COMPUTER SOFTWARE FOR ENVIRONMENTAL CHEMISTRY EDUCATION

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ENVIROLAND: AN INTERACTIVE COMPUTER TOOL FOR TEACHING ENVIRONMENTAL CHEMISTRY AND HYRDROLOGY

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Environmental chemistry and science is an interdisciplinary theme that is becoming increasingly popular at most colleges and universities. Courses that are commonly incorporated into an environmental chemistry curriculum include environmental chemistry, quantitative analysis, geochemistry, hydrogeology, solid and hazardous waste management, and the fate and transport of pollutants in the environment. However, the central underlying theme in this sequence of courses is usually chemistry, whether the environmental program is administered in a chemistry, geology, or an engineering department. Another, ever-increasing feature of chemical education is the availability and use of computers in classroom instruction. Although it is difficult to quantitatively assess the success of computers as teaching tools, most instructors believe that they increase student interest in a topic when informative, interactive software is available that can be easily integrated with the course material. Computer teaching tools should be more that a textbook on CD. They should be interactive in the sense that they require thoughtful input from the student, question the student, complement a broad range of environmental topics, and be versatile in their solution of numerical problems. These criteria were the basis for the development of EnviroLand.

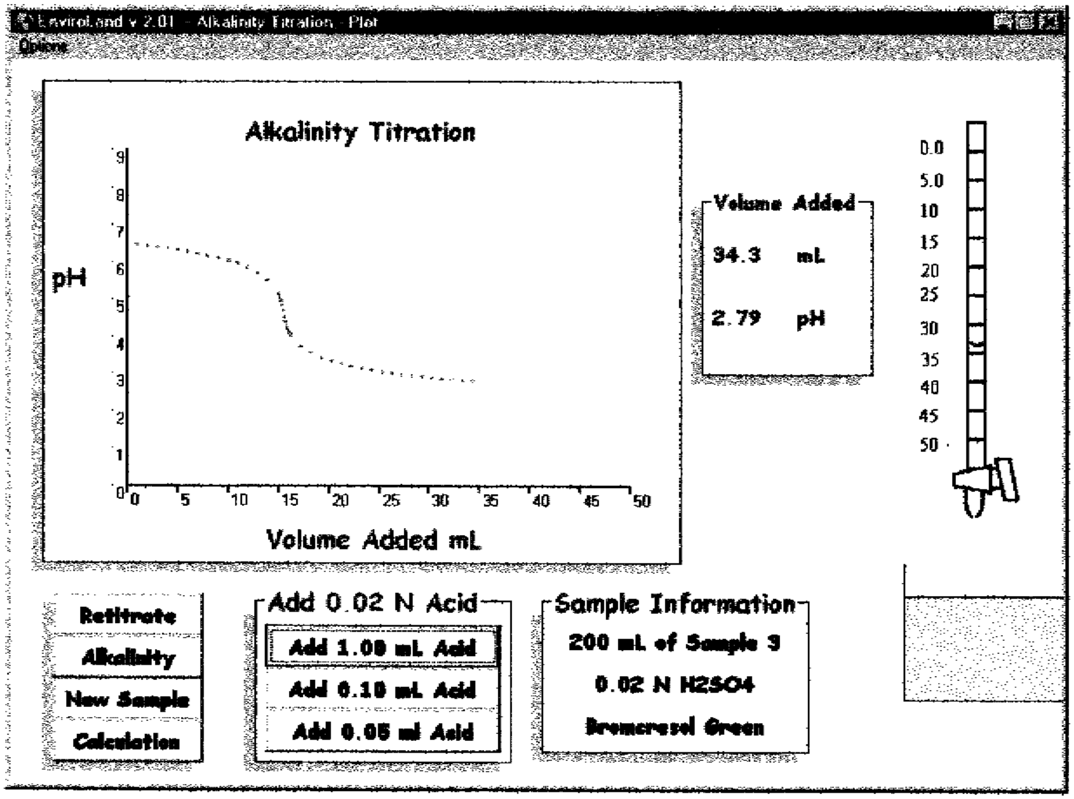
Description of Program

EnviroLand is a PC-based program written in Visual Basie 5.0 and operates under Microsoft Windows 95, 98, and NT. The current version of the program (V 2.01) needs 16 Mb of storage space, but this will be expanded to approximately 20 Mb when the program is finished in the fall of 1999. EnviroLand can be obtained (free-of-charge) at

http://hartwick.edu/~dunnivantf/frank.htm, http://www.hartwick.edu/envirsci/Enviro.htm, and http://whitman.edu/~dunnivfm. The program is designed for upper-level under-graduate courses in environmental chemistry, geochemistry, and hydrology. Many of the components are also relevant to graduate level environmental chemistry courses. The program is currently divided into three sections: Laboratory Experiments, Theoretical Calculations, and Fate and Transport Models. The Laboratory Experiments section includes simulations of alkalinity titrations, hardness titrations, dissolved oxygen determinations (titration and electrode methods), ion selective electrode determinations, and BOD determinations. The Theoretical Calculations section currently includes only a pC-pH diagram generator for acid-base systems, but will soon include a first-order decay calculator/plotter, and pC-pH diagrams for environmentally relevant systems. The Fate and Transport Modeling section contains mathematical routines for instantaneous pollutant releases to a river and lake, step pollutant releases to a river and lake, and the dissolved oxygen sag curve for a river (the Streeter-Phelps Curve). Information for these components was taken from Sawyer and McCarty (1978), Metcalf and Eddy (1991), and Snoeyink and Jenkins (1980). Each experiment, calculation, or model contains a background discussion explaining the theory behind the method, an example problem worked out in detail, and tables of relevant constants and conversion factors, and a set of homework problems.We are currently working on instantaneous and step pollutant releases for ground water systems.

Uses of EnviroLand: Laboratory Experiments

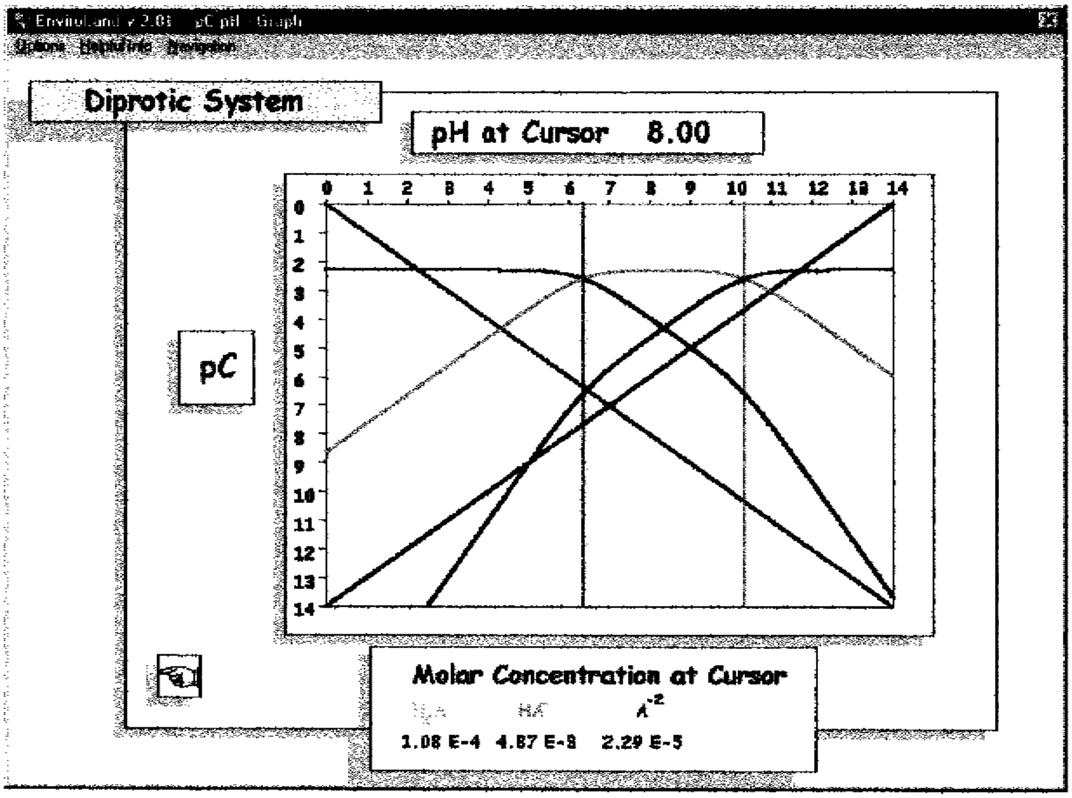
We have found that no matter how much detail a professor gives students in pre-lab instructions, they still ask "neophyte" questions such as "Which solution goes into the buret?" or "How do I convert mL of titrant into mg/L hardness?" These questions even come from the best students who you know read the procedures prior to coming to lab. One goal of EnviroLand is to minimize these types of questions and better prepare the student for the lab prior to their first titration. Prior to coming to lab, but after reading their per-lab instructions, the students are required to perform several titrations in EnviroLand. After performing these titrations they must answer a list of questions (included in EnviroLand) that are to be turned in at the beginning of lab. An example of an alkalinity simulation is shown below.



The goal of this simulation is to mimic the lab procedure as closely as is possible. This process includes selection of the sample, selection of the acid for titrant, addition of the indicator, step-by-step titration of the sample, a color change at the end-point, retitration of the sample if the end-point is overshot, and calculation of the alkalinity based on the titration data.

pC-pH Charts

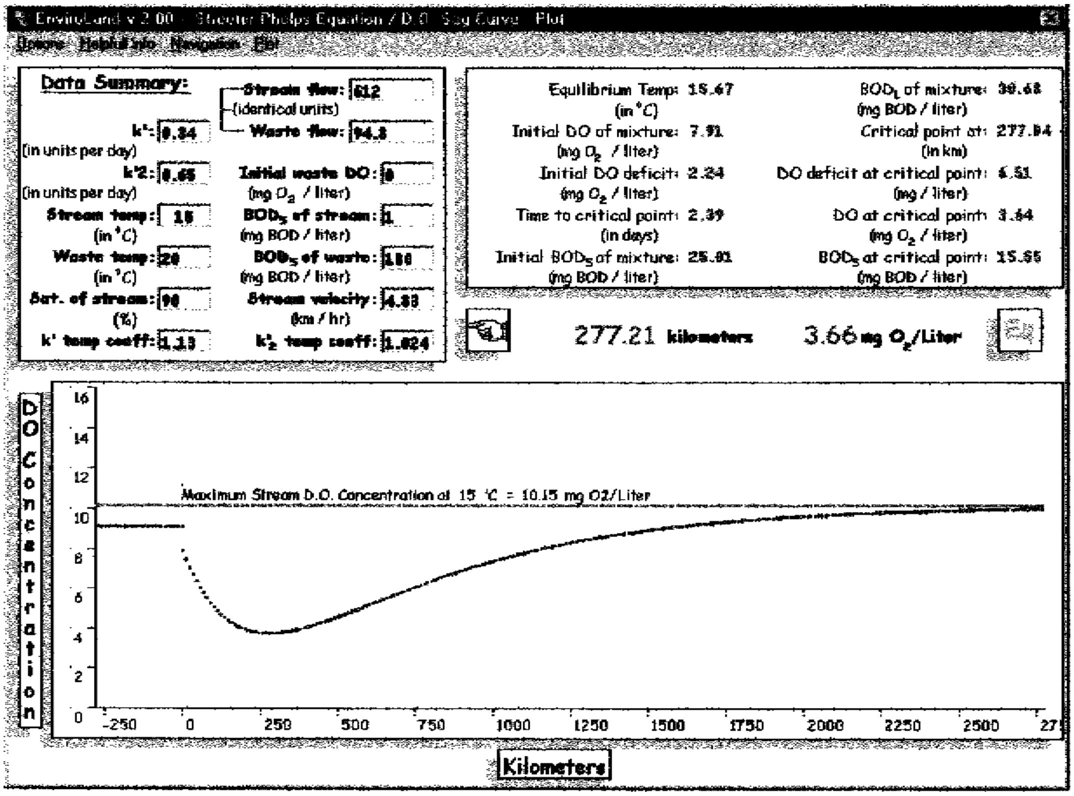
The pC-pH chart has gained notoriety for its use in describing speciation of the carbonate system, but it can be used to describe the species distribution of any conjugate acid-base system. Envirol-and is designed to draw pC-pH diagrams for monoprotic, diprotic, and triprotic systems. One important point should be made concerning the use of Envirol-and. The purpose of this component is to be used as a check for homework and to understand pC-pH diagrams. It is not a substitute for manually drawing these figures by the student (which is a common misconception by the students). So, in using this component, we first derive all of the equations for the pC-pH diagram (this is given in the background sections of the program), teach the student how to manually draw these figures, and then use Envirol-and to check their answers, An example pC-pH diagram for a 0.005 M (total) carbonate system is shown below.



By using the cursor the user can select the pH and the boxes along the bottom will display the concentrations of each species at this pH. In the figure above the cursor is set on 8.00 and the concentration of H_2CO_3 equals 1.8×10^{-4} M, HCO_3^- equals 4.87×10^{-3} M, and CO_{32-} equals 2.29×10^{-5} M.

Fate and Transport Models

Several fate and transport models have been completed in Envirol-and. The Streeter-Phelps dissolved oxygen sag curve will be used on as illustration. Again, it is important to not let EnviroLand take the place of manual calculations. In class, we first derive the equations based on a mass balance of a river system (this is given in the background section of EnviroLand) and work numerous problems manually. After the students thoroughly understand the theory behind these calculations we use Envirol-and to show relations between downstream dissolved oxygen concentrations and stream width, stream depth, water velocity, re-aeration coefficients, oxygen utilization rates, and input BOD concentration. An example of the dissolved oxygen sag curve is shown below.



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Sawyer, C.N. and P.L. McCarty. Chemistry for Environmental Engineering. (3d Edition) MaGraw-Hill Book Company, NY 1978.

Snoeyink, V.L. and D. Jenkins. Water Chemistry. John Wiley & Sons, NY 1980.