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#07 Investigating a Sewage Lagoon

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INTRODUCTION

Description

Sewage lagoon systems for treatment of wastewater, also called total containment ponds, are becoming an attractive, cost-effective alternative for single residences and small communities. A sewage lagoon system in a residential or small institutional setting usually consists of two ponds and a wetland area. Sewage is pumped into the first pond, where settling and some decomposition take place. Water flows through a pipe into a second pond where further decomposition takes place. It then flows into a wetlands area. In very wet weather, the wetlands area discharges into a creek. Using kits such as those produced by Hach, CHEMets, and LaMotte, students can investigate various analytes such as dissolved oxygen, phosphates, ammonia, and nitrates. In addition, they can investigate conditions such as temperature and pH. By comparing differences among the three areas of the system and/or changes in the system over time, students can assess the condition, progression, and effectiveness of the system.

Students can investigate the various interrelationships that exist in a lagoon system. In such a system solids settle out and undergo anaerobic decomposition by acid and methane bacteria. The products of anaerobic decomposition are soluble in water and are used by aerobic bacteria and algae. Algae require sunlight, and when they thrive they produce free oxygen which is required by aerobic bacteria. When light is not available, such as when the surface is covered with duckweed, the algae do not produce oxygen. Aerobic bacteria in the surface layer use the free oxygen and feed on the soluble organic compounds in the raw waste as well as the soluble byproducts of the anaerobic decomposition. They in turn produce some sulfate, nitrate, phosphate and carbonate compounds which are used in the metabolism of the anaerobic bacteria. Thus complex interactions exist among the inorganic materials, organic materials, and living communities. Due to the complex and dynamic nature of the system, many possibilities exist for students to research various parameters influencing its effectiveness.

Student Audience

This experiment is suitable for college-level students. The complexity, depth, and duration of the experiment can vary greatly depending on the level of the course and the purpose of the experiment. The experiment can consist of as few as two lab sessions or be as extensive as a year-long ongoing project for a group of students. This project could also be adapted for inquiry into an ordinary pond suitable for high school or college students.

Goals for the Experiment/Activity

Students will:

- Research background information pertaining to their chosen topics.
- Investigate at least one analyte/parameter/question relating to chemical/biological conditions or changes in the pond system.
- Form hypotheses.

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- Design experiments to test their hypotheses.
- Carry out the experiments they have designed.
- Draw conclusions based on data collected.
- Exchange results with the rest of the class.

Recommended Placement in the Curriculum

This experiment is suitable for a chemistry, biology, or environmental science class. It can also be used as a special project assignment.

STUDENT HANDOUT

Investigating a Sewage Lagoon

Purpose

The purpose of this lab is to investigate some aspect of the chemistry or biological-chemical relationships that occur in a small sewage lagoon system.

Scenario/Industrial Applications

Sewage lagoon systems for treatment of wastewater, also called total containment ponds, are becoming an attractive, cost-effective alternative for single residences and small communities. The system often consists of two ponds and a wetlands area. The first pond or primary cell receives sewage that has been put through a grinder or a septic tank. Solids settle out and some decomposition occurs. From there the water flows by pipe into a second pond where further decomposition takes place. Finally the water flows into a wetlands area.

The chemistry and biochemistry are complex and involve many interrelationships among living and non-living components of the ponds. The success of the system as a treatment facility depends upon the activity and interaction of these components. In this lab you will investigate some aspect of these interrelationships and determine if the sewage treatment is effective.

Safety and Disposal of Materials

Gloves, face shield, and protective apron should be worn while sampling and testing water. Follow any additional safety guidelines given with manufacturer's test kits.

Follow kit manufacturer's instructions and local ordinances when disposing of used reagents.

Materials Needed

- reference materials (see listing at end)
- field test kits, available from Hach, CHEMets, or LaMotte
- sampling equipment, if not provided in test kit
- gloves, face shield, and protective apron

Procedure

I. Choose some chemical and biological interactions to investigate and research background information. Resources such as environmental chemistry texts, limnology texts, and Environmental Protection Agency materials will be provided for you as a starting point. You should also do some additional research in the library. Listed below are some possible aspects of pond biochemistry to consider:

1. What kinds of bacteria attack solids that settle to the bottom of a pond? What are some of the products of such decomposition?

2. What kinds of organisms use products of anaerobic decomposition in water?

3. What happens when algae grow near the surface of the pond? What happens when the surface of the water is covered with duckweed?

4. How do aerobic bacteria use soluble organic compounds in the waste?

5. How does the content and form of nitrogen (organic, ammonia, nitrites, nitrates) relate to the extent of pollution? What organisms bring about changes from one form to another?

6. How do phosphates, sulfates, or carbonates relate to the extent of pollution?

7. How does temperature affect pond life and processes?

8. How does pH affect pond life and processes?

9. What is the role of dissolved oxygen in the life of a pond? What changes occur if the level drops below a certain minimum?

10. How does the amount of suspended solids relate to the extent of pollution of a pond?

II. Once you have some background information, you should consider at least one aspect of this system that you can investigate directly. Some possible questions that you could research:

1. How do the three ponds compare in levels of (a) dissolved oxygen, (b) suspended solids, or (c) ammonia nitrogen?

2. How do different sample sites within each pond compare?

3. How do results compare when using different methods? For example, how do values for dissolved oxygen using a probe (if available) and a field test kit vary? Do pH meter values agree with indicator test paper?

4. How does pond chemistry change after a large rainfall?

5. How does pond chemistry change after a sudden change in temperature?

6. How is pond chemistry changing from year to year? (Compare your data with previous classes.)

7. Describe the relationship between pond chemistry and aquatic life. Choose a chemical analyte and a life form.

III. Form one or more hypotheses. Once you have chosen one or more topics, state your prediction about the expected results.

IV. Design your experiment. Consider the materials you have available and the time you will have to conduct the research. Discuss your plan with your instructor.

V. Research. Collect and carefully record your data in a notebook. Remember to follow safety guidelines. Also remember to follow manufacturer’s test kit instructions and any additional instructions given by your instructor.

VI. Draw conclusions based on your data. Suggest possible ramifications of your results.

VII. Prepare a presentation of your research and findings to present to your class.

Suggested Reading

Eckblad, James W. “Laboratory Manual of Aquatic Biology”; Brown: Dubuque, 1978.

Lind, O.T. “Handbook of Common Methods in Limnology”; Mosby: St. Louis, 1979. (Or other limnology textbooks)

Mitsch, W.J.; Gosselink, J.G. “Wetlands”; VanNostrand Reinhold: New York, 1993.

Wrigley, T.J. *Water Research*. **1990**, 83.

Zickefoose, C.; Hayes, R.B. “Stabilization Ponds”. U.S. Environmental Protection Agency: Washington, D.C., 1977.

INSTRUCTOR NOTES

Investigating a Sewage Lagoon

Time Required

Time required will vary widely since the experiment is open-ended. In-class time needed for field work could be as little as one 2-3 hour lab period. Literature research, hypothesis formation, experimental designing, and analyzing data could be done outside of class. An additional lab period is needed for presentation of results; exact amount of time depends on class size and extent of student research. This project also lends itself to individual research, in which case class time only needs to be given for introduction and presentations. The instructor should be available to students to discuss experimental design individually.

Group Size

Individual or teams of 2-4 are recommended.

Safety, Handling, and Disposal

Gloves, face shields, and lab aprons or protective clothing should be worn. Any additional safety guidelines outlined by the particular manufacturer of test kits should be followed. When disposing of used reagents, manufacturer's instructions and local ordinances should be followed.

Points to Cover in the Pre-Lab Discussion

- Discuss safety precautions and disposal of used reagents.
- Before beginning this experiment, students should be familiar with the scientific method. Emphasize student's use of the scientific method in this research and the importance of each stage of research.
- Emphasize the importance of detailed record keeping of data and observations.
- Remind students to consider the available time and materials when choosing their topic.
- Discuss appropriate sampling techniques.
- Go over manufacturer's instructions for various test kits students will be using. Point out the importance of following instructions exactly and avoiding contamination.

Procedural Tips and Suggestions

- Be prepared to discuss with each student or group, on an individual basis, the scope of the experimental design.
- In planning for an entire class, be aware that some chemical tests will need to be done immediately in the field, while others can be done in the laboratory.
- Set the tone for presentations by discussing the importance of scientists presenting their findings clearly.
- Discuss some of the EPA regulations and monitoring as they apply to wastewater.

Sample Results

The following research was done as part of a baseline study of a recently implemented lagoon system. The research was conducted by a college-level environmental science student.

Hypothesis: The quality of water (as defined by EPA regulations) processed through the constructed wetland wastewater treatment system improves from one pond to the next.

Methods: Analysis of water consisted of dissolved oxygen, phosphate, ammonia, nitrate, and pH. Water samples were taken from the shoreline in small collection bottles, from each end of each pond.

Data:

Sampling Site	DO in mg/L	Phosphate in mg/L	Ammonia in mg/L	Nitrate in mg/L	pH
Intake end of pond 1	6	5.0	1.0	1.5	7.5
Outflow end of pond 1	1	5.0	1.0	1.5	7.0
Intake end of pond 2	10	0.5	0.5	0.5	8.0
Outflow end of pond 2	5	0.0	0.5	0.5	8.0
Intake end of wetlands	6	0.0	0.5	0.5	8.0
Outflow end of wetlands	5	0.0	0.5	0.5	8.0

Discussion of Results (in part):

The hypothesis is generally supported; water quality does improve from one pond to the next. First, the dissolved oxygen increased from pond one to pond two, but decreased by pond three, indicating a decrease in organic material present. The system passes the EPA requirement of 5.0 mg/L minimum for any discharge into public waters. Higher levels of phosphate in pond one indicate decomposition of organic material. Ammonia nitrogen decreases from pond to pond, indicating the level of pollution is decreasing. However, the level of nitrate decreases also so more tests should be done to determine the extent of nitrification. Since incoming sewage is normally 6.8- 7.6, and pH of 8 or greater is desirable for healthy pond activity, this system is improving in quality from pond one to ponds two and three.

References

Eckblad, James W. “Laboratory Manual of Aquatic Biology”; Brown: Dubuque, 1978.

Lind, O.T. “Handbook of Common Methods in Limnology”; Mosby: St. Louis, 1979. (Or other limnology textbooks)

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