# Demonstrating the Treatment of Sewage

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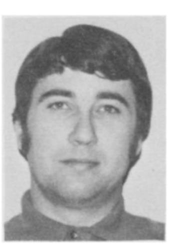
TEACHERS ARE INCREASINGLY called upon to inform their students about the most recent technologic means of improving the quality of the environment. One environment-sustaining task that has undergone important technologic change is sewage treatment. This paper tells how two recent advances in sewage treatment can be demonstrated in the high-school or college biology laboratory.

## *Primary and Secondary Treatment*

Most sewage-treatment plants provide primary and secondary treatment. Primary treatment is the removal of solids; secondary treatment is the removal of organic matter from solution. Primary treatment usually is done by allowing the raw sewage to settle in a large tank and, later, scraping the bottom to remove the precipitate, called sludge. Secondary treatment usually is accomplished mainly with the use of aerobic microorganisms. Generally, one of two methods is used: filtration ("trickling-filter" method) or aeration. In a trickling-filter system large rotary distributor-arms spray the liquid sewage over a bed of stones. As the liquid trickles over and between the stones bacteria and protozoans, as well as worms, flies, spiders, and other small creatures, ingest the nutrients. Thus they effectively break down large compounds into smaller ones (M. A. Bernarde, 1970: *Our Precarious Habitat,* W. W. Norton & Co., New York; p. 115–130).

During the breakdown process the organisms require large amounts of oxygen. The aeration method makes use of tanks that pump-in large quantities of oxygen, which keeps the organisms quite active. This high concentration of oxygen supports a very large population of organisms.



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## *Two Innovations*

Recently, two new methods have been used in primary and secondary treatment. In some sewage plants alum, ferric chloride, and calcium hydroxide are added during the primary process. This initiates the removal of solids and phosphates by flocculation. After the floc settled, most of the solids, along with the phosphates, have sunk to the bottom. The liquid is then passed through a filter and pumped through a column of activated carbon (charcoal). The carbon adsorbs the greater part of the organic matter—the nitrogen compounds; nitrogen in the form of ammonia, however, is not adsorbed.

These two techniques can be simulated in the high-school or college biology or chemistry lab. Different amounts of chemicals and activated carbon can be used to determine which concentrations are most effective. From the standpoint of laboratory time it is better to demonstrate the two processes separately. The students should work in pairs or small teams.

## *Removal of Nitrates*

To demonstrate the removal of nitrates from liquid sewage by the use of activated carbon the following materials are needed by each pair or team:

| *Code* | *Item* | *Amount* |
|---|---|---|
| *1* | Beakers, 100-ml | 2 |
| *2* | Beakers, 50-ml | 2 |
| *3* | Funnel | 1 |
| *4* | Funnel support | 1 |
| *5* | Stirring rod | 1 |
| *6* | Activated carbon, powdered | 1.4 g |
| *7* | Artificial sewage | 100 ml |
| *8* | Nitrate-test kit or colorimeter | 1 |
| *9* | Filter paper, sheets | 2 |

Here the artificial sewage—enough for the class, in teams of four—consists of 1 cg $KH_2PO_4$ + 5 mg gelatin + 1 cg $KNO_3$ + 1 l $H_2O$. I use Hach nitrate-test kits and Hach DC–DR colorimeters. A colorimeter is an instrument for determining concentrations of chemical substances in a liquid by their comparative absorption of light. On the Hach instrument the concentrations can be read directly in parts per million.

The laboratory procedure is as follows:

Obtain a small sample of artificial sewage and determine the nitrate concentration, in parts per million, with the test kit or the colorimeter. Fill the two large beakers *(1)* with 50 ml, each, of artificial sewage. Label the beakers "1" and "2." To beaker 1 add 0.4 g of activated carbon. To beaker 2 add 1 g of activated carbon. Stir both solutions vigorously for 2 min, then less vigorously for 5 min. Allow both solutions to stand for 5 min; then filter the supernatants through filter paper and collect them in the smaller beakers *(2)*. Determine the new nitrate concentration in both solutions with the test kit or the colorimeter. Compare the new concentrations with the initial concentrations.

It is doubtful that this procedure would work with real sewage, which contains a lot of "garbage" other than nitrates to adsorb to the charcoal. For this reason the laboratory use of artificial sewage is recommended.

### *Removal of Phosphates*

To determine the amount of phosphates removed from artificial sewage the following materials are needed by each pair or team:

| *Code* | *Item* | *Amount* |
|---|---|---|
| *1* | Beakers, 600-ml | 2 |
| *2* | Beakers, 150-ml | 2 |
| *3* | Funnel | 1 |
| *4* | Funnel support | 1 |
| *5* | Filter paper, sheets | 2 |
| *6* | Alum solution, 12.5 g/l | 10 ml |
| *7* | Alum solution, 5 g/l | 10 ml |
| *8* | $FeCl_2$ solution, 7.5 g/l | 10 ml |
| *9* | $FeCl_2$ solution, 2.5 g/l | 10 ml |
| *10* | $Ca(OH)_2$ solution, 20 g/l | 10 ml |
| *11* | $Ca(OH)_2$ solution, 7.5 g/l | 10 ml |
| *12* | Artificial sewage | 940 ml |
| *13* | Phosphate-test kit or colorimeter | 1 |

In this case the artificial sewage—enough for the class, in teams of four—consists of 10 cg $KH_2PO_4$ + 10 cg gelatin + 10 cg $KNO_3$ + 9.0 l $H_2O$. I use a Hach colorimeter.

Proceed as follows:

Obtain a small sample of artificial sewage. Determine the phosphate content, in parts per million, with the test kit or the colorimeter. In each of the large beakers *(1)* place 470 ml of artificial sewage and label the beakers "1" and "2." To beaker 1 add 10 ml alum *(6)*, 10 ml $FeCl_2$ *(8)*, and 10 ml $Ca(OH)_2$ *(10)*. To beaker 2 add 10 ml alum *(7)*, 10 ml $FeCl_2$ *(9)*, and 10 ml $Ca(OH)_2$ *(11)*. Stir both solutions vigorously for 1 min, then slowly for 2–3 min. Let both solutions stand for 5 min. Filter the supernatants and collect them in the small beakers *(2)*. Determine the new phosphate concentration in each beaker with the test kit or the colorimeter. Compare the new concentrations with the initial concentrations.

### *Variants and Questions*

Two different concentrations of chemicals are used in the demonstrations, to demonstrate the effectiveness of each concentration. This range could be increased to give more diversity to the tests of effectiveness.

One could change the artificial-sewage formulas to incorporate actual detergents; different kinds could be used and the results compared. The amount of phosphates present before and after treatment could be demonstrated.

Both of these laboratory investigations raise some rather important questions about sewage. Students may ask: Why is it necessary to remove phosphates and nitrates? How do phosphates and nitrates get into sewage? What happens to phosphates and nitrates that are tied up with the added compounds and the charcoal? What kind of sewage treatment does our city have? What kinds of problems might be encountered at our treatment plant in trying to implement these methods? How might one proceed toward implementing them? Some of these questions imply that the time to get involved in environmental issues is now.

## *Metabolic Rates . . .* **from p. 269**

KIMBROUGH, T. D., and G. C. LLEWELLYN. 1972. *An analysis of human function: laboratory guide and handbook.* Kendall/Hunt Division, William C. Brown Co., Publishing Co., Dubuque, Iowa.

LEVEDAHL, B. H., and A. A. BARBER. 1963. *Zoethout's laboratory experiments in physiology,* 6th ed. C. V. Mosby Co., St. Louis. P. 137-141.

MARSTON, J. H., and M. C. CHANG. 1965. The breeding, management and reproductive physiology of the Mongolian gerbil. *Laboratory Animal Care* 15(1):34.

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## Views on Compulsory Education

Teachers' views on compulsory education were obtained in a recent poll by *Scholastic Teacher.* Among secondary-school teachers 33% favored decreasing the number of years a child must stay in school, but only 18% of elementary-school teachers agreed. 15% of elementary teachers and 25% of secondary teachers favored abolishing compulsory education; 67% of elementary teachers and 42% of secondary teachers favored leaving compulsory-education laws as they are. When asked what might happen to school attendance if compulsory education were abolished, 20% of the teachers said they expected a sharp decrease, 54% expected a slight decrease, 23% expected no decrease, and 3% expected an increase.