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Biological Resources Engineering **FACTS**

FACTS 191
September 2000

Bringing a Systems Approach to the Classroom – Creating a Self-sustaining Crayfish Habitat

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In today's rapidly changing world, the public is becoming increasingly interested in and aware of the relationship between organisms and their environment. The role of ecology and ecosystem studies has a proven place in a scientifically conscious student's education. However, students tend to look at organisms as isolated elements. This project is intended to highlight the links between organisms and develop a systems approach to ecological relationships. The relationships that are created and maintained in this micro-ecosystem can be used as the basis for understanding how the environment is affected by these organisms including human beings.

In this experiment, students will work towards developing a self-sustaining habitat for a small number of crayfish. The micro-ecosystem will be made up of three living components; crayfish, aquatic plants, and bacteria. Their challenge will be to balance the system, providing enough food for the crayfish and maintaining healthy water quality.

Basic Ecology

Ecology is the study of the relationships between organisms and other components of the environment. In the ecosystem for crayfish to be created in this project, these relationships can be broken down into three components. Students should observe all of these components and try to balance the system in such a way that all of the components remain healthy.

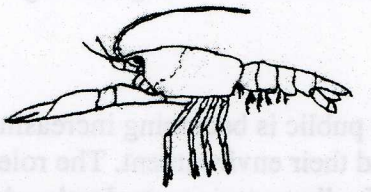
1. Macroscopic: The macroscopic component of the ecosystem consists of the plants and animals present within the environment. The environment in this case is a ten-gallon aquarium tank containing water.
2. Microscopic: The microscopic component consists of the algae and bacteria that are present in the water and in the tank in general. They are a vital component of the system

as they are responsible for the breaking down and recycling of waste products keeping the water safe for the crayfish.

3. Chemical: The chemical component of the tank refers to chemicals dissolved in the water and thus the water quality. These levels are monitored to ensure that the water in the tank is still safe for the crayfish. By using these tests effectively, one can observe how the organisms affect the environment and what reverse effect the environment has on the organism.

The Crayfish

Crayfish are freshwater crustaceans that are abundant on every continent except Antarctica. They tend to be smaller than lobsters but similar in appearance and anatomy. Crayfish require aquatic habitats but they are able to survive on dry land as long as their gills remain moist. In a favorable environment, crayfish have the potential to live three years or longer.



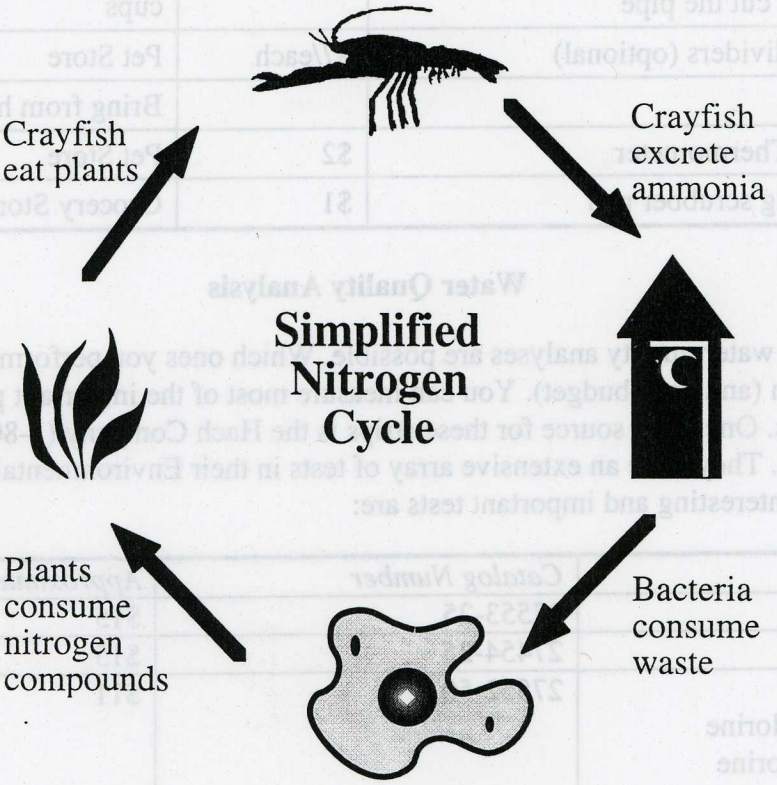
Crayfish tend to hide during the day and scavenge for food at night. They are very aggressive in nature, which leads to frequent fights and even cannibalism. When molting, a crayfish forms a vulnerable new exoskeleton and instinctively seeks cover in rocks and other hiding places during these times. Their omnivore diet can consist of submerged aquatic vegetation, emergent plants, small fish, snails, insect larvae, worms, and of course other crayfish. Crayfish in captivity should be provided with large quantities of high-protein plants.

The Nitrogen Cycle

Multiple educational benefits and concepts can be learned from this project. Learning the cyclic nature of the ecosystems is an important ecological concept that has multiple applications in education. The recycling and processing of nutrients and wastes within an ecosystem can teach the valuable lesson that every component of the environment depend on every other one. Examples of the nitrogen cycle and other cycles can be easily illustrated within an enclosed ecosystem such as the one being set up here.

The nitrogen cycle describes how the nutrient nitrogen is recycled through an ecosystem. In our system, crayfish eat plants and subsequently excrete waste that contains ammonia (NH_3) and organic nitrogen compounds. The organic nitrogen comes from waste products and decaying of plants and animals. The organic nitrogen is then broken down into inorganic nitrogen through a process called mineralization. The second step of the cycle consists of the inorganic nitrogen in the form of ammonia (NH_4^+) being converted to nitrite (NO_2^-) and then nitrate (NO_3^-) by a bacterially mediated process called nitrification. Nitrification is accomplished by bacteria in an ecosystem. The nitrite is further nitrified into nitrate (NO_3). Nitrate is then reabsorbed by plants, which use the nitrogen to synthesize proteins. One experiment, for example, is to track the

ammonia, nitrite and nitrate levels as they change (and eventually stabilize). This is a great example of the cycles that exist in any ecosystem. A simplified sketch of the nitrogen cycle is shown on the next page.



Suggested Materials

The materials that should be obtained prior to setting up the tank are listed below. Approximate prices (in US dollars for the year 2000) follow each item. The aquarium, aquarium dividers, gravel, plants, and animals can be purchased at local pet stores.

Item	*Cost*	*Source*
Ten-gallon glass aquarium tank	$20	Pet Store
Aquarium gravel (5 lb. bag)	$7	Pet Store
Several larger stones (>1" diameter)	free	Your Backyard
Crayfish (2 to 4)	$1/each	Carolina Biological Supply or a Pet Store

Dechlorination Chemicals	$5	Pet Store
Snail (1 to 6)	$1/each	Pet Store
Anacharis plants (1 bundle of 6 stalks per crayfish)	$2-3/bunch	Pet Store
PVC pipe (~1 1/2" diameter) and a Hacksaw to cut the pipe	free	use scrap or small plastic cups
Aquarium dividers (optional)	$7/each	Pet Store
Bucket		Bring from home
Aquarium Thermometer	$2	Pet Store
Dishwashing scrubber pad	$1	Grocery Store

Water Quality Analysis

A wide range of water quality analyses are possible. Which ones you perform are limited only by your imagination (and your budget). You can measure most of the important parameters using simple test strips. One good source for these strips is the Hach Company (1-800-227-HACH or www.hach.com). They have an extensive array of tests in their Environmental Education Catalog. Some interesting and important tests are:

Parameter	*Catalog Number*	*Approximate Cost*
Ammonia	27553-25	$15
Nitrate/Nitrite	27454-25	$15
5 in 1 Test: Total Chlorine Free Chlorine Total Hardness Total Alkalinity pH	27552-50	$11

Tank Set-up Guidelines

1. If the tank is not new, thoroughly wash it out with soap and water. A dish scrubber will make removal of the algae easier.

2. Pass tap water through the gravel for about ten minutes using a screen or pasta strainer. This will help to remove dust particles, impurities, and biological contaminants from the gravel.

3. Cover the bottom of the tank evenly with gravel to a depth of approximately 1".

4. Cut the PVC tubing into 4" sections using a hacksaw. Have at least one PVC section or cup per crayfish. These "houses" are essential in providing a safe haven for the crayfish when they are undergoing their vulnerable molting stage.

5. Place the "houses" in the tank strategically, allowing each crayfish to have a personal territory equally distant from the other crayfish.

6. If desired, add aquarium dividers to separate the crayfish territories permanently. These should definitely be used if there is a problem with cannibalism, but be warned that crayfish can also learn to climb the dividers.

7. Declorinate about 6 gallons of water. You can use water treatment chemicals from your local pet store or run the water through a water purifier (such as Brita). A greater volume of water allows for a slightly greater buffering capacity for wastes but beware: crayfish are escape artists and may be able to escape easily if the water level is high enough.

8. Add plants to the aquarium. Include about one bundle of 5-6 stalks per crayfish. Remember that there need to be enough plants that they can grow to replace the plant materials that are eaten. The plants can be kept in bundles for ease or may be placed separately as desired. Bury the root ends of the plants in the gravel and cover with several stones. This will help to prevent the crayfish from pulling up the plants.

9. Add crayfish to the system. The crayfish should be acclimated to the temperature of the water slowly to prevent shock. Don't let the change occur faster than 5-10°/hour. This can be done by mixing the water that they are kept in initially slowly with the water from the aquarium. Reducing the crayfishes' stress in the system is always important.

Experimental Data Gathering

Once the tank is set up, water quality should be tested on a regular basis to insure that the environment is safe and healthy for the organisms present. One of the traits of ecological systems is that they will "self organize." That is to say, if properly set up, over time the system will change and move towards a steady state. After the ecosystem is established and the bacteria and algae are properly recycling nutrients and breaking down wastes, this testing can be done on a less regular basis.

However, while the system is organizing itself, it is also the most fragile. It is during this time that testing should be done on a daily basis. After the ecosystem has established itself, testing can be done on a less regular basis is order to save money on expensive testing equipment. If the budget allows, more tests can be added and the students can examine different parameters that may contribute to crayfish health. Factors other than just the water should be recorded. Observing the crayfish can be an important indicator on the ecosystem is doing. Such observations as feeding habits and behavior can indicate the levels of certain water quality parameters. Doing research on the behavior of crayfish can give students the opportunity to apply theoretical knowledge to an actual experiment. To observe these changes, set up a log sheet for the tank. The ones that we use have columns for time of day, pH, ammonia, nitrite, nitrate, alkalinity, temperature, and animal and plant behavior.

- pH – pH levels should be maintained within the range of 6.7 to 8.5. (Lee and Wickins, 1992).

- Alkalinity – the alkalinity is related to pH and is determined by the concentration of carbonates dissolved in the water. In general, alkalinity measures the amount of calcium carbonate ($CaCO_3$) capable of neutralizing the acidity of the water (Lee and Wickins, 1992). For a desirable living environment, the alkalinity should remain between 40-200 mg/L $CaCO_3$. If the alkalinity is low, baking soda (calcium bicarbonate) can be added to the tank to increase the alkalinity. Calcium is used in the crayfishes' exoskeleton.

- Ammonia/Nitrite/Nitrate - the ammonia levels in the tank should remain below 1 mg/L. Ammonia is a result of waste excretions from the crayfish; the more they excrete the higher the ammonia concentrations. Ammonia can be tested using ammonia strips from Hach.

Another invaluable benefit is the hands on experience that can be had with a project such as this. Working with the chemicals and methods required for water testing and setting up the tank can be carried over into other projects and even other fields. Students will have the opportunity to approach complex projects in an organized scientific manner. Furthermore, the crayfish habitat provides a unique opportunity to combine several fields of science. Students can apply chemistry, biology, and design. Seeing how all of this works together will give student a chance to see how science in a real world setting can be more complex and interesting than science that is confined to a textbook.

Learning More

The following references are excellent sources for information on crayfish:

Frye, F. 1992. *Captive Invertebrates A guide to their Biology and Husbandry* Malabar, FL: Krieger Publishing Company.

Groves, R.E. 1985. *The crayfish: its nature and nurture*. Farnham, England: Fishing New Books Ltd.

Harrel, M. Regional Source. 1987. Crawfish Culture in Maryland, University of Maryland Sea Grant Extension Program, UM-SG-MAP-87-02. (Free)

Lee, D. and Wickens, J. 1972. *Crustacean Farming*, New York: Halston Press

http://bioag.byu.edu/mlbean/Crayfish/crayhome.htm

http://www.ceismc.gatech.edu/zooary/zoo/arthropods/crayfish.html

Acknowledgements

The authors would like to thank the spring, 2000 class of ENBE 484 for their assistance in the development of this document. We would especially like to thank Linda Rinko for providing some of the graphics.