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Learn STEM

Innovative Model of learning STEM
in secondary schools

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WP2: LearnSTEM Pedagogical Model

STEM Practices Implementation Handbook

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1 Learning Resources

1.1 Module 1- Pollution: The Tanker spills oil

1.1.1 Background

Provide a brief summary of the topic or concept that will be covered in the lesson. Include its importance and relevance to the curriculum and why it's important for students to learn.

An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially marine areas, due to human activity. The term is usually applied to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land.

Although not as destructive as human-made global climate change, the environmental damage due to an oil spill can be devastating to ecosystems. This lesson will introduce some basics of aquatic ecosystems and how they can be changed by the introduction of petroleum.

During this lesson, students will learn about oil spills that occur in various bodies of water and the environmental and social implications they have on surrounding areas, including Indigenous communities. Students will use hands-on activities to explore the different technology that is used for cleanup and remediation efforts.

1.1.2 Content

LearnSTEM Pedagogical Model **Module 1: Pollution: The Tanker spills oil**	
Aim of the module/ learning unit	The aim of this module is to study the environmental effects of oil spills and create an awareness about cleaning up oil spills and its paramount importance.
Duration	**90 - 120 min**
Learning Objectives	On successful completion of this module/learning unit (LU), trainees will be able to: 1 Understand the environmental effects of oil spills. 2 Understand the different methods of cleaning oil spills. 3 Work as a team to identify the best method(s) for cleaning up a model oil spill. 4 Enhance their communication skills by participating in class discussions and presenting their findings
Resources&Materials Required (worksheet, charts, handouts, didactic video, excerpt from	• didactic video (WP2-P2-LearnSTEM-Learning resource-Pollution_The Tanker spills oil_EN.mp4), • PPT (WP2-P2-LearnSTEM-Learning resource-Pollution_The Tanker spills oil_EN.pptx),

books/manuals, mind maps, etc.)	• additional resources (WP2-P2-LearnSTEM_text_The Tanker spills oil-ADDITIONAL RESOURCHES_EN.docx), • assessment (H5P) (WP2-P2-LearnSTEM_text_The Tanker spills oil-H5P_EN.docx), • experiment (similar to the video presented above)
Procedure	Instructional steps which trainees need to follow: 1. Presentation and discussion of oil spills. Have students recall the damage an oil spill can do to a natural environment (15-20 min). 2. Introduce the challenges of cleaning up an oil spill and what methods are used (10 min). 3. Display the video (10 min) 4. Create a model oil spill and discuss the concept of a model. Assemble the team and systematically test the many different methods for cleaning up the model oil spill. Students should record their findings. (30-40 min). **Experiment – Cleaning up oil spills** **Materials:** Cotton balls Container Sponge, string Vegetable oil: amount depends on the container Plastic spoons Dawn dish soap Plastic cups: to put soap and cotton balls in Cocoa powder: to mix with oil and make it look like crude oil Bird feathers **Procedure:** Each group will need to clean up “oil” from a simulated oil spill disaster that includes feathers to represent marine life. The activity may resume in a few different ways, depending on the constraints of the class. It might set a time limit to allow the trainees to clean up the oil spill and feathers as much as possible. Then discuss the challenges faced with the different methods and materials used to try to eliminate the oil. Because the oil is separated from the water, qualitative comparisons may be observed and measured then used to complete maths problems related to this activity. Discuss findings and decide what methods worked the best. Explain how the different methods in the experiment related to the methods used in real life. 5. Assessment (H5P) (10 min)

	6. Discard the model oil spills and clean up any messes (5-10 min).
Content Delivery Methods (lecture, discussions, research, group work, etc.)	lecture, discussion, brainstorming, research, group work
Assessment Method	H5P
References (if necessary) (please use APA Style)	

1.2 Learning Unit 2- Pollution: Sulphur Dioxide Destroys Plants and Buildings

1.2.1 Background

Provide a brief summary of the topic or concept that will be covered in the lesson. Include its importance and relevance to the curriculum and why it's important for students to learn.

Air pollution is caused by the accumulation of one or more chemicals or substances in the air in high enough concentrations to harm humans, other animals, vegetation, or materials. Air pollution consists of chemicals or particles in the air that can harm the health of humans, animals, and plants. It also damages buildings. Pollutants in the air take many forms. They can be gases, solid particles, or liquid droplets.

Air pollution can result from both human and natural actions. Natural events that pollute the air include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity. Pollution from natural occurrences are not very often. Human activities that result in air pollution include emissions from industries and manufacturing activities, burning fossil fuels, and household and farming chemicals. For instance, common causes of air pollution are emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, chemical solvents, roadway dust, and smoke.

Air pollution can cause many health problems such as burning eyes, cancer, birth defects, brain damage, or even death. Air pollution can also damage the environment and property such as food crops, trees, lakes and buildings.

Pollutants are unwanted chemicals or other materials found in the air, at high enough concentrations to endanger the environment and people's health. Emissions are discharges of a pollutant from a particular source (e.g., a factory) or group of sources (e.g., vehicles) into the air. Processes such as fossil fuel burning in industry, motor vehicles and buildings emit pollutants that cause local and regional pollution.

Acid rain looks, feels, and tastes just like clean rain. Walking in acid rain, or even swimming in an acid lake, is no more dangerous for humans than walking or swimming in clean water. However, breathing air that contains the pollutants that cause acid rain can damage human health. Sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter, and ozone all irritate or even damage our lungs. These effects are mostly seen in people whose lungs have already been weakened by respiratory illness, but even healthy people can sometimes have pain or difficulty breathing because of air pollution.

SO2 and NOX, the pollutants that cause acid rain, can also reduce visibility, limiting how far into the distance we can see. These pollutants form small particles in the atmosphere. These particles reduce visibility by scattering light. Reduced visibility is most noticeable in places like National Parks, where people go to see some of the nation's most beautiful landscapes.

Acid rain eats away at stone, metal, paint—almost any material exposed to the weather for a long period of time. Human-made materials gradually deteriorate even when exposed to unpolluted rain, but acid rain speeds up the process. Acid rain can rust metals and cause marble statues carved long ago to lose their features. This happens because marble is made of a compound called calcium carbonate, which can be dissolved by acids. Calcium carbonate is also found in limestone. Many buildings and monuments are made of marble and limestone and are damaged by acid rain. Repairing acid rain damage to buildings and monuments can cost billions of euros.

1.2.2 Content

LearnSTEM Pedagogical Model **Module 2 Pollution: Sulphur Dioxide Destroys Plants and Buildings**	
Aim of the module/ learning unit	The aim of this module is by using a variety of activities to help students understand the environmental problems that Sulphur Dioxide creates as one form of pollution that results mainly from burning fossil fuels.
Duration	**90 – 120 min**
Learning Objectives	On successful completion of this module/learning unit (LU), trainees will be able to: 1. Identify some of the main causes, effects and sources of air pollution. 2. Explain the effects of Sulphur Dioxide on vegetation 3. Explain the effects of Sulphur Dioxide on water 4. Explain the effects of Sulphur Dioxide on man-made objects 5. Explain the effects of Sulphur Dioxide on humans 6. Describe what can be done to solve the Sulphur Dioxide problem
Resources&Materials Required	

(worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)	• didactic video (WP2-P2-LearnSTEM-Learning resource-Pollution_Sulfur Dioxide Destroys Plants and Buildings_EN.mp4), • PPT (WP2-P2-LearnSTEM-Learning resource-Pollution_Sulfur Dioxide Destroys Plants and Buildings_EN.pptx), • additional resources (WP2-P2-LearnSTEM_text_Sulfur Dioxide Destroys Plants and Buildings-ADDITIONAL RESOURCHES_EN.docx), • assessment (H5P) (WP2-P2-LearnSTEM_text_Sulfur Dioxide Destroys Plants and Buildings-H5P_EN.docx), • experiment (similar to the video presented above)
Procedure	Instructional steps which trainees need to follow: 1. Presentation and discussion: What Are Air Pollutants? Air Pollution Sources. How Do Air Pollutants Affect Us? Sulphuric Acid is formed when water vapour interacts with Sulphur Oxides, as a by-product of coal burning, from volcano gases, etc. Acid Rain changes the pH of aquatic systems. (20 min) 2. Display the video (10 min) 3. **Experiment 1 Acid rain on buildings. (20-25 min)** **Purpose** To demonstrate the effect of acid rain on statues and buildings. **Objective** Students will learn how acid rain is an air pollution problem. **Materials** Chalk Clear cups, glasses, or jars Vinegar Optional: Long nails **Procedure** Explain that acids react chemically with limestone. Explain that vinegar is an acid and that chalk is limestone, or give your students pH paper and get them to assess whether vinegar is an acid or base. Give each group a piece of chalk and you can choose to give them a long nail to scratch a design on the side of the chalk. I usually go with squiggly lines or the students' initials. This will make their chalk unique, and will represent their statue. Add vinegar to the groups' glass/cup/jar and ask them to drop in their statue, observing closely. Ask students about their observations.

Ask students what would happen if they had used acid rain instead of vinegar. You may want to remind them at this point that vinegar is more acidic than acid rain.

Experiment 2 Acid Rain & Plants (20-25 min)

Purpose

To demonstrate the effect of acid rain on plants

Objective

Students will learn how acid rain is an air pollution problem.

Materials

Labels
Plants
Water bottles or spray bottles
Measuring cup/cylinder
Pens
PH paper
Vinegar
Water

Procedure

Explain to the students that they are going to do an experiment about acids, bases, and plants. What do they think will happen if we water plants with liquids of different pHs? What changes do they expect to see? How long do they think it will take plants to change?

Split students into groups.

Give each group a plant and a water bottle/spray bottle.

Give each group their recipe for their liquid (see below).

Recipe for liquids

Group 1: water
Group 2: 5 parts water, 1 part vinegar
Group 3: 2 parts water, 1 part vinegar

Ask the groups to label their water bottle and plant with their group number or allow them to create a group name.

Ask the groups to take responsibility to water their plant each day and take notes on whether they notice any change in colour, foliage, and health over the next two weeks.

At the end of the two weeks, lead a discussion about the differences observed in the plants that they took care of.

Ask the students if they should be concerned about acid rain? Why? How can we try to prevent it? (Remember the sources, factories, automobiles, and utilities). Answers should relate to driving less (carpool, bus, bike, and walk), saving energy (turning off lights,

	lowering a.c.), and buying less stuff (the 3 R's: reduce, reuse, recycle). Who Cares? Why Do We Need Pollution Solutions? 4. Assessment (H5P) (10 min) 5. Clean up any messes (5-10 min).
Content Delivery Methods (lecture,discussions, research, group work, etc.)	lecture, discussion, brainstorming, research, group work
Assessment Method	H5P
References (if necessary) (please use APA Style)	

1.3 Learning Unit 3- Pollution: Acid Rain pH

1.3.1 Background

Provide a brief summary of the topic or concept that will be covered in the lesson. Include its importance and relevance to the curriculum and why it's important for students to learn.

A substance that is neither acidic nor basic is neutral. The pH scale measures the acidic or basic level of a substance. The pH scale ranges from 0 to 14. A pH of 7 is neutral, while a pH less than 7 is acidic and a pH greater than 7 is basic. Pure water is neutral. However, when chemicals are mixed with water, the mixture can become either acidic or basic.

Acid rain is rain that is more acidic than it should be. Acid rain is a complicated problem affecting soil and water chemistry, as well as the life cycles of plants and animals on land and in the water.

Water moves through the air, streams, lakes, oceans, and every living plant and animal in the hydrologic cycle. When water droplets form and fall to the Earth they pick up particles like the dust and chemicals that float in the air. Even clean, unpolluted air contains particles such as dust or pollen. Clean air also contains naturally occurring gases such as carbon dioxide (CO2). The interaction between the water droplets and the CO2 in the atmosphere gives rain a pH of 5.6, making even clean rain slightly acidic. However, when rain contains pollutants, especially SO2 and NOX, the rainwater can become very acidic.

Acid rain and the air pollution that causes it can severely damage ecosystems.

Every ecosystem is very interconnected, and the organisms that live there rely heavily on each other. For example, ecosystems have food webs, where species depend on one another for food. If any animal is affected, so are several others. This is how acid rain can affect entire ecosystems. Acid rain may only

damage a few organisms in an ecosystem, but everything else is indirectly affected. The damage acid rain causes can also take years, or even decades to reverse.

1.3.2 Content

LearnSTEM Pedagogical Model Module 3: Pollution: Acid Rain pH	
Aim of the module/ learning unit	The aim of this module is to know why it matters combating acid rain
Duration	**90 – 120 min**
Learning Objectives	On successful completion of this module/learning unit (LU), trainees will be able to: 1. to describe what acid rain and pH are. 2. understand the concept of chemical balance (pH) as a way to clarify what "acid" is and means in the context of "acid rain." 3. determine the natural and manmade contributions to acid rain formation. 4. demonstrate understanding of the pH scale. 5. determine the effects of acid rain on the environment and human health. 6. explore options for reducing man made contributions to acid rain formation.
Resources&Materials Required (worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)	• didactic video (WP2-P2-LearnSTEM-Learning resource-Pollution_Acid Rain pH_EN.mp4), • PPT (WP2-P2-LearnSTEM-Learning resource-Pollution_Acid Rain pH_EN.pptx), • additional resources (WP2-P2-LearnSTEM_text_Acid Rain pH-ADDITIONAL RESOURCHES_EN.docx), • assessment (H5P) (WP2-P2-LearnSTEM_text_Acid Rain pH-H5P_EN.docx), • experiment (similar to the video presented above)
Procedure	Instructional steps which trainees need to follow: 1. Presentation and discussion of what is Acid rain? What gases cause acid rain? What type of pollution causes acid rain? What is pH? What form can acid rain occur in?(wet, dry). (15-20 min). 2. Mention some human activities that cause damage (10 min).

	3. Display the video (10 min) 4. Create an experiment (similar to video displayed) to demonstrate acid rain impacts on marine, animal life, forests, soil, vegetation, buildings, monuments and humans. (20-30 min) **EXPERIMENT** **Materials** vinegar water 2 medium sized egg shell pieces 2 small green leaves two paper clips two containers with lids **Procedure** Before activity, make predictions. If vinegar contains acid, then how will some items placed in vinegar change? If these items were placed in water, would they change in the same ways as in vinegar? 1. Pour vinegar in one container. Place an eggshell piece, a leaf, and a paperclip in the container. Put the lid on the container. 2. Pour water in the other container. Place an eggshell, a leaf, and a paperclip in this container. Put the lid on the container. 3. Let the two sealed containers sit overnight. 4. Remove the container lids. Observe any changes that took place in the two containers. Write down observations. **Results** In the container of water, the items will not show noticeable changes. In the container of vinegar, the eggshell will be soft, the leaf will have brown spots on it, and the paperclip will not show a noticeable change. This activity indicates that acidic solutions can be harmful. **Extensions** Measure the acid in several solutions using inexpensive pH papers. Suggestions for solutions to be tested are: lemon juice (pH of 2.0) vinegar (2.2) apple juice (3.0) tomato juice (4.2) milk (6.2) pure water (7.0) Compare the solution pH values with acid rain (below 5.6) and normal rain (above 5.6). Explain that some foods we

	eat have healthy acids like citric acid, which is not harmful. However, there are stronger acids, which are the products of factories and industries, which are harmful. 5. Discuss findings and relate to issues we have to deal with in real life about soil erosion, marine life degradation, wall degradation, forests and species extinction, humans life degradation. (15-20 min). 6. Assessment (H5P) (10 min) 7. Clean up any messes (5 min).
Content Delivery Methods (lecture,discussions, research, group work, etc.)	lecture, discussion, brainstorming, research, group work
Assessment Method	**H5P**
References (if necessary) (please use APA Style)	

1.4 Learning Unit 4- Pollution: Fertilizer, Acid rain and algae growth

1.4.1 Background

Provide a brief summary of the topic or concept that will be covered in the lesson. Include its importance and relevance to the curriculum and why it's important for students to learn.

The effects of acid rain are most clearly seen in aquatic environments such as streams, lakes, and marshes. Acid rain flows to streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Acid rain also falls directly on aquatic habitats.

Most lakes and streams have a pH between 6 and 8, because the buffering capacity of soil usually neutralizes slightly acidic, clean rain. Lakes and streams become acidic (pH value goes down) when the rainwater itself is so acidic that the surrounding soil cannot buffer the rain enough to neutralize it. For this reason, some lakes in areas where soil does not have a lot of buffering capacity are naturally acidic even without acid rain.

As lakes and streams become more acidic, the numbers and types of fish and other aquatic plants and animals that live in these waters decrease. Some types of plants and animals are able to tolerate acidic waters. Others, however, are acid-sensitive and will leave or die as the pH declines.

Most commercial fertilizers contain high levels of nitrogen, phosphorus and potassium since plant growth is typically limited by these nutrients. When the fertilizer washes into a natural body of water,

it causes rapid growth of microalgae (phytoplankton) and macroalgae. This excess algae causes many problems.

1.4.2 Content

LearnSTEM Pedagogical Model Module 4: Pollution: Fertilizer, Acid rain and algae growth	
Aim of the module/ learning unit	The aim of this module is to create awareness of acid rain and its effects on the natural world. Trainees also will be able to learn about eutrophication and harmful algal growth and the consequences on the environment.
Duration	**90 - 120 min**
Learning Objectives	On successful completion of this module/learning unit (LU), trainees will be able to: 1. be aware of the adverse effects of acid rain and the ways humans affect the environment. 2. develop critical thinking skills by analysing the causes and effects of acid rain. 3. gain an understanding of the global impact of acid rain and the importance of environmental conservation. 4. understand the problem with harmful algal blooms 5. explain the process of eutrophication and what factors can magnify or mitigate it. 6. become more environmentally aware to act.
Resources&Materials Required (worksheet,charts, handouts, didactic video, excerpt from books/manuals, mind maps, etc.)	• didactic video (WP2-P2-LearnSTEM-Learning resource_Fertilizer, Acid rain and algae growth_EN.mp4), • PPT (WP2-P2-LearnSTEM-Learning resource-Pollution_ Fertilizer, Acid rain and algae growth_EN.pptx), • additional resources (WP2-P2-LearnSTEM_text_ Fertilizer, Acid rain and algae growth_ADDITIONAL RESOURCHES_EN.docx), • assessment (H5P) (WP2-P2-LearnSTEM_text_Fertilizer, Acid rain and algae growth-H5P_EN.docx), • experiment (similar to the video presented above)
Procedure	Instructional steps which trainees need to follow: 1. Presentation and discussion of (15-20 min). 2. Introduce the issue of eutrophication and harmful algal growth and the consequences on the environment. (10 min) 3. Display the video (10 min) 4. **EXPERIMENT (30-40 min)** **Materials:**

	two-litre plastic bottles with the tops cut off or glass jars, phosphate-based dishwasher detergent, vinegar, fertiliser, distilled water, tap water, lake water. **Procedure:** Prepare the bottles: Fill one bottle with distilled water, one bottle with tap water, and some bottles with lake water. Add phosphates to some bottles filled with lake water by adding the high-phosphate dishwasher detergent. Add vinegar and fertiliser to other bottles. Add different quantities. Label the bottles clearly, and mix well. Leave one bottle of lake water as the control. Place the bottles together in a warm place that receives plenty of sunlight. **Observations:** Appoint one-two students to record observations for each day on the Observation Chart. Students should record any subjective observations they have about the flasks. Things to look for include: overall appearance, turbidity, colour, sediments, and odour. Keep the water levels constant from day to day by adding enough water to replace the loss from evaporation. Unless your water is heavily chlorinated, tap water will do. **Class discussion:** At the end of two weeks, gather the class and discuss the results. What was the relationship between nutrients and algae growth? What did the algae do to the quality of the water? What would be the best way to keep algae from growing in Lakes and Seas? Be sure to bring up the subject of nonpoint source pollution. How can it be prevented? **Options:** Teachers might elect to have trainees measure algae concentrations by preparing microscopic slides then counting the number of algae found in a microscopic field. This data could then be recorded and charted on a graph. A bottle can be prepared identically to one of the others, but then placed in a dark area to produce the effect of no sunlight on algae growth. 5. Discuss findings and relate to issues we have to deal with in real life about soil erosion, marine life degradation, wall degradation, forests and species extinction, humans life degradation. (15-20 min). 6. Assessment (H5P) (10 min) 7. Clean up any messes (5 min).
Content Delivery Methods (lecture,discussions, research, group work, etc.)	lecture, discussion, brainstorming, research, group work
Assessment Method	H5P
References (if necessary) (please use APA Style)	