

Hazard Literacy Center

Hazard Literacy Education Program

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Why Does a Manhole Cover “Pop” Up? Urban Disasters Caused by Pressure



1. Program Overview

This program is a hazard literacy–based educational program designed around the Disasters and Safety unit of the Grade 9 Science curriculum in Korea’s 2022 Revised National Curriculum. It aims to help students scientifically understand why manhole covers may be lifted or suddenly propelled upward during heavy rainfall and apply this understanding to safe decision-making and behavior. Grade 9 is an appropriate stage for students to apply scientific concepts related to fluids, such as pressure and buoyancy, to the interpretation of real-world hazards and disasters. The Disasters and Safety unit is also designed to help students scientifically understand the causes of natural hazards and explore ways to prepare for and respond to them. Because students have relatively few opportunities to study fluid pressure as an independent concept in high school, connecting scientific concepts to real-world disaster situations at the middle school level provides a particularly meaningful learning experience. Achievement standard [9과22-01] requires students to investigate data related to cases of hazards and disasters and scientifically analyze their causes and impacts. Achievement standard [9과22-02] requires students to use scientific principles to develop strategies for disaster preparedness and response. Accordingly, this program focuses on real-world incidents in which manhole covers are lifted or propelled upward during torrential rainfall. Students first identify the hazardous situation and then conduct a small-scale model experiment using the POE (Predict–Observe–Explain) model. Through the experiment, they observe how a manhole cover can be lifted as pressure inside a sewer system increases and investigate the relationship between pressure and force. Finally, students connect their experimental findings to real-world urban flooding. They use scientific principles to explain why areas around manholes can become dangerous during heavy rainfall and discuss appropriate safety behaviors. Through this process, students move beyond simply learning pressure as a scientific concept or formula and apply it to a real-life hazard. In doing so, they develop hazard literacy—the ability to anticipate risks based on scientific reasoning and make informed decisions for their own safety.

Grade Level	Grades 9 (Middle School)	Instructional Methods	POE (Predict–Observe–Explain) model, inquiry-based experiments, discussion, and presentation
Learning Environment	Science Lab	Duration	90 minutes (45 minutes × 2 class periods)
Required Materials	Manhole model experiment kit, syringes, transparent cups, plastic wrap, rubber bands, coins, water, and worksheets		

2. Learning Objectives (Hazards Literacy Framework)

① Students will be able to explain why manhole covers may be lifted or propelled upward during heavy rainfall by applying the relationship between pressure and force.

② Students will be able to use experimental evidence to explain the relationship between changes in pressure inside a sewer system and the lifting of a manhole cover.

③ Students will be able to scientifically explain why areas around manholes should be avoided during heavy rainfall and practice appropriate safety behaviors.

Learning Objectives	Knowledge & Understanding		Reasoning & Skills					Values & Attitudes			Psychology & Emotion			Behavioral & Practical Enagement		
	A1	A2	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2	D3	E1	E2	E3
Objective ①	O	O	O													
Objective ②				O	O											
Objective ③								O						O	O	

3. Key Concpets

· Causes of Urban Flooding Disasters and the Role of Pressure (Increased pressure inside sewer systems during heavy rainfall and the resulting upward movement of manhole covers)

· Interpreting Disaster Phenomena through the Relationship between Pressure and Force

· Investigating Changes in Pressure and the Upward Movement of Manhole Covers through a Small-Scale Model Experiment

· Understanding Urban Flooding Disasters and Practicing Safe Behavior Based on Scientific Principles

4. Program Sequence

Learning Activities	
Introduction	·Introduce the problem situation by watching a video of a manhole cover being propelled upward during heavy rainfall. ·Predict: "Why can a heavy manhole cover be lifted during torrential rainfall?"
Activity1	·Draw and examine the structure of an underground sewer system. ·Review key concepts related to pressure (water pressure and air pressure) and force. ·Develop a model-based hypothesis to explain what causes a manhole cover to rise.
Activity2	·Conduct a small-scale model experiment to investigate the upward movement of a manhole cover. ·Observe how the results change depending on whether the drainpipe is open or blocked, the mass placed on the model manhole cover, and the presence or absence of water above the cover. ·Compare and record the movement of the cover under different experimental conditions.
Activity3	·Compare the experimental results with real-world urban flooding incidents. ·Interpret the relationship between increased pressure inside sewer pipes and the upward movement of manhole covers. ·Examine the risks around manholes during torrential rainfall and discuss appropriate safety behaviors.
Wrap-up	·Review the scientific concepts by comparing students' initial predictions with the experimental results. ·Summarize a scientific explanation for why people should stay away from manholes during torrential rainfall.

5. Theoretical Background and Activity Design for Disaster Education

In urban areas, torrential rainfall can cause a large volume of rainwater to flow into sewer systems within a short period of time, potentially exceeding their drainage capacity. When water and air inside the sewer system cannot be discharged efficiently, internal pressure can increase, exerting a large upward force on the underside of a manhole cover. As a result, the cover may be lifted or displaced. This phenomenon is not simply caused by an increase in the amount of water; rather, it is an urban disaster phenomenon involving the combined effects of pressure, force, area, and fluid behavior.

Accordingly, this program is designed to help students recognize the hazardous situation through videos of actual manhole cover displacement incidents and investigate its causes using the POE (Predict–Observe–Explain) model. Students first predict why a manhole cover may be lifted and then use a small-scale model experiment to directly observe how an increase in pressure inside a sewer system can cause the cover to rise. They then interpret their experimental results based on the relationships among force, pressure, and water pressure and connect these findings to real-world urban flooding. Using scientific principles, students explain why areas around manholes should be avoided during heavy rainfall.

Through these activities, students develop hazard literacy by using scientific principles to interpret disaster phenomena, anticipate potential risks, and make evidence-based decisions about appropriate safety behaviors.

6. Instructional Considerations

Students may initially explain the upward movement of a manhole cover simply by saying that “there is more water, so it pushes the cover upward” or that “the water above the manhole cover is heavy, so the cover moves.” Teachers should therefore use the experiment to help students recognize that even when water is present above the manhole cover, a sufficiently large increase in pressure inside the sewer system can exert a greater upward force from below.

Teachers should also clarify that the small-scale experiment is a model that represents key features of the phenomenon in order to investigate the relationship between increased pressure inside a sewer system and the upward movement of a manhole cover. Students should understand that actual manhole-related accidents during heavy rainfall are more complex and can be influenced by multiple factors, including rainfall intensity, drainage conditions, and the structure of the sewer system.

During the POE activities, the emphasis should not be on whether students’ initial predictions are correct or incorrect. Instead, students should be encouraged to explain the reasoning behind their predictions. After the experiment, teachers should guide students to compare their initial ideas with the experimental evidence and reflect on how their scientific understanding of manhole cover displacement has changed.

Finally, teachers should avoid limiting the activity to memorizing formulas related to pressure. Instead, students should apply the scientific principles they have learned to real-world safety decisions, such as understanding why they should stay away from manholes during torrential rainfall. In this way, the activity can extend beyond scientific understanding to the behavioral and practical dimensions of hazard literacy.

7. References

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Why Do Manhole Covers Pop Up?
The Science of Pressure in Urban Disasters

Topic	Understanding why manhole covers pop up during heavy rainfall by exploring the relationship between pressure and force
What Will We Learn?	① I can explain why manhole covers pop up during heavy rainfall using the relationship between pressure and force. ② I can identify the direction of the force caused by pressure in a real-life disaster situation. ③ I can explain why we should stay away from manholes during heavy rainfall and practice appropriate safety behaviors.

1 Exploring the Problem Situation

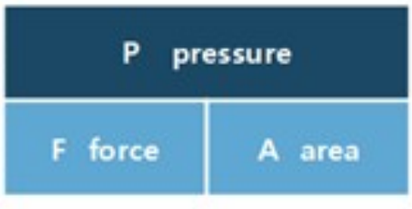
- [Video] Let's watch a video showing a 40 kg manhole cover popping up during heavy rainfall.

Q1. Describe what happens in the video in one sentence.

Did you know?
Every summer, during periods of heavy rainfall, accidents involving manhole covers suddenly popping up are reported across the country.Why does this keep happening?
Let's use the principles of pressure to find out!

2 Making a Prediction

Key Concept: The Relationship among Pressure (P), Force (F), and Area (A)



Pressure (P) = Force (F) ÷ Area (A)
Force (F) = Pressure (P) × Area (A)

$P = \rho \times g \times h$
The greater the water depth h, the greater the pressure.

Q2. "Why does a heavy manhole cover pop up during heavy rainfall?"
Choose the most reasonable prediction and put a ✓ next to it.

- (A) During heavy rainfall, too much water accumulates, and the weight of the water pushes the manhole cover upward.
- (B) The manhole cover pops up because of the impact of cars passing over the road.
- (C) The manhole cover pops up because it has become weak over time and expands in the summer heat.
- (D) The pressure inside the sewer suddenly increases, and the resulting force pushes the manhole cover upward.

Why did you choose this answer? What evidence supports your prediction?

✦ Our Group's Hypothesis:

3 Conducting the Experiment

Experiment
Why Does a Manhole Cover Lift Up in a Blocked Sewer?

Materials: Transparent plastic cup, plastic wrap, rubber band, straw, 50 mL syringe, small disk (lid), modeling clay, water, ruler sticker or ruler, water-based marker

▸ Exploring the Experimental Setup



Cup = space inside the sewer
Plastic wrap (orange dashed line) = barrier blocking the sewer
Straw + syringe = device used to increase pressure
Disk = manhole cover (adjust its weight using modeling clay)



Modeling clay thickness: 0.5 cm / 1 cm

▸ Setting Up the Experiment (Assemble the apparatus only once.)

① Stretch the plastic wrap tightly and evenly over the opening of the cup and secure it with a rubber band.
② Make a hole in the side of the cup and connect the straw to the syringe.
③ Place the small disk on top of the plastic wrap.

▸ Testing Different Conditions (Test each of the following four conditions.)

① Disk Only (Basic Condition)
Slowly push the syringe to inject air. Observe whether the disk lifts up.

② Adding Modeling Clay (No Water)
Place a thin layer of modeling clay on the disk and repeat the experiment in the same way as in Condition ①.

③ Modeling Clay + 0.5 cm of Water
Pour water onto the modeling clay until the water level reaches 0.5 cm. Check the height using a ruler, and repeat the experiment in the same way as before.

④ Modeling Clay + 1 cm of Water
Add more water until the water level reaches 1 cm. Repeat the experiment and compare the amount of force needed to push the syringe.

▸ Precautions

☐ Push the syringe slowly.
☐ Use only a small amount of water.

▸ Observation Record

Record how much the cover lifts, the amount of force needed to push the syringe, and any other observations under each condition.

Condition	How Much the Cover Lifts	Force Needed to Push the Syringe	Other Observations
① Disk Only (Basic Condition)			
② Modeling Clay (No Water)			
③ Modeling Clay + Water (0.5 cm)			
④Modeling Clay + Water (1 cm)			

💧 TIP: Measure the water level on the modeling clay accurately using a ruler or ruler sticker so that you can compare the conditions fairly.

4 Explaining the Results

Q3. As the water level on the modeling clay increased (0.5 cm → 1 cm), how did the pressure (force needed to push the syringe) required to lift the cover change? Explain your answer using the relationship between pressure, force, and area.

Q4. Did the cover still lift when there was water on top of it? Based on your observation, write your opinion about the idea that "a manhole cover is safe when it is submerged in rainwater."

Compare your initial prediction with the experimental results.

Initial Prediction

Experimental Results

Q5. Based on the results of this experiment, explain why a manhole cover may lift or be blown off during actual heavy rainfall.

5 Connecting to Safety Actions & Wrap-Up

Q6. Write at least three safety actions we can take during heavy rainfall.

1 _____

2 _____

3 _____

Q7. Write about the most important new thing you learned from today's activity or something you became more curious about.

🔑 Today's Key Takeaways

Pressure (P) = Force (F) ÷ Area (A)

→ In a smaller space, even the same force can produce greater pressure.

During heavy rainfall, pressure inside a sewer can suddenly increase and push up a manhole cover. Therefore, during heavy rainfall, never go near manholes or storm drains!