). One plot should use the half-life given and the other should ignore the rate constant. (b) When does each plot reach a steady-state concentration?

2. Pine lake is a kettle lake located in upstate New York. The lake has a volume of 198100 m^3. The stream draining the lake has a average flow rate of 6603 m^3/day. A herbicide is applied to the surrounding area and leaching from rainfall and groundwater infiltration results in 1kg of herbicide entering the lake per month. The background concentration of herbicide in the lake is 0.005 mg/L. (a) How long will it take for the concentration to reach equilibrium? (b) Create a concentration versus time plot showing the change in concentration for a 1 year period, and (c) compare the concentration plot to one created without the first-order removal process. Assume that the insecticide degrades with a half-live of 3 months.

3. Many large lakes were severely contaminated from industrial activities prior to 1980. Since this time considerable effort has been made to remove or minimize these industrial inputs. For purposes of this section, say that Toxin Q was released into a lake (volume = 3.68×10^{12} m^3) starting in 1920 at a rate of 5000 kg/year. The lake has a hydraulic residence time of 3.00 years and Toxin X does not significantly degrade. (a) When will be the concentration of Toxin Q in 1975? (b) When will the concentration reach equilibrium? Assume that the background concentration of Toxin Q in 1920 is zero.