



POLLUTION SOLUTION

STEM²D Topic
Science

Target Population:
Students, ages 12–14



Pollution Solution is part of the **STEM²D Student Activities Series** developed by FHI 360 for Johnson & Johnson's WiSTEM²D initiative (**W**inning in **S**cience, **T**echnology, **E**ngineering, **M**ath, **M**anufacturing, and **D**esign). The series features interactive and fun, hands-on activities for youth globally, ages 12–18.

Pollution Solution

STEM²D Topics: Science

Target Population: Students, ages 14–18

ACTIVITY DESCRIPTION

In this team-based, hands-on activity, students will learn how pollution affects the environment and will brainstorm solutions to pollution in the world around them.



ESTIMATED TIME

This session typically takes **60 minutes** to complete and should be conducted in **one** session.

STUDENT DISCOVERIES

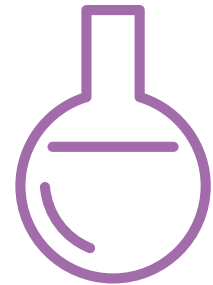
Students will:

- Participate in a team-based learning experience.
- Build important STEM²D skills, such as collaboration, investigation, teamwork, and testing.
- Realize that STEM²D offers diverse and exciting career opportunities.
- Have fun experiencing STEM²D.

GETTING READY

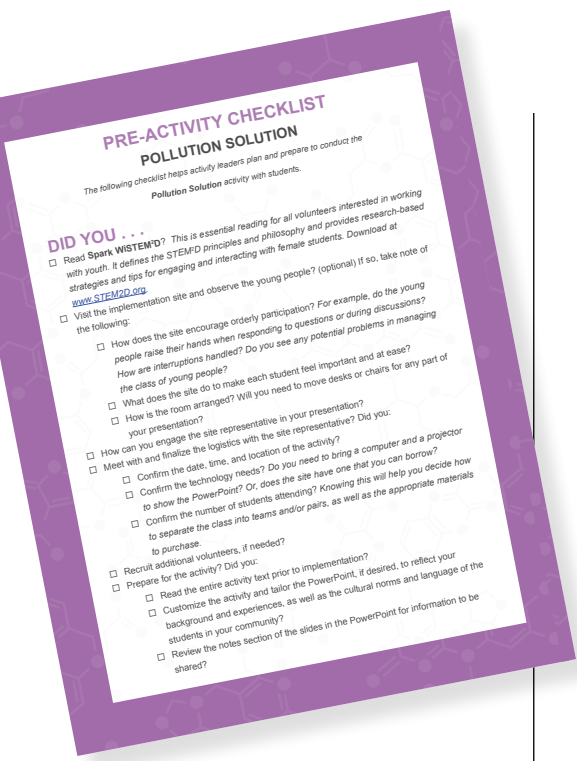
Materials:

- Computer with projector
- PowerPoint: Pollution Solution
- Pre-Activity Checklist
- Tell My Story Form
- Colored markers, *1 pack per team*
- Food coloring (red, yellow, green)
- Flip chart or poster-sized paper, *1 piece per team*
- Hand wipes or paper towels (for clean-up)



STEM²D Skills

- Collaboration
- Communication
- Critical Thinking
- Decision Making
- Investigative and Laboratory Skills
- Problem Solving
- Scientific Inquiry
- Teamwork



- Paper towels (for clean-up)
- Pen/pencil, *1 per student*
- Tablecloths (number will depend on tables being used)
- Tape or Blue-Stik™ (for hanging the team-created posters on the wall)
- Pollution Solution materials, *1 set of the following items for the activity leader (for demonstration), as well as 1 set per team:*
 - 1 large, clear, plastic tub (12–quart / 11–liter, minimum)
 - 4 plastic, 16-ounce cups (475 mL), each filled with one of the following liquids:
 - 8–12 oz. (250–350 mL) of water with green food coloring added
 - 8–12 oz. (250–350 mL) of water with red food coloring added
 - 8–12 oz. (250–350 mL) of water with yellow food coloring added
 - 3 Tbs. (44 mL) cooking oil
 - 3 straws (any size)
 - 2 plastic bottle caps
 - 1 aluminum soda can

Estimated Materials Cost:

Activity leaders can expect to incur less than \$20.00 (excluding optional items) in materials costs when completing this activity with 20 students organized into teams of three to four students.

Activity Leader Preparation

- Read Spark **WiSTEM²D**. This is essential reading for all volunteers interested in working with youth. It defines the **STEM²D** principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM²D.org.
- Review the **Pre-Activity Checklist** (at the end of this document) for details and specific steps for planning, preparing, and implementing this activity.
- See the **STEM²D Student Activities Overview** for additional information.

STEP-BY-STEP INSTRUCTIONS: POLLUTION SOLUTION

1. Welcome and Introduction (5 minutes)

- Welcome the students.
- Introduce yourself by saying your name, title, and your organization/company.
- Share that students will be learning about STEM²D careers and will be applying STEM²D skills during the session.
- **(What is STEM²D? Slide)** Explain that **STEM²D** refers to: Science, Technology, Engineering, Math, Manufacturing, and Design.
- Ask students and other volunteers to introduce themselves and state their favorite area of STEM²D.
- **(Today's Plan Slide)** Review the agenda. Explain that in addition to information about STEM²D, students will learn about different types of pollution and brainstorm ways to reduce or eliminate pollution in the world around them.

2. Career Awareness: Science in the World of Work

(10 minutes)

- **(STEM²D in the World of Work Slide)** Initiate an opening discussion and brainstorming activity. Consider asking:
 - How do you think STEM²D is used every day in the workplace?
 - What kinds of careers do you think people with an interest, aptitude for, or degree in science would have?
- **(My Story Slide)** Talk about your educational and career path. Use the Tell My Story form as the basis for your remarks. Be prepared to describe your job or a typical day and provide information about your background including:
 - When/why you developed an interest in science.
 - The classes/courses you took in secondary school.
 - Your postsecondary path, including the institution you attended and your degree. *If you switched disciplines, make sure you explain why to the students.*
 - What your current position entails. *Be sure to include how you use STEM²D subjects on a typical work day.*

KEY WORDS

- Biodegradable
- Contamination
- Deforestation
- Eco-friendly
- Land degradation
- Pollution
- STEM²D

TIPS ABOUT STEM²D CAREERS

Share with students that there are many different kinds of careers related to STEM²D. Some STEM²D careers related to this activity are:

- Ecologist
- Environmental Biologist
- Environmental Engineer
- Horticulturalist
- Marine Biologist
- Nature Conservation Officer
- Soil and Plant Scientist

TIPS FOR MAKING CONNECTIONS

Encourage students to:

- Ask questions if they don't understand.
- Summarize what they have learned.
- Explain their thinking process aloud.
- Describe pollution they have seen in their local environment.
- Talk through their ideas and solutions.

- Weave in facts about STEM²D and STEM²D careers:
 - Tell the students that your career is only one of the many careers available in the STEM²D disciplines.
 - Explain that STEM²D careers are high-demand, high-growth careers and are predicted to remain in demand over the next 10 years.
 - Share a few Johnson & Johnson job titles and careers that might align with this activity.

3. Content Presentation (15 minutes)

- **(What is Pollution? Slide)** Before showing the definition, ask two to three students to give a definition of pollution.
- Share that **pollution** is any contamination of air, soil, water, and environment. Indicate that **contamination** means to make something impure or unsuitable by pollution or poisoning. Indicate that students will learn about air, land, and water pollution.
- **(Air Pollution Slide)** Using the following text, provide some content and background information on air pollution:
 - Air pollution occurs when gases, dust particles, fumes (or smoke), or odors are introduced into the atmosphere in a way that makes it harmful to humans, animals, and plants.
 - Human activities that result in air pollution are: emissions from industries and manufacturing activities, burning of fossil fuels, and household and farming chemicals.
 - Some common air pollutants are:
 1. Carbon monoxide (CO): fuel combustion from vehicles and engines.
 2. Ground-level ozone (O₃): formed by chemical reaction of volatile organic compounds and nitrous oxide in the presence of sunlight.
 3. Lead (Pb): coming from metal refineries—also called smelters—and other metal industries, waste incinerators, and battery manufacturing.
 4. Nitrogen dioxide (NO₂): from fuel combustion by vehicles, big industrial boilers, electric utilities, and wood burning.

5. Particulate matter (PM): formed through chemical reactions; fuel combustion (e.g., burning coal, wood and diesel fuel; farming; road construction).
 6. Sulfur dioxide (SO₂): from fuel combustion (especially high sulfur coal); industrial processes; natural occurrences like volcanoes.
- Air pollution effects our health. Issues include heart disease, reduced oxygen to breathe, lung disease, worsened asthma, damage to nervous system, and respiratory problems. Particulate matter causes irritation to the eyes, nose, and throat; upper respiratory infections; lung cancer; heart disease; and damage to the brain, nerves, liver, or kidneys.
 - Acidification (acid rain) harms vegetation, kills trees, and harms animals, fish, and other wildlife. Ground-level ozone (chemical reactions involving air pollutants that create a poisonous gas ozone) affects human health and damages vegetation and animal life).
- **(Land Pollution Slide)** Give some background information on land or soil pollution:
 - Land or soil pollution is the deterioration (destruction) of the earth's land surfaces, which is often directly or indirectly a result of man's activities and misuse of land resources.
 - It occurs when waste is not disposed of properly or when humans throw chemicals onto the soil in the form of pesticides, insecticides, and fertilizers as part of agricultural practices.
 - Exploitation of minerals (mining activities) has also contributed to the destruction of the earth's surface. Since the Industrial Revolution, natural habitats have been destroyed and environments have been polluted—causing diseases in both humans and many other animal species.
 - Human actions have also caused many large areas of land to lose or reduce their capacity to support life forms and ecosystems. This is known as land degradation. Note that **land degradation** can result from many factors, and soil pollution is only one of them.

- Types of soil pollution are:
 1. Solid Waste: Garbage from home, school, hospitals, market, and workplaces; paper; plastic containers, bottles, and cans; food; used cars; broken electronic goods and furniture; and hospital waste are all examples of solid waste. Some solid waste is **biodegradable**, or capable of being broken down by the action of living organisms such as bacteria. Paper, for example is biodegradable; plastics, metals, aluminum cans, and broken computer and car parts are not.
 2. Pesticides and Fertilizers: Many farming activities use fertilizers, pesticide, and insecticides for higher crop yield. While these actions help produce more food, the chemicals that end up in the soil can kill insects and small animals, along with larger animals that eat the smaller animals. The chemicals can also be washed down into the soil with rain and over time end up in the water table.
 3. Chemicals: Chemical and nuclear plants produce waste materials that must be stored somewhere. In many cases, they are stored in an environmentally safe way. But some find their way into landfills and other less safe storage facilities. They may also find their way into leaking pipes and gutters. The chemicals end up polluting the soil and making crops harmful to our health.
 4. Deforestation: **Deforestation** is the clearing or cutting down of forests. Trees absorb carbon dioxide (a greenhouse gas) from the air and enrich the air with oxygen. They also provide a habitat for many land animals, insects, and birds; replenish soils; and help retain nutrients from being washed away. Millions of acres of trees have been cut down for wood, construction, farming, and mining—with new trees never being planted.

- The consequences of soil pollution can be catastrophic. Contaminated land and environments can affect the human respiratory system, trigger skin problems, and cause various kinds of cancer.
- The toxic materials that pollute the soil can get into the human body by coming into direct contact with the skin and being washed into reservoirs and rivers. Other routes include eating fruits and vegetables that have been grown in polluted soil and breathing in dust or particles.
- **(Water Pollution Slide)** Review water pollution:
 - Water pollution occurs when pollutants (particles, chemicals, or substances that make water contaminated) are discharged directly or indirectly into water bodies without enough treatment to get rid of harmful compounds.

4. Learning Activity: Pollution Lake (5 minutes)

- **(Pollution Lake Activity Slide)** Share that teams will now complete a quick learning activity to see what water pollution looks like up close.
- Break students into teams of three to four students. Distribute the materials to each team.
- Indicate that the tub of water represents a water source that provides water for plants, animals, and humans.
- Explain that while the water source looks clean now, when different types of pollutants are introduced to the water, the water becomes polluted.
- Hold up the cup of red water. Explain:
 - The red water represents fertilizer that is used by large farms. It is a type of ground water pollution.
 - While the fertilizer helps the crops to grow, it contains chemicals that are harmful to plants, animals, and humans.
 - When it rains, the fertilizer in the soil finds its way into underground rivers and streams, ending up in a larger body of water.
- Pour the cup of red water into the plastic tub and tell students to do the same. Ask students to make observations about the water.

TIPS FOR WORKING WITH STUDENTS

- Encourage students to ask questions to gain deeper understanding.
- Ask open-ended questions to encourage student reflection and discussion.
For example: Can you tell me about your solution?
- Help students stay on track with time during the group challenge.
- Encourage all students to participate in the different stages of the challenge.
- Encourage students to look at things from a different perspective.
For example: Have you thought about trying this...?
- Move around the learning space and provide support when necessary.

- Next, hold up the cup of green water. Indicate:
 - The green water is nutrient pollution. Nutrient pollution is wastewater, fertilizers, and sewage containing nutrients that encourage algae and weeds to grow. The algae use up all the oxygen, causing the other water organisms to die of oxygen starvation.
 - Nutrient pollution makes the water undrinkable.
 - Pour the green cup of water into the plastic tub and have students do the same. Invite students to make observations about the water.
- Hold up the cup of cooking oil. State:
 - The oil comes from cars and trucks that travel the roadways near water sources. This is called oil spillage. While the oil has a localized effect on wildlife, it can spread for miles.
 - Oil is not only harmful when ingested by humans, it can cause the death of many fish and can cover the feathers of the seabirds living along the seashore, preventing the seabirds from being able to fly and catch food or return to their nests.
- Pour the cup of oil into the plastic tub and tell students to do the same. Then, encourage students to share their observations about oil spillage and what the water looks like.
- Hold up the cup of yellow water. Explain:
 - Many industries and farmers work with chemicals that end up in the water. This is considered chemical water pollution.
 - Chemical water pollution includes chemicals that are used to control weeds, insects, and pests. Metals and solvents from industries can pollute water bodies as well. They are poisonous to many forms of aquatic life and may slow their development, cause them to be unable to reproduce, or kill them.
- Pour the cup of yellow water into the plastic tub and have students do the same. Ask students to share their thoughts and observations about the water.
- Hold up the straws and the bottle caps. State:



- While plastic straws with their small size may not appear to be a major source of pollution, they are surface water pollution, and they often find their way into water sources on the earth's surface.
- The bottle caps represent plastic bottles and other types of packaging that are not recycled and find their way into water sources. This is also surface water pollution.
- Plastic is manmade and is not biodegradable. The nets of plastic rings that connect plastic soda bottles together can trap animals who live in and around the water, often leading to the death of the animal.
- Place the plastic straws and bottle caps in the plastic tub and instruct students to do the same. Finally, hold up the aluminum soda can. Indicate:
 - Aluminum cans are also not biodegradable and therefore must be recycled. If they are not recycled, they often find their way into water sources, not only contaminating the water but also posing a threat to the animals that use the water and area around it as their habitat.
- Place the aluminum cans in the plastic tub and ask students to do the same.
- **(How does Pollution Affect the World Around You? Slide) (5 minutes)**. Have students reflect on the polluted lake and share their thoughts and observations. Ask students:
 - How does pollution affect the water you drink?
 - How does pollution affect the air you breathe?
 - How does pollution affect the food you eat?
 - How does pollution affect the plants and animals in the natural environment?
- Encourage two to three students to share their thoughts. If students are unable to answer the questions, provide examples that they can relate to (e.g. air pollution makes it difficult to breathe and may cause respiratory problems).



TIPS FOR STARTING CONVERSATIONS

- What area of STEM²D is your favorite?
- Why did you choose that area of STEM²D as your favorite?
- What would your dream job be?
- Where do you see yourself in 5–10 years?

5. What's the Solution? Challenge (15 minutes)

- **(What's the Solution? Challenge Slide)** Introduce the challenge using the instructions below. Indicate:
 - With your team, choose a type of pollution that we discussed today and that you see in the world around you.
 - Brainstorm solutions with your team to reduce or eliminate the pollution.
 - Using the flip chart paper, create a poster detailing your team's solution or solutions to the type of pollution you've chosen.
 - Teams have 10 minutes to make their poster.
- After 10 minutes, call time and instruct each team to hang the poster on the wall with the tape provided.
- Have one member of each team briefly present its solution(s).

6. Conclusion and Student Reflection (5 minutes).

- **(Eco-Friendly Practices Slide)** Close the activity with a brief discussion about environmentally friendly practices. Consider sharing some of Johnson & Johnson's eco-friendly policies and practices:
 - **Eco-friendly** policies and practices are environmentally friendly and not harmful to the environment.
 - As stated in its Credo, Johnson & Johnson is committed to protecting the environment and natural resources. There are many examples of how Johnson & Johnson is living the Credo and instituting eco-friendly policies.
 - Band-Aid Brand Adhesive Bandage™ boxes are made with materials certified by the international Forest Stewardship Council (FSC), assuring that the trees used come from responsibly managed forests.
 - The U.S. Environmental Protection Agency (EPA) Green Power Partnership lists Johnson & Johnson as the nation's seventh largest purchaser of renewable energy. At its Titusville, New Jersey campus in the United States, there is a 4.1-megawatt ground mounted solar system with an array of 13,496 solar panels that track the sun from east to west; it is estimated to generate over 70 percent of the

campus' annual electricity needs, or roughly the amount needed to power 600 homes annually. Sheep graze between, underneath, and around the solar panels. By constantly trimming the grass and clover, they act as a built-in landscaping crew.

- At the Beerse, Belgium campus, Johnson & Johnson extracts the vast reserves of hot water lying deep beneath the facility. The geo-thermal energy powers everything on the site, from washing machines to air conditioners. The geothermal energy initiative, which will help slash the site's CO₂ emissions by nearly one-third, is the first of its kind for Johnson & Johnson—and just one of the clever ways the company is investing in smart sustainability innovations across the globe.
- Finally, Johnson & Johnson incorporates sustainability into the design and construction of all new facilities and major renovations. LEED (Leadership in Energy and Environmental Design) is the standard used in the Americas and the Asia Pacific region for design, construction, and high-performance buildings. In Europe, the EU Green Building Programme (GBP) is used for energy considerations, and LEED is used for other aspects of building design. The U.K. relies on the Building Research Establishment's Environmental Assessment Method (BREEAM). Several Johnson & Johnson facilities are Certified LEED platinum sites—the ranking system's highest level. They ensured water and energy efficiency, used construction components with sustainability in mind, and used high-efficiency air filtration systems.
- **(Reflection Slide)** Ask students to reflect on the activity. Have them spend a few minutes thinking about the following questions:
 - What did you learn about pollution?
 - What did you learn about eco-friendly practices?
 - How do you think this activity relates to a career in Science and/or working at Johnson & Johnson?

- Can you see yourself as a STEM2D professional? Why or why not?
- What would you need to do to make that happen?

Extended Learning

Here are a few ways to extend the learning. Other activities can be found in the Resources and References section of the lesson.

- Observe algae growth caused by excess fertilizer use.
- Perform clean-up of polluted waterways and land.
- Explore run-off and how water pollution works its way through water systems.

Key Words

- **Biodegradable:** able to be broken down by the action of living organisms such as bacteria.
- **Contamination:** to make something impure or unsuitable by pollution or poisoning.
- **Deforestation:** the clearing or cutting down of forests.
- **Eco-friendly:** not harmful to the environment.
- **Land degradation:** large areas of land lose or reduce their capacity to support life forms and ecosystems.
- **Pollution:** any contamination of air, soil, water, and environment.
- **STEM2D:** Science, Technology, Engineering, Math, Manufacturing, and Design.

Resources and References

The following resources provide additional information or activities:

- Cool Facts and Tips on Air Pollution: <http://eschooltoday.com/pollution/air-pollution/what-is-air-pollution.html>
- Cool Facts and Tips on Land Pollution: <http://eschooltoday.com/pollution/land-pollution/what-is-land-pollution.html>
- Cool Facts and Tips on Water Pollution: <http://eschooltoday.com/pollution/water-pollution/what-is-water-pollution.html>
- The Environment—Water Pollution: https://www.ducksters.com/science/environment/water_pollution.php
- The Environment—Air Pollution: <https://www.ducksters.com/>

PRE-ACTIVITY CHECKLIST

POLLUTION SOLUTION

*The following checklist helps activity leaders plan and prepare to conduct the **Pollution Solution** activity with students.*

DID YOU . . .

- Read **Spark WiSTEM²D**? *This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM2D.org.*
- Visit the implementation site and observe the young people? (optional) If so, take note of the following:
 - How does the site encourage orderly participation? *For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems in managing the class of young people?*
 - What does the site do to make each student feel important and at ease?
 - How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
- How can you engage the site representative in your presentation?
- Meet with and finalize the logistics with the site representative? Did you:
 - Confirm the date, time, and location of the activity?
 - Confirm the technology needs? *Do you need to bring a computer and a projector to show the PowerPoint? Or, does the site have one that you can borrow?*
 - Confirm the number of students attending? *Knowing this will help you decide how to separate the class into teams and/or pairs, as well as the appropriate materials to purchase.*
- Recruit additional volunteers, if needed?
- Prepare for the activity? Did you:
 - Read the entire activity text prior to implementation?
 - Customize the activity and tailor the PowerPoint, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
 - Review the notes section of the slides in the PowerPoint for information to be shared?

- Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students? *If desired, include key points about your story on the PowerPoint (see Tell My Story Slide).*
- Practice your presentation, including the hands-on, minds-on activity? Did you:
 - Do the activity? *Make sure you can explain the concepts to students, if needed, and that you know the correct answers?*
- Obtain the required materials? *See the Materials and Estimated Materials Costs sections.*
- Set up the site appropriately for the activity? Did you:
 - Make sure tables and chairs are arranged to accommodate teams of three to four students?
 - Line tables with table cloths to contain water spills and ease clean-up?
 - Prepare the materials for the Pollution Lake activity? *For each team, fill the plastic cups with each of the specified liquids: 1 cup with 8–12 oz (250–350 mL) of water with green food coloring added; 1 cup with 8–12 oz (250–350 mL) of water with red food coloring added; 1 cup with 8–12 oz (250–350 mL) of water with yellow food coloring added; and 1 cup with 3 Tbs. (44 mL) cooking oil. (See the Step-by-Step Instructions for more information.)*
 - If additional volunteers are available, assign adults to specific teams?
 - Set up the computer and projector for the PowerPoint presentation?
 - Bring a camera, if desired, to take photographs?
 - Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- Have fun!**



Tell My Story Form

This form will help activity leaders and other volunteers prepare to talk about their STEM²D interests, education, and career path in a relevant and personal way.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM²D? _____

What do you hope young people will get out of this activity? _____

FUN FACT

Share a little about your background. Ideas:

- Share a memory from childhood when you first had your spark or interest in STEM²D.
- Detail your journey, highlighting what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

How did you know you wanted to pursue a STEM²D career? _____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why.* _____

What your current position entails. *Be sure to include how you use STEM²D during a typical work day.*
