A Protocol for an Undergraduate Ecology Laboratory on Water Quality Impacts Utilizing Sealed Microcosms

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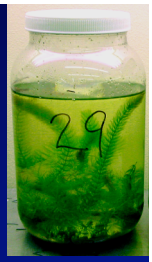
Lab Development Goals

- Increase student appreciation for important ecological concepts (in this case, trophic structure; biotic effects on abiotic conditions)
- Have a manipulative experimental laboratory that applies scientific techniques to ecology
- Demonstrate important anthropogenic impact(s) on ecosystems (in this case, water quality)
- Generate data appropriate for student analysis and interpretation, developing analytical and writing skills
- Minimize cost while maximizing lab safety, convenience, and simplicity
- Avoid using vertebrates (other than students)

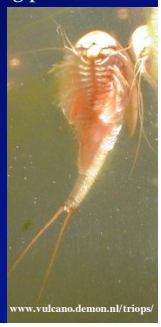
Aquatic Microcosms



- Can be constructed and maintained indoors as a semester-long project
- Can be established with a variety of freshwater biota
- Can be manipulated by additions of common household chemicals, yet can still simulate relevant impacts on aquatic ecosystems and water quality
- A variety of measurements are possible using inexpensive test kits and instruments
- Produces consistent and obvious results that reinforce concepts presented in lecture
- Complexity of lab protocol can be tailored to fit the students' achievement level

Microcosm Lab Biota

- **Pond water** (contains bacteria, phyto- and zooplankton
- **Hornwort** (*Ceratophyllium*) – a non-rooting plant that does well without sediments
- ***Daphnia magna*** – a 1° consumer of phytoplankton: *must* be acclimated to pond water before lab starts
- **Branchiopods (*Triops*)** – a 2° consumer of *Daphnia* (optional): will become more abundant during the experiment if hatched 10-14 days before lab starts
- **Snails** of several genera do well and reproduce
- **Planarians** – detritivorous species also do well, but should be acclimated to pond water *first*



Microcosm Lab Protocol

- Students examine last year's microcosms. Each student then cleans out one of last year's microcosms (*very* important!)
- Fill each 3.96-L PET bottle with 3 L of pond water
- Measure water quality parameters
- Weigh and add plants; count and add animals.
- Seal and maintain under light source for 5-6 weeks
- Measure water quality parameters, add bleach, fertilizer or sulfuric acid, repeat water quality measurements after treatments
- Seal and maintain under light source for another 5-6 weeks
- Measure water quality parameters; weigh plants and count animals

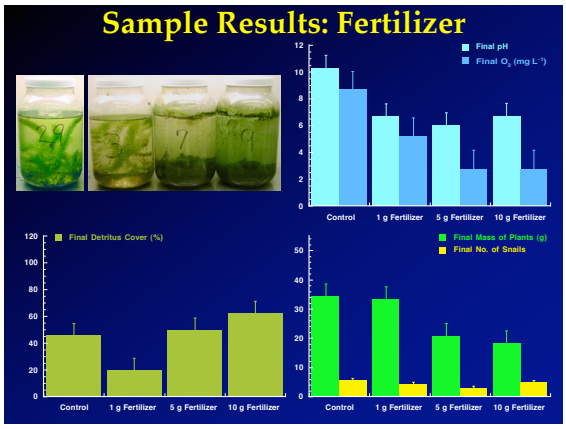
Measurements

- Measurements of nitrogen (ammonium, nitrite and nitrate) and free and total chlorine are made using test kits ('dip stick'-type kits are fast, simple, easy to read, non-hazardous, and sufficient for the range of values encountered)
- Measurements of conductivity, dissolved O_2, and pH are done with inexpensive meters (the latter two can also be measured with test kits)
- Wet mass of plants and counts of invertebrates
- Qualitative estimates of water color (ranging from clear through yellow to green or brown) and amount of detritus are also made

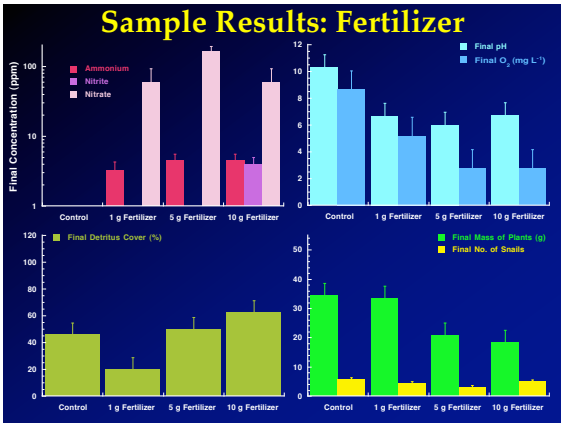
Microcosm Manipulations

- Successful manipulative experiments have been conducted that demonstrate:
- *Eutrophication* (inorganic fertilizer runoff) through additions of NPK fertilizer: 0.1, 1.0, and 10.0 g
- *Chlorine* (paper manufacture, chlorination of water supplies) through additions of chlorine bleach: (10 ppb, 1 ppm, 100 ppm buffered sodium hypochlorite)
- *Acid deposition* (combustion of fossil fuels) through additions of H_2SO_4 to reduce pH by 0.5, 1, and 2 pH units from the value at 5 or 6 weeks

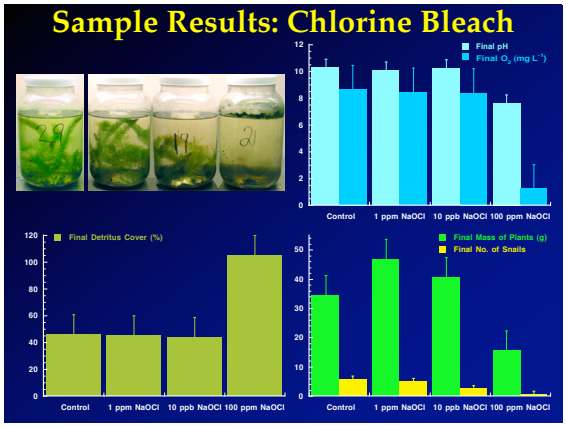
Sample Results: Fertilizer



Sample Results: Fertilizer



Sample Results: Chlorine Bleach



Analysis and Interpretation

- In the first class, we discuss the rationale for the experiments and the hypotheses to be tested
  - The students are given worksheets and the lab protocol
- We collect all data on a laptop during each of the three lab periods and distribute handouts showing graphical results at all steps
- We conduct the final statistical tests for differences in means or medians
  - We then share these with the students, and discuss the significance of the statistical outcomes
  - Where appropriate, we conduct post-hoc tests and guide the students through the process of determining which treatment means differ from the others
- The students then write up the experiment in the form of a short scientific paper

Possible Microcosm Variants

- Competition studies under pollution stress (or not) of different planarians, i.e., brown planarians (*Dugesia tigrina*), black planarians (*Dugesia dorotocephala*), and white planarians (*Procotyla fluviatilis*)
- Studies comparing water from two sites (reducing the number of variables manipulated to 1 or 2)
- Studies involving other common water pollutants, e.g., household pesticides and herbicides, motor oil, or gasoline
- Other organisms: amphipods (e.g., *Hyalella azteca*), aquatic oligochaetes (e.g., *Tubifex*)

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