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LESSON:

Coco Locomotion

Summary: Students read a brief description about the use of coconuts to produce biodiesel fuel. Then they calculate the quantity of greenhouse gas emissions and cost differences of different types of automobiles and fuels.

EHP Article: "Coco Locomotion," *EHP Student Edition*, April 2005, p. A27
http://ehp.niehs.nih.gov/docs/2005/113-1/forum.html#beat

Objectives: By the end of this lesson, students should be able to:

1. calculate and compare greenhouse gas emissions for different vehicles and fuels,
2. convert liters/100 kilometers to miles/gallon,
3. calculate the annual cost of fuel for different vehicles and fuels.

Class Time: 20–30 minutes for math sections only, add 30–40 minutes if students answer the Research/Extension Questions

Grade Level: 9–12

Subjects Addressed: All sciences, Math

Prepping the Lesson (10–15 minutes)

INSTRUCTIONS:

1. Obtain a class set of *EHP Student Edition*, April 2005, or download the article at http://ehp.niehs.nih.gov/docs/2005/113-1/forum.html#beat.
2. Make copies of the student instructions.
3. If you want the students to answer the Research/Extension Questions, you may want to share the Resources section of this lesson and/or have students conduct their own research to answer the questions.

MATERIALS (per student):

- 1 copy of *EHP Student Edition*, April 2005, or 1 copy of "Coco Locomotion"
- 1 copy of student instructions

VOCABULARY:

Biodiesel, Petrodiesel

RESOURCES:

Environmental Heath Perspectives, Environews by Topic page. Choose International Environmental Health, Transportation and Fuels, http://ehp.niehs.nih.gov/topic

Adverse Health Effects of Exposure to Ambient Carbon Monoxide, http://www.airinfonow.org/pdf/CARBON%20MONOXID2.PDF

Biodiesel, http://www.biodiesel.org/

Biodiesel Emissions, http://www.biodiesel.org/pdf_files/emissions.PDF

Energy Technology and Fuel Economy, http://www.fueleconomy.gov/feg/atv.shtml

Fuel Economy, http://www.fueleconomy.gov/

Health and Environmental Effects of Particulate Matter, http://www.epa.gov/ttn/oarpg/naaqsfin/pmhealth.html

It Smells Like Popcorn and It's Catching On, http://seattlepi.nwsource.com/local/212626_biodieselfans18.html

Nitrogen Oxides Health Effects, http://www.atsdr.cdc.gov/tfacts175.html

Pumped Up About Cleaner Fuels, http://seattlepi.nwsource.com/local/212618_biodiesel18.html

Sulfur Dioxide Health Effects, http://www.atsdr.cdc.gov/toxprofiles/phs116.html

UNH Biodiesel Group articles, http://www.unh.edu/p2/biodiesel/research_index.html

Implementing the Lesson

INSTRUCTIONS:

1. Have the students read the article "Coco Locomotion."
2. Hand out the student instructions.
3. Review unit conversions and calculations as needed.
4. Provide the Resources section of this lesson or research instructions for students to answer the Research/Extension Questions.

NOTES & HELPFUL HINTS:

- This lesson nicely complements a unit on greenhouse gases or global warming.
- In a chemistry class, students could investigate the chemistry of combustion and the differences between biodiesel and petrodiesel.
- In a physical science class, students could investigate the use and distribution of energy in an automobile combustion engine.

Aligning with Standards

SKILLS USED OR DEVELOPED:

Computation, Critical thinking and response, Tables (reading), Unit conversions

SPECIFIC CONTENT ADDRESSED:

unit conversions, biodiesel, fuel, greenhouse gases

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Unifying Concepts and Processes

- Systems, order, and organization
- Change, constancy, and measurement

Science in Personal and Social Perspectives

- Personal and community health
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge

Assessing the Lesson

Unit conversions and dimensional analysis are two very important computational tools used in science. In order to become proficient in these techniques, students must get into the habit of always including the units in their calculations and even letting the units guide their calculations, and to check whether they approached the problem correctly. When doing calculations, many times students are uncertain about how to approach the problem—for example, whether to multiply or divide. However, if they look at the units with which they need to end up, like miles/gallon, then they know they need to divide miles by gallons. Likewise, if they begin with the unit kilometers but want to end up with miles, they know they have to set up the equation using a unit conversion. Another reason it is important for students to keep track of and always include units is because numbers are meaningless without them.

Because the inclusion of and proper use of units are so important in learning common scientific computation, assessment should strongly lean toward students' clearly and methodically showing their work with units, as opposed to grading for the correct answer. One computation example is shown for each section of student calculations, and the correct answers are given in the table. Students should show their work for ALL of the calculations.

a) This is a simple calculation, but again students should show units and their cancellation. Answer: 4 tons/year x 5 years = 20 tons.

b) How many times greater are the emissions from the Dodge Durango compared to:

- Honda Civic Hybrid? Answer: 61.5 tons/20 tons = 3.1 times greater
- Volkswagon Beetle on 100% Biodeisel? Answer: 61.5 tons/4.9 tons = 12.6 times greater

c) The number of new sport utility vehicles (SUVs) sold in the United States in 2000 was 2,979,465. Estimate the tons of greenhouse gases emitted from new SUVs alone in 2000. Assume 12.3 tons of greenhouse gases are emitted per year per SUV. Show your calculations and units.

2,979,465 x 12.3 tons = 36,647,420 tons of greenhouse gases

d) If everyone who bought an SUV in the year 2000 bought a Volkswagen Beetle and ran it on biodiesel, how much less would the emissions have been with just that group of people?

Answer: 2,979,465 x 4.9 tons = 14,599,378.5 tons of greenhouse gases

36,647,420 tons - 14,599,378.5 tons = 22,048,041.5 tons fewer of greenhouse gases would have been emitted.

Car Type	Greenhouse Gas Emissions tons/yr	Greenhouse Gas Emissions over 5 years, tons
Honda Civic Hybrid	4	20
Volkswagen Beetle running on diesel	5.5	27.5
Volkswagen Beetle running on 100% biodiesel	0.98 (estimated)	4.9
Dodge Durango 4WD	12.3	61.5

e) Calculate the highway miles per gallon for each vehicle listed in the chart. Use the information below to aid your calculations. Show your calculations and include UNITS.

- 1 kilometer = 0.621 mile
- 1 liter = 0.264 gallon
- Assume the following prices: $1.70/gallon for gasoline, $1.80/gallon for petroleum diesel, and $2.16/gallon for biodiesel

Miles/gallon calculation: Honda Civic Hybrid: 4.9 Liters/100 km x 1 km/0.621 miles x 0.264 gallon/1 liter = 4.9/100 x 1/0.621 x 0.264 gallons/mile = 0.049 x 1.61 x 0.264 gallons/mile = 0.021 gallons/mile

But the questions asks for miles/gallon, so 1 mile/0.021 gallons = 1/0.021 miles/gallon = 47.6 miles/gallon

Cost-of-fuel calculation: 1 gallon/47.6 miles x 15,000 miles x $1.70/gallon = 15,000/47.6 x $1.70 = $536

Car Type	Fuel Type	Liters/100 km (hwy)	Miles/gallon	Cost of fuel per year (assume 15,000 miles traveled/year)
Honda Civic Hybrid	gasoline	4.9	47.6	$536
Volkswagen Beetle running on diesel	diesel	5.1	45.5	$593
Volkswagen Beetle running on biodiesel	biodesiel	5.1	45.5	$712
Dodge Durango 4WD	gasoline	13.1	17.9	$1,425

Research/Extension Questions:

f) Answers will vary; be sure students provide full citations of references they used. Answers may include reduction in the following exhaust products and corresponding health effects:

Particulate matter: respiratory problems including asthma attacks; allergy symptoms; cardiovascular (refer to "Environmental Cardiology: Getting to the Heart of the Matter," *EHP Student Edition*, February 2005, pp. A880–A883).

Carbon monoxide: cardiovascular effects; nervous system effects (headache, dizziness, drowsiness, behavioral); nausea

Sulfur dioxide: respiratory effects; nasal irritation; cardiovascular effects.

Polycyclic aromatic hydrocarbons: some are carcinogenic; they contribute to the formation of ground-level ozone, which is a respiratory irritant and can induce asthma attacks.

NO_X: respiratory irritant; cardiovascular effects

g) Other forms of biodiesel include canola, mustard, rapeseed, corn, soy (biodiesel can be made from almost any high-oil-content plant).

h) Why might college campuses with large cafeterias and car fleets be interested in this work on biodiesel? They could recycle cooking grease to make biodiesel to use in their motor fleet. It could cut down on amount of money spent on fuel, and it would be environmentally friendly.

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Student Instructions: Coco Locomotion

Step 1: Read "Coco Locomotion," *EHP Student Edition*, April 2005, p. A27.
http://ehp.niehs.nih.gov/docs/2005/113-1/forum.html#beat

Step 2: The article states that cocodiesel "burns cleaner than regular diesel." In general, biodiesel (cocodiesel is a type of biodiesel) has fewer emissions than regular petroleum diesel, or petrodiesel.

a) For each vehicle, calculate the amount of greenhouse gases produced over 5 years. Write the answer in the table.

Show your work below including the units.

Car Type	Greenhouse Gas Emissions tons/yr	Greenhouse Gas Emissions over 5 years, tons
Honda Civic Hybrid	4	
Volkswagen Beetle running on diesel	5.5	
Volkswagen Beetle running on 100% biodiesel	0.98 (estimated)	
Dodge Durango 4WD	12.3	

b) How many times greater are the emissions from the Dodge Durango compared to:

- Honda Civic Hybrid?

- Volkswagen Beetle running on 100% biodeisel?

c) The number of new sport utility vehicles (SUVs) sold in the United States in 2000 was 2,979,465. Estimate the tons of greenhouse gases emitted from new SUVs alone in that year. Assume 12.3 tons of greenhouse gases are emitted per year per SUV. Show your calculations and units.

d) If everyone who bought an SUV in 2000 bought a Volkswagen Beetle and ran it on 100% biodiesel, how much less would the emissions have been with just that group of people?

Step 3: People often make decisions based on financial factors. As the price of gasoline goes up (which it will because there is a finite supply), so too will the cost of operating a vehicle. Cocodiesel and other biodiesel, are a renewable resource, so the supply can remain comparatively constant, which steadies the price. Also, as biodiesel production becomes more efficient, the cost over time will decrease. Eventually, biodiesel will cost less per gallon than gasoline. As mentioned in the article, cocodiesel already costs less than petrodiesel to use, it just needs to be produced in great enough quantities for the public to be able to access it.

e) Calculate the highway miles per gallon for each vehicle listed in the chart. Use the information below to aid your calculations. Show your calculations and include units.

- 1 kilometer = 0.621 mile
- 1 liter = 0.264 gallon
- Assume the following prices: $1.70/gallon for gasoline, $1.80/gallon for petrodiesel, and $2.16/gallon for biodiesel

Car Type	Fuel Type	Liters/100 km (hwy)	Miles/gallon	Cost of fuel per year (assume 15,000 miles traveled/year)
Honda Civic Hybrid	gasoline	4.9		
Volkswagen Beetle running on diesel	diesel	5.1		
Volkswagen Beetle running on 100% biodiesel	biodesiel	5.1		
Dodge Durango 4WD	gasoline	13.1		

Research/Extension Questions:

f) How might the use of biodiesel positively affect human health, compared to the use of fossil fuels? Be sure to cite your sources of information.

g) Cocodiesel is only one form of biodiesel. What are other three other forms?

h) Why might college campuses with large cafeterias and car fleets be interested in this work on biodiesel?