Encouraging High School Students to Learn about Bioremediation

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Outline

- Purpose
- Background
- Methods and Materials
- Results and Discussion
- Conclusions

Purpose

- To stimulate interest in high school students towards Environmental Engineering.
- Develop a simple, hands-on laboratory experience that students can perform to understand how microorganisms can be used to clean up the environment.

Bioremediation

- A natural process that uses indigenous microorganisms found in soil and water
- These microbes can be used for oxidizing organic compounds that may have been inadvertently released to the environment
- Detoxify wastes

Heterotrophic Organisms

- Use organic carbon in synthesis
- Use organic carbon as their energy source
- May be either aerobic, facultative, or anaerobic

Stoichiometric Equations

Synthesis

$$C_6H_{12}O_6 + O_2 + NH_3 \rightarrow C_5H_7O_2N + CO_2 + 4H_2O$$

Oxidation for Energy

$$C + O_2 \rightarrow CO_2 + Energy$$

Bacterial Growth

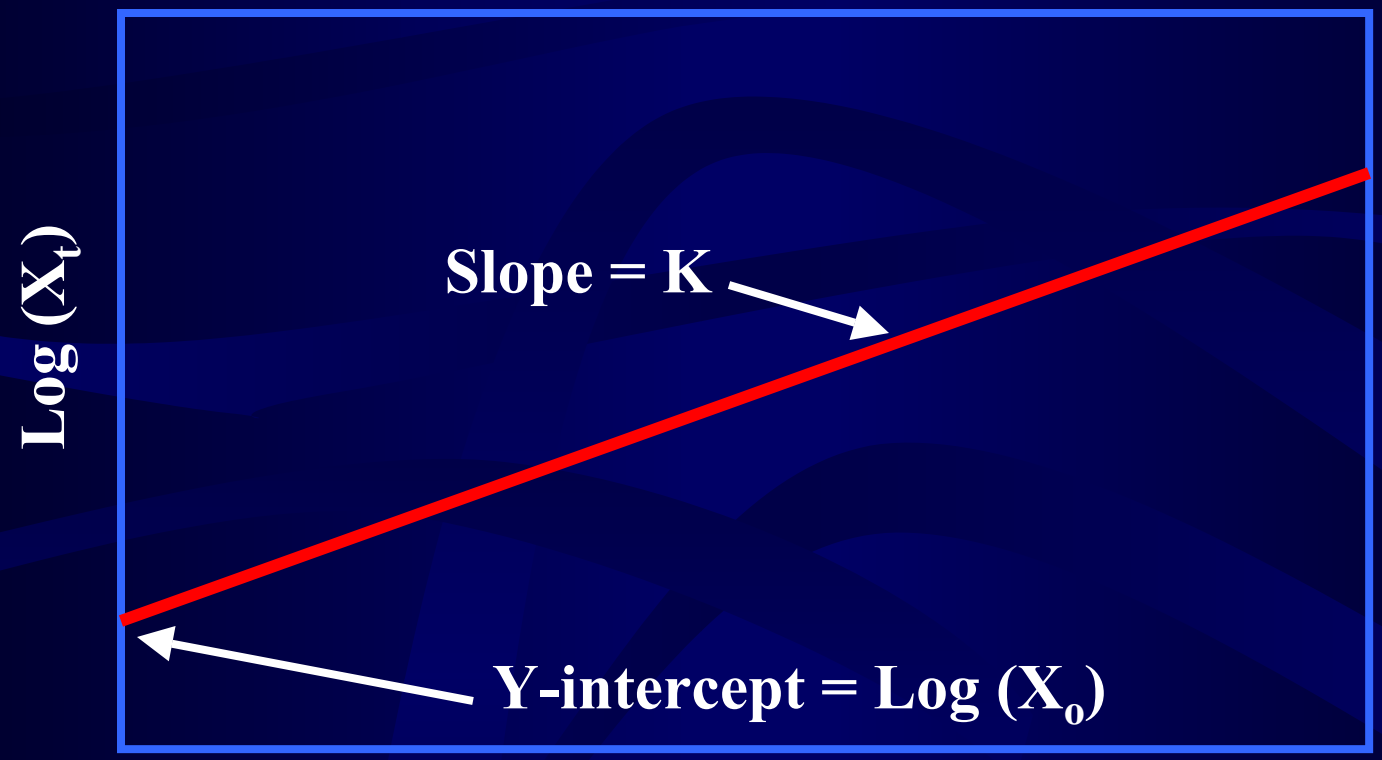
$$X_t = X_o e^{(Kt)}$$

X_o and X_t = Initial and final microorganisms concentration, mg/L,

K = Microorganisms growth coefficient, days^{-1}, and

t = Monitoring period, days.

Determination of Growth Coefficient K



Substrate Degradation

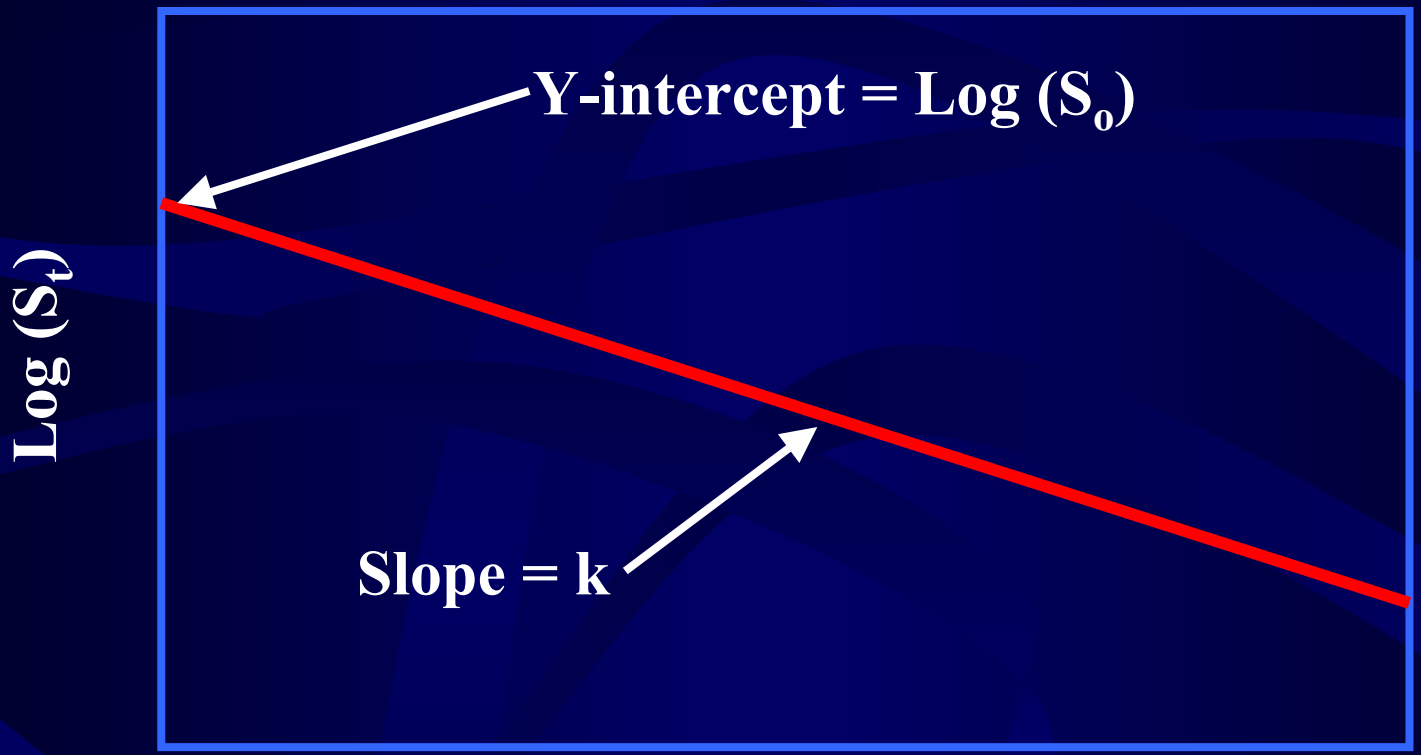
$$S_t = S_o\, e^{(-kt)}$$

S_o and S_t = Initial and final substrate concentration, mg/L,

k = Substrate removal rate coefficient, days^{-1}, and

t = Monitoring period, days.

Determination of Substrate Removal Rate Coefficient k



Materials

- Six, 2-L plastic bottles or Erlenmeyer flasks
- 600-grams of soil
- Glucose stock solution, 100 g/L
- 3-L of tap water and funnel
- Analytical balance

Materials continued

- Dissolved oxygen meter and probe
- pH meter and probe
- Glucose reagent determination strips or equipment for measuring BOD or COD
- Fish-pump compressor, tubing, diffuser
- Heterotrophic plate count

Procedures

1. Add 100 grams of soil and 500-mL of distilled water or tap water to six, 2-L plastic bottles.
2. Prepare stock solution of glucose or add appropriate amounts of glucose directly to each 2-L bottle.
3. Add 2.5, 5.0, 10.0, 20.0, 20.0, and zero mL of the stock 100 g/L of glucose solution to each of the six bottles. Bottle #6 is the control. Mix gently for 1 to 2 minutes.

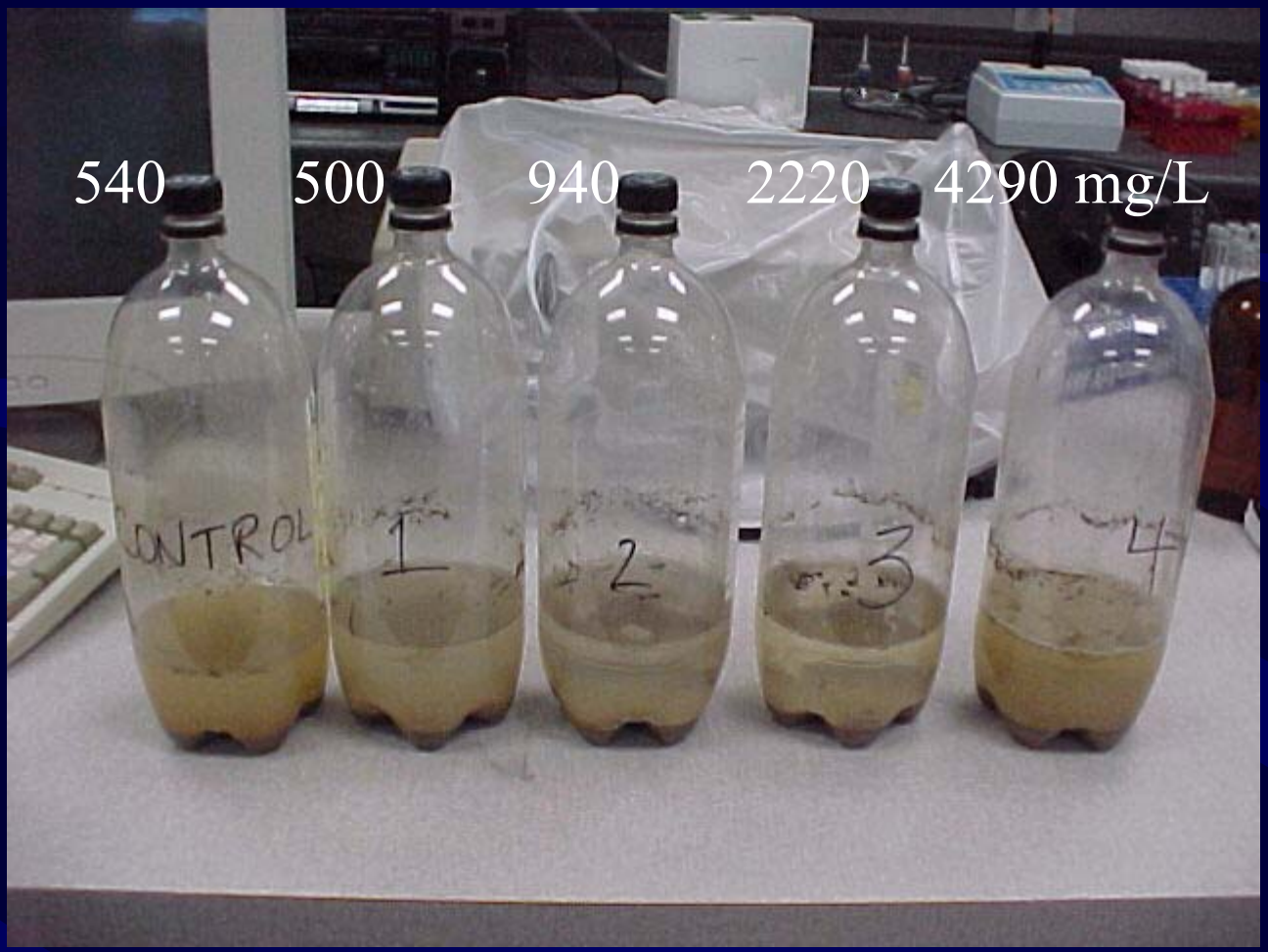
Procedures Continued

4. Measure the initial DO, pH, Glucose, and/or COD concentration of the combined mixture of soil, tap water and glucose solutions. Optional measurements include: turbidity, CFU or HPC.
5. Incubate the 2-L bottles at room temperature; measure the DO, pH, glucose, and/or COD of the liquid portion daily or every other day for at least five days. ***Aerating the bottles for 1 - 2 minutes after each sampling period will enhance degradation.***

Theoretical & Actual CODs (mg/L)

Date	Control	#1	#2	#3	#4	#5
17-Dec	0	533	1067	2133	4267	4267
17-Dec	10	440	910	1790	3100	3820
18-Dec	540	500	940	2220	4290	4830

COD in Soil Bioreactors

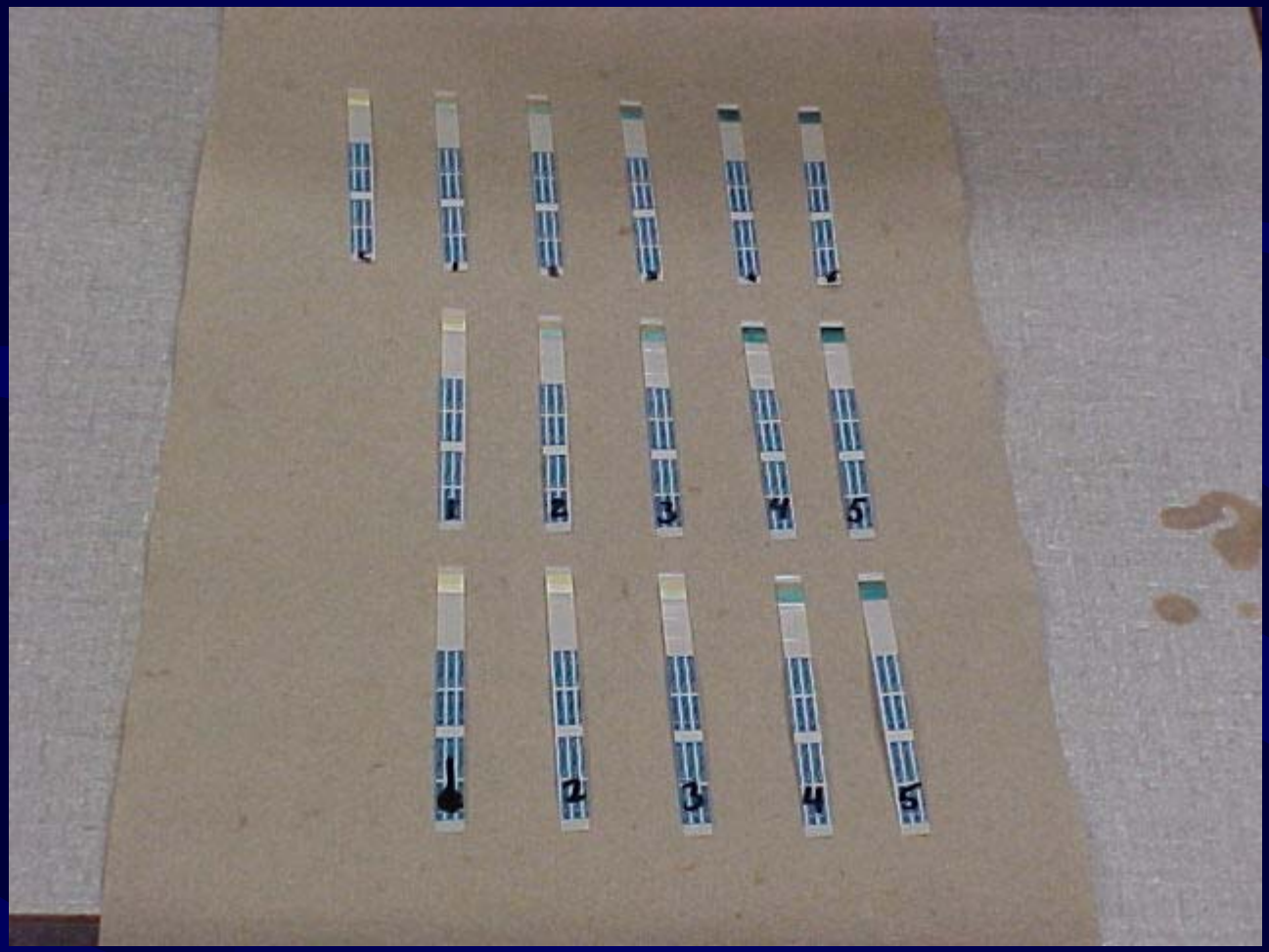


Soil Bioreactor #5 Constantly Aerated

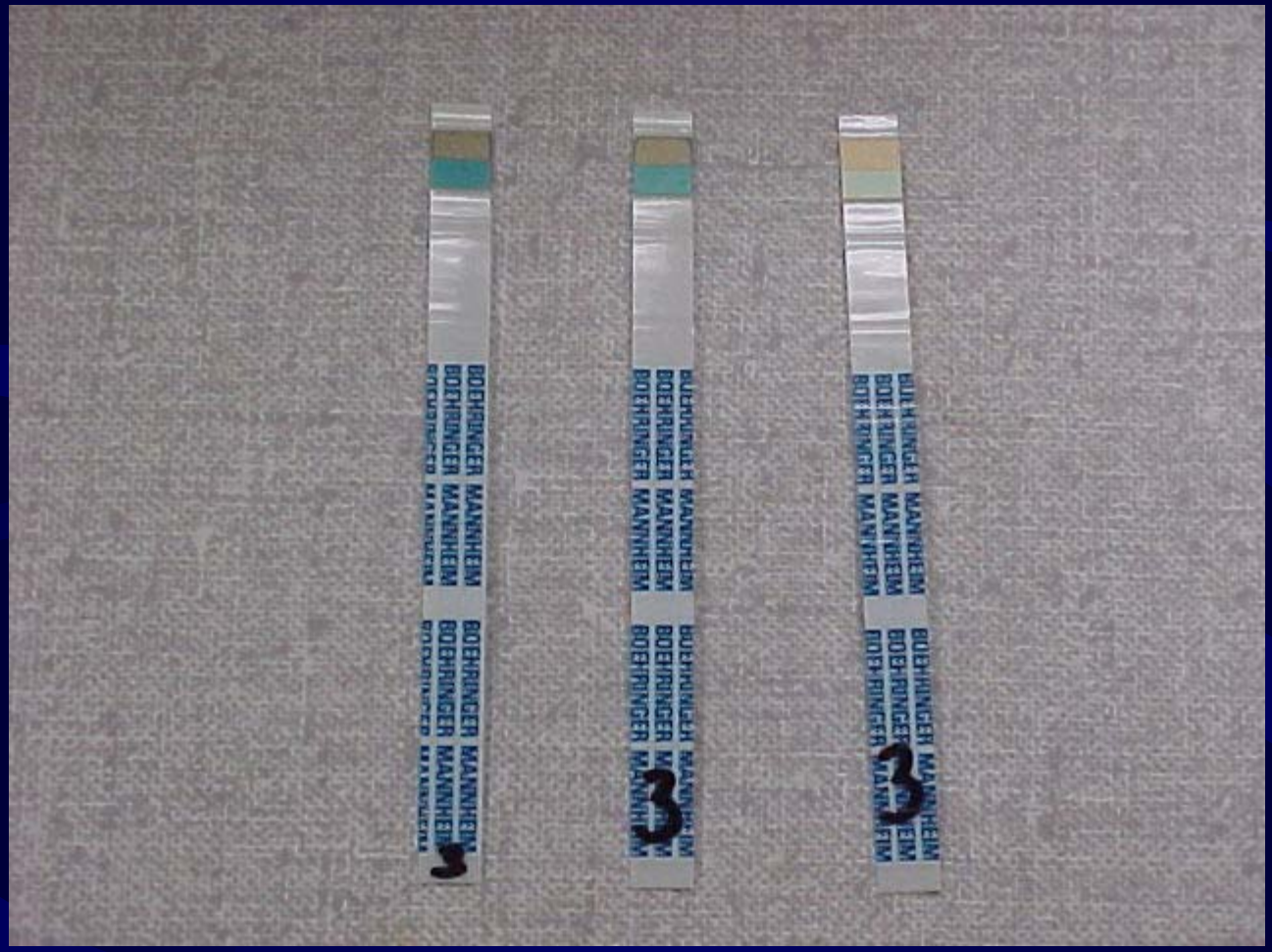
Soil Bioreactor #4

Close-up of Soil Bioreactor

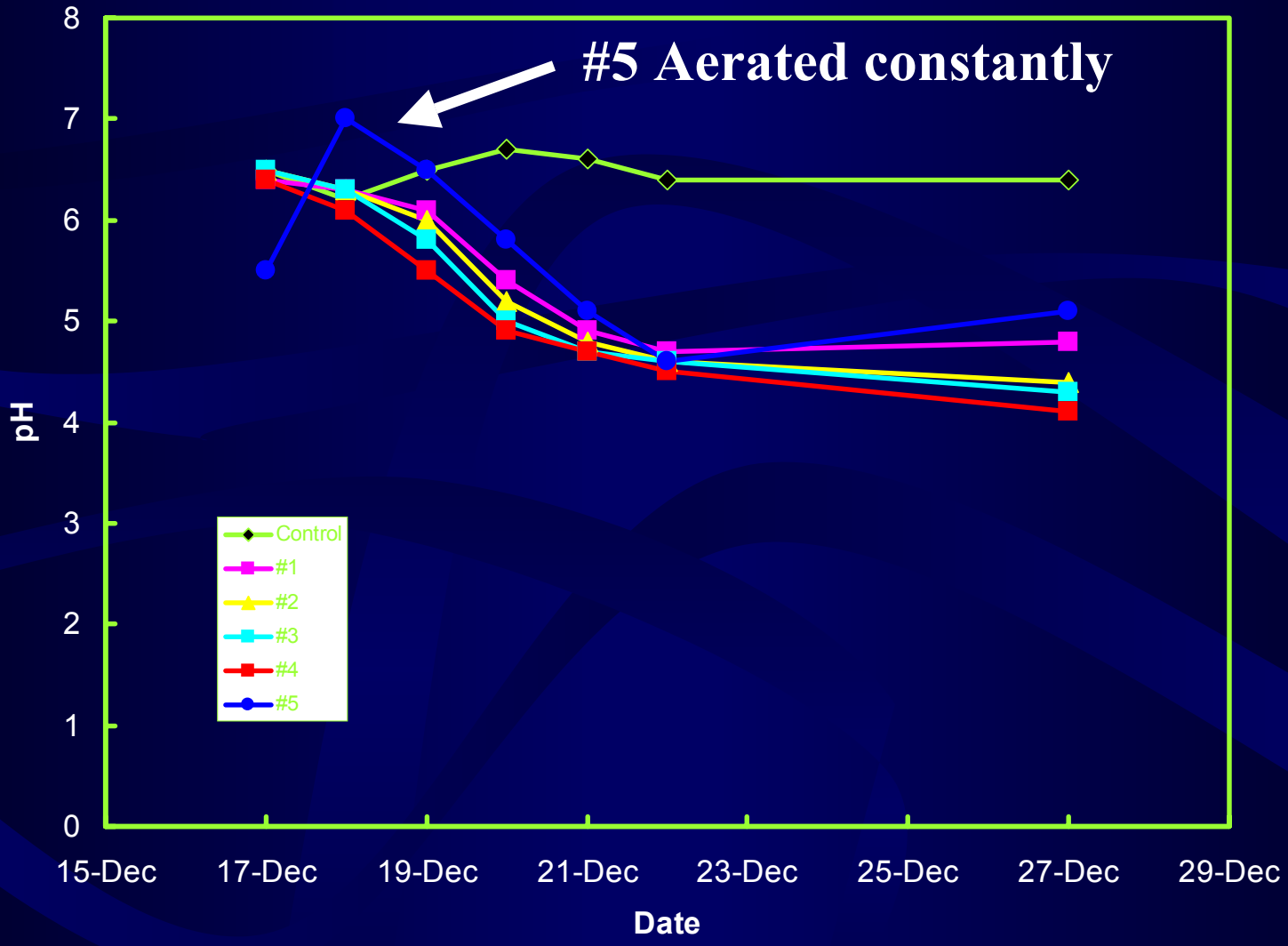
Glucose Strips



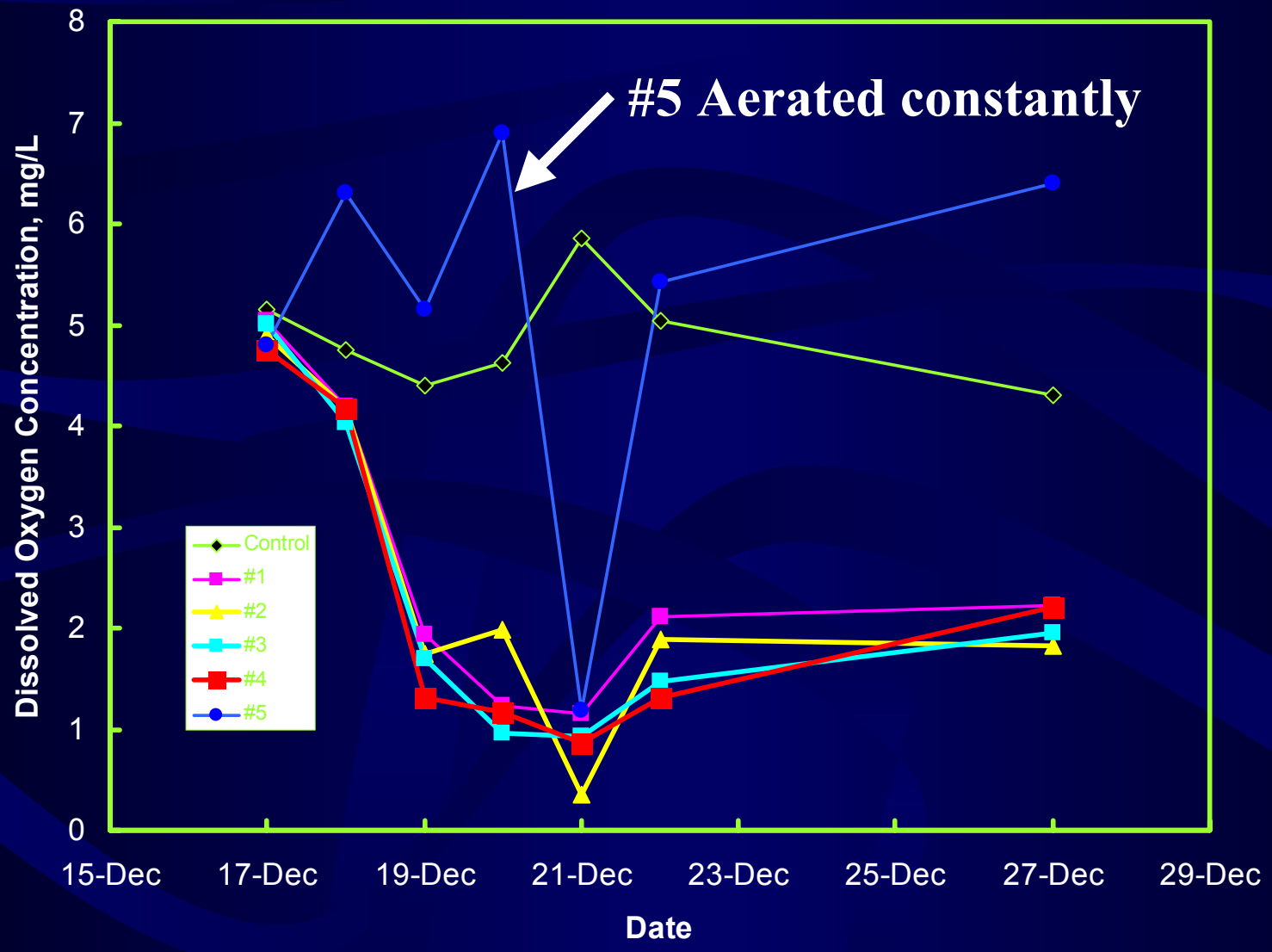
Close-up of Glucose Strips



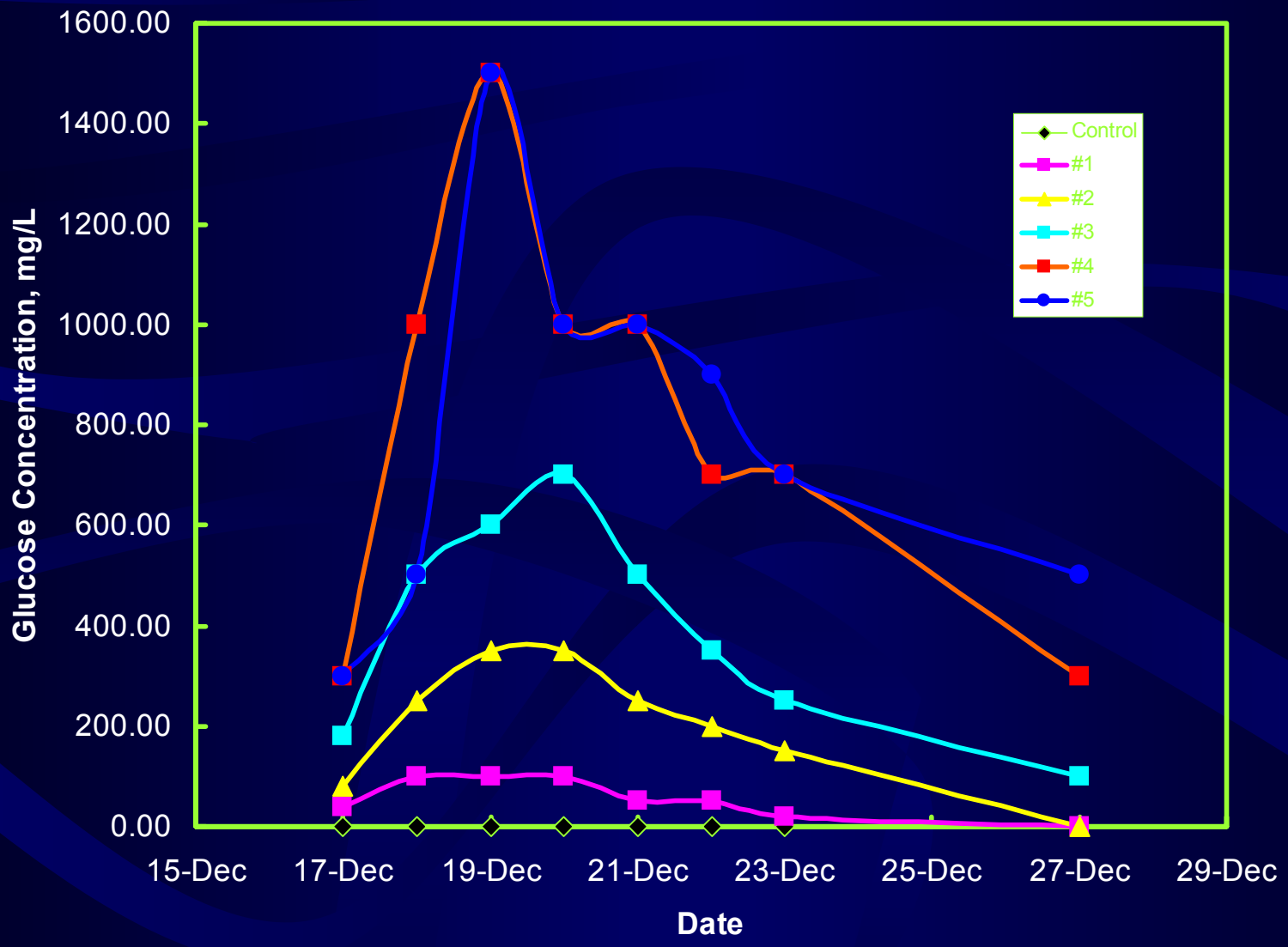
pH versus Time



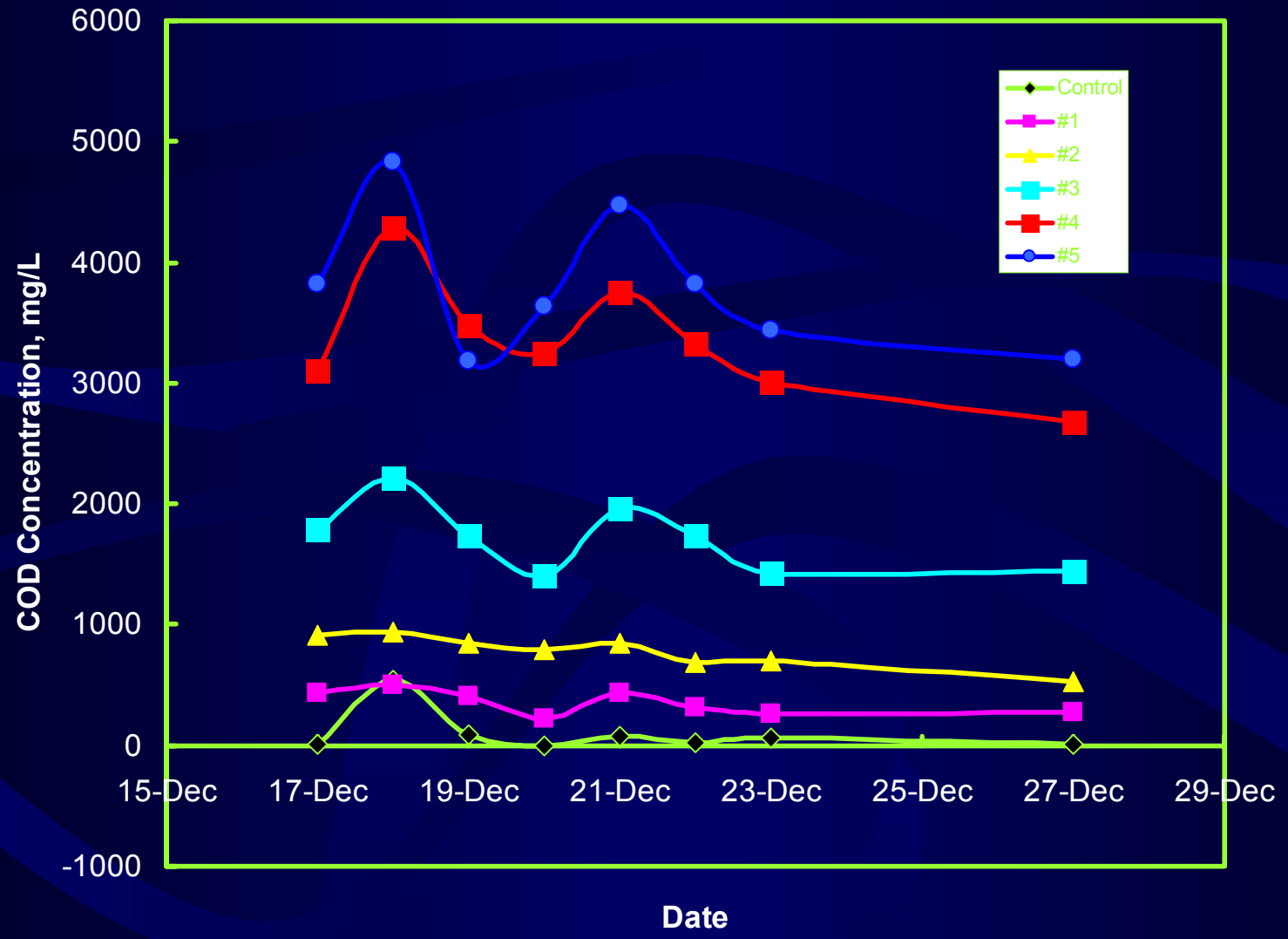
DO versus Time



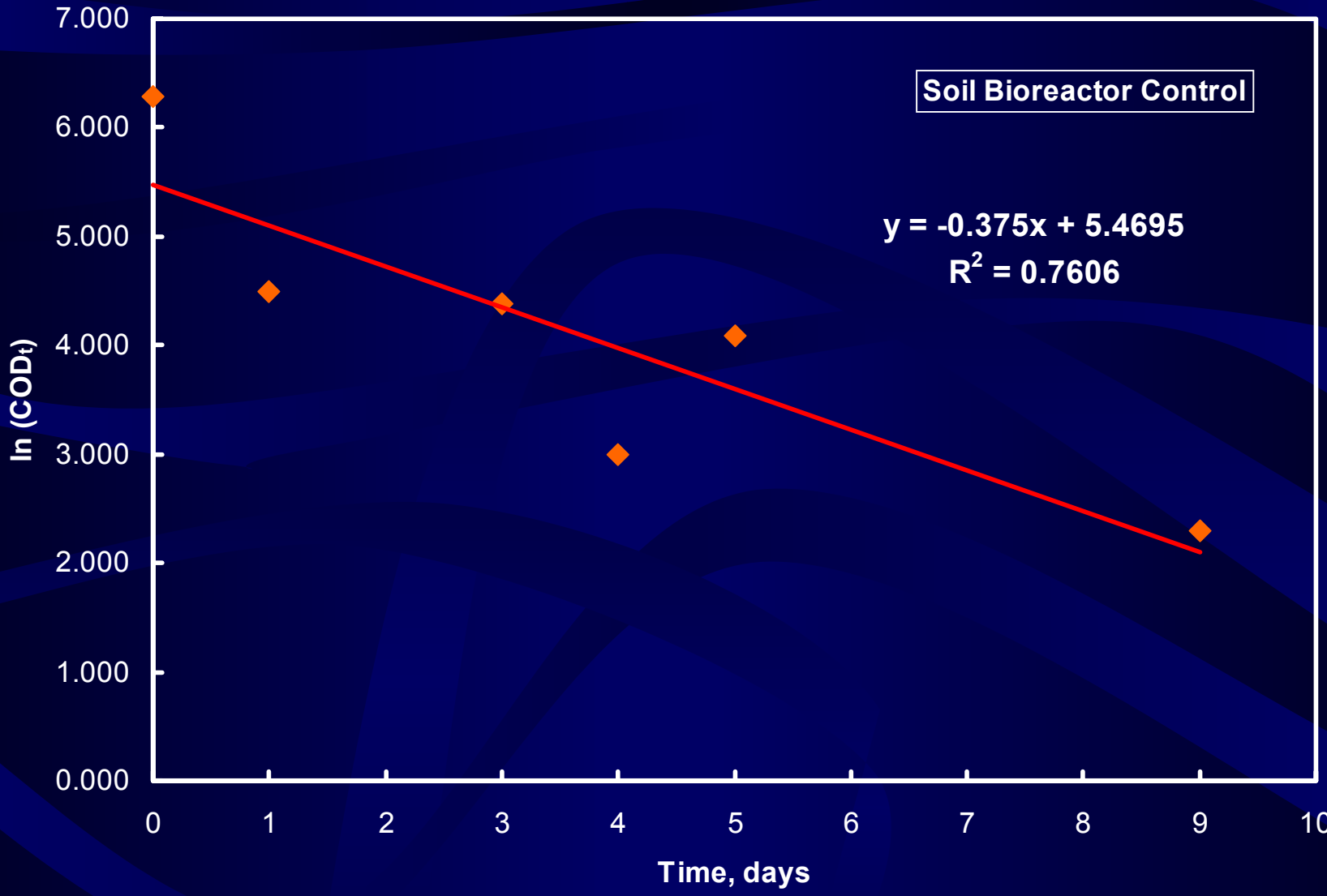
Glucose Concentration versus Time



COD Concentration versus Time



COD Degradation Coefficient Determination



COD Removal Rates

Control	#1	#2	#3	#4	#5
0.375	0.053	0.061	0.035	0.044	0.028

Conclusions

1. Glucose degradation occurred in soil bioreactors #1 - #5.

2. The pH of the supernatant decreased in each reactor due to the production of CO_2.

Conclusions continued

3. The DO concentration decreased in each reactor with exception to the control which averaged 4.9 mg/L. Each reactor was aerated for approximately 2 minutes each day.

4. Both the glucose and COD concentrations in the supernatant decreased during the monitoring period due to microbial utilization by the indigenous organisms in the soil.