WORKSHEET

Texas and the Clean Air Act

Introduction:

Can you imagine a world where the air we breathe is filled with clouds of smoke?

In the 1950s and 1960s, Texans, along with the rest of America, observed that their major cities were beginning to be covered by a dense smog. This smog was a mixture of smoke and fog and came from a wide range of sources – mostly industrial. The air around these major cities became increasingly unhealthy for people to breathe. In metropolitan areas of Texas like Houston, Dallas-Fort Worth, and San Antonio, air pollution was visible for most of the day and became a hazard for motorists and pedestrians alike.

This pollution was linked to unregulated emissions from cars, trucks, and factories. Since there were no controls on these sources, air pollution was rampant. The U.S. Congress passed the Clean Air Act (CAA) in 1970 and made major revisions in 1977 and 1990. Currently, the CAA requires the U.S. Environmental Protection Agency (EPA) to establish air quality standards for six key criteria air pollutants that are the most dangerous to humans and the environment: carbon monoxide, nitrogen dioxide, ozone, particulate matter, sulfur dioxide, and volatile organic compounds. The CAA also requires states to adopt enforceable plans to achieve and maintain those standards.

Figure 1: Smoke from the burning of discarded auto batteries from a factory near Houston, Texas, April 1972: Marc St. Gil - NARA (#549634)

The Texas Commission on Environmental Quality (TCEQ) is the state agency responsible for developing state plans to meet these air quality standards in Texas. TCEQ also sets up and maintains dozens of air quality monitors across the state.

In this activity, we will use data from the EPA's **National Emissions Inventory** webpage to create visual representations of how our air quality has changed since the CAA was passed. We will use the following data to create ratios for the ingredients in our experiments.

	1990	2019
CO	143.6 mil tons	44.7 mil tons
NO_x	25.2 mil tons	8.7 mil tons
O_3	3.2 mil tons	N/A
PM-10	23.1 mil tons	2.3 mil tons
SO_2	23.1 mil tons	2.0 mil tons
VOC_2	23.1 mil tons	12.3 mil tons

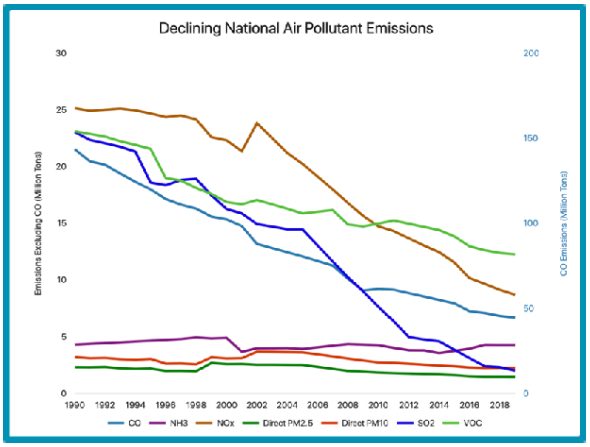

Figure 2: U.S. EPA National Emissions Inventory

Procedure:

The CAA helps us control the sometimes-invisible air pollutants that can be harmful to humans. In this experiment, we will use different visible materials to show these unseen pollutants.

One container will represent the air quality in the U.S. before the CAA was passed, and the other container will represent our current air quality.

1. Fill both containers with water. This water will be your “air.”
2. Gather the materials that will be representing the six criteria air pollutants that were designated by the EPA. The materials will correspond to the pollutants listed in the chart below:

Air Pollutant	Experiment Ingredients
Carbon monoxide	Red food coloring
Nitrogen dioxide	Green food coloring
Ozone (O_3)	Yellow food coloring
Particulate matter (PM)	Black pepper
Sulfur dioxide (SO_2)	Lemonade mix
Volatile organic compounds	Salt

Tip: Wear gloves to keep food coloring from dyeing the skin.

3. We will start with Carbon Monoxide (CO). This pollutant comes from exhaust of cars, trucks, and other machines. In 1990, the U.S. was emitting 143.6 million tons of CO, but in 2019 we only produced 44.7 million tons. That gives us a ratio of about 3:1. After adding the “pollutant,” mix the solutions together.

Container #1 - Before the CAA	Container #2 - After the CAA
3 drops of red food coloring	1 drop of red food coloring

4. Next, we will add Nitrogen Dioxide (NO_2). This pollutant also primarily comes from the burning of fossil fuels. In Texas, NO_2 is monitored along with other nitrous gases—all of which are referred to as NO_x gases.

In 1990, we were producing 25.2 million tons of NO_x gases, but in 2019 the U.S. only produced 8.7 million tons. This also gives us a 3:1 ratio. After adding the "pollutant," mix the solutions together.

Container #1 - Before the CAA	Container #2 - After the CAA
3 drops of green food coloring	1 drop of green food coloring

5. Ozone (O_3) is tricky because it is not emitted directly. O_3 is actually caused by NO_x gases and VOCs mixing together in the lower atmosphere with heat from the sun. It is very unhealthy for humans to breathe, especially if they have health conditions that affect respiration, like asthma. We know that 8-hour ozone concentrations have dropped by about 25% since 1990, meaning the ratio should be 4:3. After adding the "pollutant," mix the solutions together.

Container #1 - Before the CAA	Container #2 - After the CAA
4 drops of yellow food coloring	3 drop of yellow food coloring

6. Particulate Matter (PM) is a mixture of small particles and water droplets in the air. When it is present in large amounts, it can mix with ozone and other dangerous pollutants to become smog. In the U.S., we track two different sizes of particulate matter: PM-10, which is particles 10 micrometers or smaller, and PM-2.5, which is particles 2.5 micrometers or smaller.

   In 1990, the U.S. directly produced 3.2 million tons of PM-10, but by 2019 that amount reduced to 2.3. These numbers give us a 3:2 ratio. Using a ¼ teaspoon as our unit, we will end up with 3/4 teaspoons and 2/4 teaspoons (1/2 teaspoon). After adding the "pollutant," mix the solutions together.

Container #1 - Before the CAA	Container #2 - After the CAA
¾ tsp of black pepper	½ tsp of black pepper

7. Sulfur Dioxide (SO_2) comes from the burning of sulfur materials. The main sources of SO_2 are power plants and other large industrial facilities. In 1990, the U.S. was producing 23.1 million tons of SO_2, but we only produced 2 million tons in 2019. This gives us an almost 14:1 ratio. After adding the "pollutant," mix the solutions together.

Container #1 - Before the CAA	Container #2 - After the CAA
3 and ½ tsp of lemonade mix	¼ tsp of lemonade mix

8. Volatile Organic Compounds (VOCs) is a broad term for gases emitted from chemicals. These gases can come from paints, aerosol cans, cleaners, disinfectants, pesticides, and other common chemicals used by humans. In 1990, the U.S. produced 23.1 million tons of VOCs but, in 2019, that amount dropped to 12.3 million tons. This gives us a 2:1 ratio for our experiment. After adding the "pollutant," mix the solutions together.

Container #1 - Before the CAA	Container #2 - After the CAA
½ tsp of salt	¼ tsp of salt

9. Compare the two containers of water. Record your observations below.

10. Which pollutant was reduced the most by the Clean Air Act?

11. Which container of “air” would you rather breathe?

12. Watch the video “**How US Cities Would Look Without The Clean Air Act**”. If we never passed the CAA, what might be some other negative effects on large metropolitan areas if they looked like this?

13. What are some ways we can reduce the air pollution in our area?

Glossary:

- **Carbon Monoxide** – an odorless gas that is emitted from cars, trucks, and factories through the burning of a fuel source. When inhaled in large amounts, carbon monoxide can limit blood flow to the brain.
- Environmental Protection Agency (EPA) – the government organization created by President Richard Nixon in 1970 for environmental protection and compliance with the Clean Air Act (CAA).
- **Nitrogen Dioxide** – a very reactive gas that is primarily produced through the burning of fossil fuels. In high amounts, it can irritate one’s respiratory system, and could also produce detrimental environmental effects such as acid rain.
- **Ozone** – a gas that forms when three oxygen molecules bond together. It performs a very important job in our upper atmosphere by protecting the earth from the sun’s harmful rays. This blanket of ozone is called the ozone layer. However, when ozone is in our lower atmosphere where we breathe air, it can be harmful to humans.
- **Particulate Matter** – a mixture of small particles and water droplets in the air. When it is present in large amounts, it can mix with ozone and other dangerous pollutants to become smog. This is unhealthy for people to breathe, especially if they have asthma or other health conditions that might make them sensitive to air pollution.
- **Sulfur Dioxide** – a gas that is released through the burning of sulfurous materials, commonly produced by power plants and other industrial facilities.
- **Volatile Organic Compounds** – a broad term for several gases emitted from different organic chemicals, compounds, and mixtures of these compounds. These gases can come from paints, aerosol cans, cleaners, disinfectants, pesticides, and other common chemicals that we either use or encounter on a daily basis.