Lab 6 – Nonlinear Curve Fitting-Part II

Aeration for Wastewater Treatment
CENG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills
8 October, 2013

Due Date

Submit your memo *via email* before lab on October 22.

Learning Objectives

1. Fit laboratory data to a mathematical model using non-linear curve fitting.
2. Create, discuss, and analyze high-quality figures that that contain graphs with data and model fits.
3. Communicate the results of a combined laboratory and modeling study in a formal memo to a supervisor.

Overview

This lab is a continuation of Lab 3, where you learned to fit non-linear data to mathematical models, and to present data and model fits in high-quality plots. In this assignment you will extend what you learned in Lab 3 and incorporate two plots into a clear and concise memo to your supervisor. While grading, I will focus on the quality of the figure, as well as how well you communicate the results to your supervisor.

Background—Mass Transfer of Gaseous Compounds into Aqueous Systems

Aeration, or delivery of dissolved oxygen (O_2), represents approximately one half of the operating costs associated with conventional aerobic wastewater treatment. Therefore, a well-designed O_2 delivery system is critical for cost-effective treatment. As part of an upgrade to an existing treatment plant, you've been asked to assess the effectiveness of three oxygen delivery systems—agitation (or mixing), and sparging (or bubbling) with two different diffuser sizes—by modeling experimental data gathered by one of your colleagues. To do so, you need to model the mass transfer rate of O_2 into the liquid phase of the treatment reactor using Eq.1:

$$\frac{dC}{dt} = k_{La}(C^* - C) \tag{1}$$

where C = aqueous concentration of O_2 at time = t (mg/L),

C^* = aqueous concentration of O_2 when the water in the pond is in equilibrium with the atmosphere (mg/L),

k_{La} = mass transfer rate coefficient (time^{-1}).

Eq. 1 is based on empirical studies, and engineers estimate values of k_{La}—the mass transfer rate coefficient—from laboratory data and model fitting. Note that k_{La} depends on temperature, pH, salinity, and system geometry (e.g., bubble size).

The integrated form of Eq. 1, which you will use to model the dissolved oxygen vs. time data, is presented as Eq. 2:

$$C = C^* - (C^* - C_0)e^{-k_{La}t} \tag{2}$$

where C = aqueous concentration of O_2 at time = t (mg/L),

C^* = aqueous concentration of O_2 when the water in the pond is in equilibrium with the atmosphere (mg/L),

C_0 = aqueous concentration of O_2 at time = 0 (mg/L), and

k_{La} = mass transfer rate coefficient (time^{-1}).

Assignment

The Southern Maryland Wastewater District contracted the engineering firm that you work for to conduct a combined laboratory and modeling study to determine the effect of three O_2 delivery systems on the rate of O_2 input into treatment reactors: (1) mixing only, (2) O_2 sparging with a fine (small) diameter diffuser, and (3) O_2 sparging with a coarse (large) diameter diffuser.

Your colleague has collected data, which is summarized in the data file titled "O2 Delivery", which is located on Moodle in the "Lab Six" folder. The file contains three data sets of dissolved O_2 concentration versus time that were taken by aerating water via three methods:

1. mixing only,
2. sparging with coarse (large) bubbles, and

3. sparging with fine (small) bubbles.

Your assignment includes the following:

- Use KaleidaGraph to fit the three-parameter (C^*, C_0, and k_{La}) non-linear mass transfer equation (Eq.2), which I briefly introduced in class last week in lecture, to each data set. (Note that you may want to look up a reasonable value for C^*, or calculate it based on Henry's constant, so you have an initial value to input into KaleidaGraph.)
- Create one plot that shows all three sets of C vs. t data points, and a line/curve that illustrates the model fit to each data set.
- Think about how well the model fits the three data sets, and whether you think the model is appropriate or not. Note that you will not conduct proper statistical tests for goodness of fit, but you should be able to visually assess whether the model is appropriate or not, and you should include this assessment in your memo.
- Create a column graph with three columns, showing the value of the mass transfer coefficient (k_{La}) on the y-axis that corresponds to each aeration method on the x-axis.

Deliverables

Summarize your work in a memo addressed to your supervisor, Dr. Toby Ahrens. For this assignment include the following sections: (1) Introduction, (2) Objective, (3) Methods, (4) Results and Discussion (this is where you'll include the figures you created), and (5) Conclusions.

Make sure you think about your audience (i.e., your supervisor), what he is hoping to receive from you (a design recommendation?), and how you will convince him that your design choice is appropriate. Refer to the instructions handed out in CENG350 for formatting and writing style, and the sample memo that you received in this course. Pay attention to the conclusions you draw, and make sure that they come out of the data and model fits you present in the figures. Finally, refer to the comments you received on Lab Report 3 and please contact me if you have questions.