Lesson 6- Automobile Emissions

Traffic Jam

Background Information

Emissions from an individual car are generally low, relative to the smokestack image many people associate with air pollution but in numerous cities across the country, the personal automobile is the single greatest polluter with emissions from millions of vehicles on the road. Driving a private car is probably a typical citizen's most "polluting" daily activity.

The Clean Air Act of 1970 gave EPA broad authority to regulate motor vehicle pollution, and the agency's emission control policies have become progressively more stringent since the early 1970's.

EPA standards dictate how much pollution autos may emit but automakers decide how to achieve the pollution limits. The emission reductions of the 1970's came about because fundamental improvements in engine design plus the addition of charcoal canisters to collect hydrocarbon vapors and exhaust gas recirculation valves to reduce nitrogen oxides.

The advent of "first generation" catalytic converters in 1975 significantly reduced hydrocarbon and carbon monoxide emissions. The use of converters provided a huge indirect benefit as well. The converters lead to the widespread introduction of unleaded gasoline because lead inactivates the catalyst. This resulted in dramatic reductions in ambient lead levels and alleviated many serious environmental and human health concerns associated with lead pollution.

The next major milestone in vehicle emission control technology came in 1980-81. In response to tighter standards, manufacturers equipped new cars with even more sophisticated emission control systems. These systems generally include a "three-way" catalyst, an on-board computer, and an oxygen sensor. This equipment helps optimize the efficiency of the catalytic converter.

Provisions of the 1990 Clean Air Act are further reducing vehicle emissions. Mobile source provisions include even tighter tailpipe standards, increased durability, improved control of evaporative emissions, and computerized diagnostic systems that identify malfunctioning emission controls.

Even though efforts by government and industry have greatly reduced typical vehicle emissions, the number of miles Americans drive has more than doubled since 1970. The increase in travel has offset much of the emission control progress. The net result is a modest reduction in each automotive pollutant except lead for which aggregate emissions have dropped by more than 95 percent.

With ozone continuing to present a persistent urban air pollution problem, future vehicle emission control programs will emphasize hydrocarbon and nitrogen oxide reductions. Carbon monoxide control will remain critical in many cities and limits on vehicle-generated carbon dioxide may become important in the future.

Objectives

After completing the lesson, the students will be able to:

1. Describe how automobile emissions pollute the air.
2. Make inferences and predictions about traffic and air pollution.
3. Organize the data into charts and tables for interpretation.
4. Choose a reasonable solution from various alternatives.
5. Interpret data and draw conclusions pertaining to traffic.
6. Name the benefits of using high occupancy vehicles.

Materials

1. One Traffic Simulation Data Table 1 per student
2. One Traffic Simulation Data Table 2-5 per student
3. 16 oz. plastic soda bottles (one per team of 2-4 students)

4. Large lima beans, kidney beans, black beans, lentils, and split peas or other beans or objects of comparable size (enough to more than fill all the soda bottles)
4. Plastic cups (five per team of 2-4 students)
5. One calculator per student (optional)

Preparation

1. You will need to make one “traffic simulator” per every 2-4 student team. A traffic simulator is a soda bottle filled with three kinds of beans of different sizes. To make the simulators, place one large lima bean in each bottle. This bean represents a form of mass transit (bus) carrying 55 people. Next, place two black beans in each bottle. The black beans represent a car pool with three people in the vehicle. Then fill the rest of the bottle with small kidney beans until it is tightly packed. The kidney beans represent vehicles (cars, trucks, SUVs) carrying one person. Finally, put the top on the bottle and close tightly.

2. To go with each traffic simulator you made, you will also need to prepare two small cups of small beans (one with lentils representing bicycles; the other with split peas representing pedestrians). Later in the lesson, the students will be asked to exchange these smaller beans with some of the larger beans in the simulators.

3. On the board, make the Traffic Simulator Key chart.

Procedure

1. Ask the students if they have ever been in a traffic jam and discuss briefly.

2. Have the students draw a quick sketch of a traffic jam. Give them about five minutes to draw and then ask them what they think causes traffic jams.

3. Have the students draw something to represent air quality in their pictures. Remind them of the “Knocking Over Pollutants” lesson and how the class had made invisible things visible. Give them time to complete this and then discuss. Guide students to identify ground-level ozone, nitrogen oxides, and carbon monoxide as the most common pollutants that come heavily from cars, trucks, and other motor vehicles.

4. Write the word “emissions” on the board and explain that the exhaust that comes from car tailpipes is called “emissions.” Emissions also come from under the hood of the car when the engine gets hot. Ask the students to explain why a traffic jam would cause even more pollution than a large number of cars moving freely. Guide students to understand that cars idling in traffic or at the drive-through windows use fuel inefficiently because they are not moving forward toward their destination.

5. Write the word “congestion” on the board and ask the students to define it and explain how “congestion” is applied to traffic. Tell the students that there are people called transportation planners whose job it is to figure out how to get rid of the congestion in cities. These people often use models in their work to get a picture of what traffic might be like in a city. Traffic planners have to think a lot about how to reduce air pollution.

6. Show students a pre-make traffic simulator and tell them that in this lesson they will be transportation planners using a model called a “traffic simulator.”

7. Divide the students into teams of 2-4 (depending on the number of traffic simulators available). Give each team a simulator and explain that the simulator represents a traffic jam.

Explain what each type of bean represents using the Traffic Simulator Key chart.

8. Have the students shake their simulators. Ask them what happens. They should respond that the beans barely move. Ask the students why this model is like a highway or street. Point out that it is a confined space and can only hold a finite amount. When you have too many cars on the highway, the vehicles slow down and can't move very much. When there is all that congestion, air pollution increases.

9. Explain that this model represents a "rush hour" situation in which people are trying to get to work in the morning. Discuss the size of each "vehicle" and the number of people it can move. Give each student a copy of the "Traffic Simulation Data Table 1" handout. Have the students open the traffic simulators and count the number of beans/vehicle of each type currently in the simulator. Have them record this data in Data Table 1.

10. Guide the students to determine the mathematical operation for discovering how many total people are carried by each type of vehicle (multiplication) and demonstrate with an example (e.g. 5 buses x 55 people per bus = 275 people carried by buses). Ask the students to calculate the total number of people carried by each type of vehicle and enter this data in Data Table 1. Instruct the students to also calculate the total number of vehicles in this scenario as well as the total number of people being moved and write the numbers in the Total column of Table 1. Tell the students to leave the "Pollution Value" row blank for now.

11. Tell the students that, as good transportation planners, we want the beans/vehicles to move about freely so that the people can get where they are going in a timely fashion and not create excess air pollution.

12. Ask the students if there are any other options for getting to work other than the ones already named. (If the students suggest trains, planes, or boats, indicate that we are focusing on

roads in cities.) Focus on bicycles and walking as two ways people can get to work and write them in on the traffic simulator key in the blank spaces next to lentil and split pea. Indicate that they carry one person and write that in the “number of people” column.

13. Hand out two additional cups of small beans; one with lentils representing bicycles and the other with split peas representing walkers or “pedestrians”. Discuss why these beans are small (a bicycle takes up approximately 1/12 of the space a car does). Indicate, however, that it takes longer to go far distances by bicycle and even longer to go by foot. In addition, tell students that some employees are allowed to telework which means that they can work from home rather than at the office. In this activity, no more than five people who are represented in the simulators at the beginning will be allowed to telework so the students may take out up to five beans.

14. Now challenge the students to work in a group using the simulator to find bean combinations that allow the bean “traffic” to move freely but to move the maximum number of people as possible. Give each team three additional plastic cups for their extra beans. Make extra beans of each type available to the students. Hand out copies of the Traffic Simulation Data Tables 2-5 to each student. Have the groups work together to try different combinations and shake simulators to determine if the scenario allows for movement of the vehicles and people.

15. After each trial combination, each student should individually record the numbers of vehicle types, bikes, or pedestrians and calculate the number of people moving by each mode of transportation. Students should try at least four different combinations and record their results in the other data tables. Remind students to calculate the total number of vehicles, bikes, or pedestrians and total number of people moved for each scenario and write the numbers in each table’s “totals” column. Tell the students to leave the “Pollution Value” rows blank for now.

16. Each team should select their “best-case scenario” model that allowed the bean vehicles, bikes, and pedestrians to move most freely while moving the greatest number of people.

17. Have each group share their results with the class. Guide students to draw some conclusions as transportation planners about what can be done to reduce traffic jams.

18. Tell students that calculating the number of people moving freely is very important in transportation planning but planners also have to think about air quality. The Environmental Protection Agency insists that transportation planners in certain cities use models to calculate pollutants from cars. Tell the students that as planners we are going to assign a number to each mode of transportation according to how much pollution it puts out for every person it carries.

19. On the traffic simulator key, write the number “10” in the Pollution Value column in the Car row. Write in “3” for Car Pools, “2” for Buses, “0” for Bicycles, and “0” for pedestrians. Briefly explain why the number assigned to a carpool is approximately 1/3 as much as for a single-occupancy car and why the number assigned to a bus is very small. Ask the students to explain why the number for bicycles and walking is “0”.

20. Demonstrate on the board how to calculate the Total Pollution Value by multiplying the number of people carried per vehicle by the pollution value assigned. Work through the pollution values calculations for Table 1 as a class. Have the students work in groups to calculate pollution values for at least two of their other trials including the “best-case scenario” for movement. The students should record the totals in the “Pollution Value” row of their data tables. Ask students to share their results with the class.

21. Have the students use what they learned about traffic pollution and traffic planning to create solutions to traffic

problems in their area. The students can make posters to post around the city encouraging people to carpool and take public transportation.

Extensions

1. Have the local traffic planner come to class to speak about his or her job and traffic problems in the area.

2. Have the students make observations about the traffic congestion around the school building especially in the mornings and afternoons when the students are arriving or leaving the school building. Challenge the students to create a "School Transportation Plan" that gets students to school on time, reduces congestion, and improves air quality. Have the students present their plan to the school principal.

3. Discuss how Oklahoma no longer requires Vehicle Inspection Stickers. How does this decision affect air quality? What can be done to change this situation?

Sources

"Teacher Resource Manual" *Georgia Clean Air Campaign.* www.cleanaircampaign.com/index.php/cac/for_school.

"Traffic Jams" *Georgia Clean Air Campaign*. www.cleanaircampaign.com/index.php/cac/for_school.

Traffic Simulator Key

Bean	Mode of Transportation	Number of People	Pollution Value
Lima	Bus	55	.2
Black	Car Pool	3	3
Kidney	Car, SUV, Truck	1	10
Lentil	Bicycle	1	0
Split Pea	Pedestrian (Walker)	1	0

Traffic Simulation Data Table #1

	Buses	Car Pools	Cars, SUVs, Trucks	Totals
Number of Vehicles, Bicycles, or Pedestrians				
Number of People				
Pollution Value				

Notes and Calculations:

Traffic Simulation Data Table #2

	Buses	Car Pools	Cars, SUVs, Trucks	Bicycles	Pedestrians	Totals
Number of People, Bicycles, or Pedestrians						
Number of People						
Pollution Value						

Traffic Simulation Data Table #3

	Buses	Car Pools	Cars, SUVs, Trucks	Bicycles	Pedestrians	Totals
Number of People, Bicycles, or Pedestrian						
Number of People						
Pollution Value						

Traffic Simulation Data Table #4

	Buses	Car Pools	Cars, SUVs, Trucks	Bicycles	Pedestrians	Totals
Number of Vehicles, Bicycles, or Pedestrians						
Number of People						
Pollution Value						

Traffic Simulation Data Table #5

	Buses	Car Pools	Cars, SUVs, Trucks	Bicycles	Pedestrians	Totals
Number of Vehicles, Bicycles, or Pedestrians						
Number of People						
Pollution Value						