CARBON TREATMENT FOR WATER POLLUTION CONTROL

9-12

OBJECTIVES

The student will do the following:

1. Describe different types of carbon.
2. Determine which type of carbon is most effective for removing organic pollutants.
3. Explain how carbon removes organic pollutants from water.

SUBJECTS:
Science (Chemistry, Ecology)

TIME:
1 class period

MATERIALS:
pulverized coal
activated charcoal(carbon)
charcoal (ground)
food coloring
16 capped containers
color pencils

BACKGROUND INFORMATION

Granular activated carbon selectively removes soluble organics from water or wastewater by adsorption of these molecules to the carbon particle surfaces. Granulated carbon has an extremely large surface area per unit weight (approximately 1000 m^2/gram) due to the many pores within the carbon particles and the vast areas of the walls within these pores.

In aqueous environments, carbon has a preference for large molecules and for substances nonpolar in nature. The forces of attraction between the carbon and adsorbed organic molecules are greater the closer the molecules are to the size of the pores in the carbon.

Carbon is used in multimedia filters in drinking water treatment plants to remove organics, in carbon columns for treatment or advanced treatment of wastewater, and in the powder form (powdered activated carbon or PAC) in biological treatment plants to remove the organics where treatment organisms may be slow or unable to remove them.

Carbon treatment has advantages and disadvantages. It is very effective for pollutants of a large or complex molecular structure (pesticides, color, ringed organics, branched organics). It is ineffective for most simple organics (formaldehyde, simple alcohols). However, it requires regeneration (usually by burning off adsorbed organics), which is very expensive, is sophisticated to operate, and may have unforeseen side results as production of sulfides or odorous chemicals. Carbon beds may also become plugged. With its positives and negatives, however, carbon adsorption is often the treatment of choice if treatment needs and surrounding circumstances are appropriate.

Terms

activated carbon (charcoal): material made from coal by driving off hydrocarbons under intense heat without oxygen, leaving a tremendous surface area on which many chemicals can be adsorbed

adsorption: phenomenon by which molecules in a fluid phase are attracted to a solid surface (e.g., activated carbon) and are held there by physical or weak chemical bonds

aqueous: of, pertaining to, or dissolved in water

biological treatment: treatment of wastewater using microorganisms to decompose undesirable organic compounds in an aqueous waste stream

carbon column: compressed activated carbon in a tube; used for adsorption processes

filtration: the process of passing a liquid or gas through a porous article or mass (e.g., paper, sand, gravel, membrane) to separate out matter in suspension; used in both wastewater and drinking water treatment

multimedia filters: filters that contain more than one type of filtering material

nonpolar molecule: covalent molecule that does not exhibit any partial (+) or (-) charges or fields

organic molecule: any molecule that contains carbon and hydrogen

polar molecule: covalent molecule that has a partial (+) and partial (-) end

regeneration: the process of being renewed or reconstituted

PROCEDURE

I. Setting the stage

A. Have three types of carbon in class - pulverized coal, ground up activated charcoal (sold with aquarium supplies), and ground charcoal.

B. Mix different solutions of different food coloring (red, yellow, green, and blue). Record what colors were used for each mixture on Data Sheet. (If 4 mixtures are made, 16 capped containers will be needed.)

II. Activity

A. Add equal amounts of each color to three capped containers with equal amounts of carbon in each (each color mixture having one of each carbon source).

B. Shake each of the containers thoroughly mixing the carbon sources and food coloring.

C. Observe, record, and compare the color of each solution after settling or filtering to the color of the original food coloring solution in the containers without carbon. Use coloring pencils to indicate the results.

III. Follow-up

A. What happened to the food coloring? This same thing happens to some types of pollutants in an actual application.

B. Were certain colors removed better than others? Why?

C. Determine the clarity of each of the food colors. What does this tell you about the chemistry of each of the food colorings?

D. What does this tell you about matching carbon pore size to the molecular pollutant to be removed?

E. Find out how many acres (approximately 1000 m^2/gram) of surface area one pound of activated charcoal has.

IV. Extensions

A. Call the local water and wastewater treatment facilities to see if they use activated carbon in their plants. Find out what pollutants they are removing.

B. Locate the source (sources) of organic pollutants in water in the area. Discuss means of reducing these pollutants.

C. Try the same process with non-organic dyes.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Culp, R.L. and G.L. Culp, Advanced Wastewater Treatment, Van Nostrand Reinhold Company, 1971, pp.133-140.

Cunningham, William P. and Barbara Woodworth Saigo, Environmental Science: A Global Concern, Wm. C. Brown Publishers, Dubuque, IA, 1997.

EPA Facts About Activated Carbon Treatment, June 1992.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Data Sheet

Colors Used

Mixture 1 -

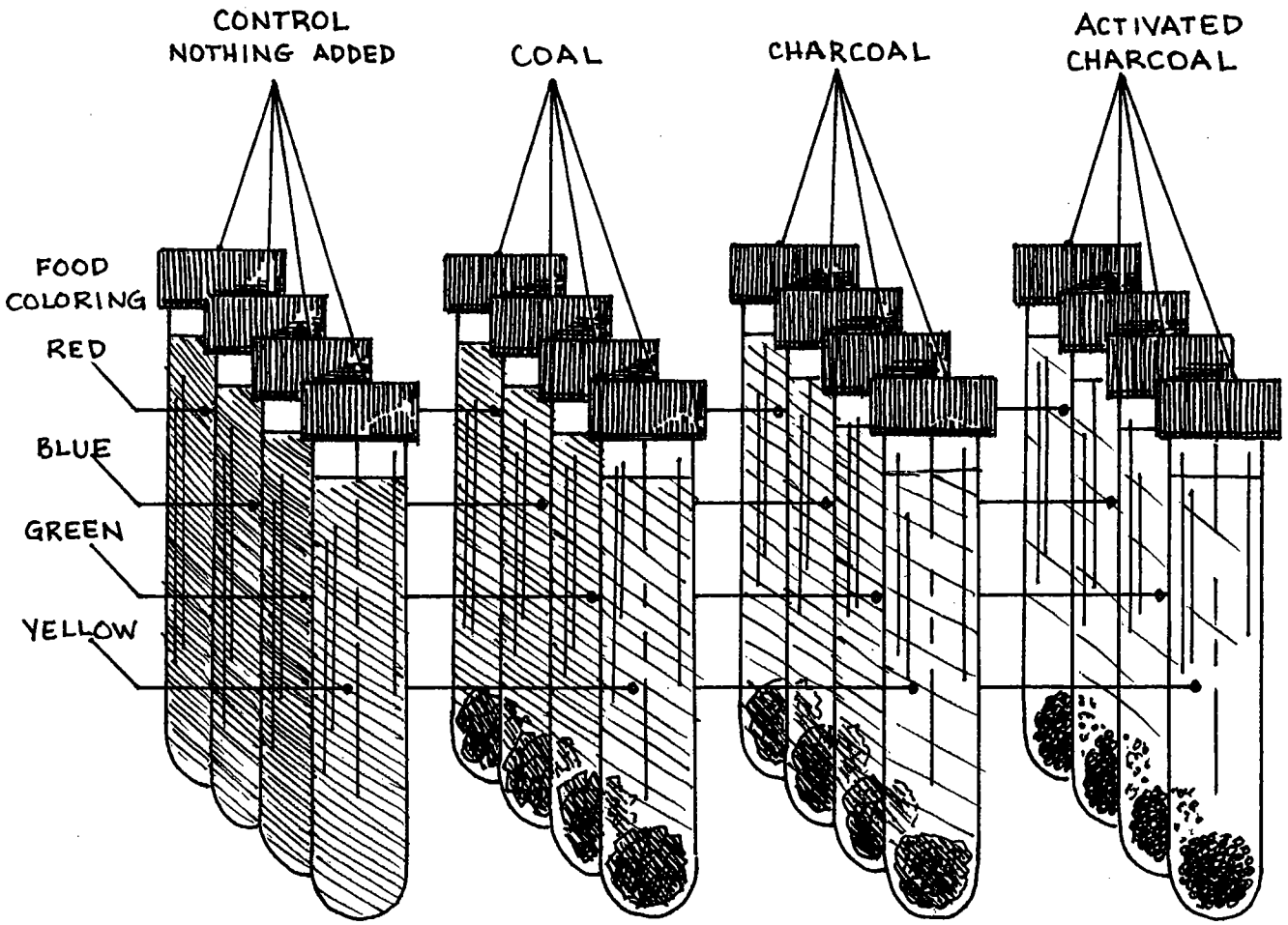
Mixture 2 -

Mixture 3 -

Mixture 4 -

Change in Color

	Pulverized Coal	Activated Charcoal	Ground Charcoal
Mixture 1			
Mixture 2			
Mixture 3			
Mixture 4			


CONTROL
NOTHING ADDED
COAL
CHARCOAL
ACTIVATED
CHARCOAL
FOOD
COLORING
RED
BLUE
GREEN
YELLOW