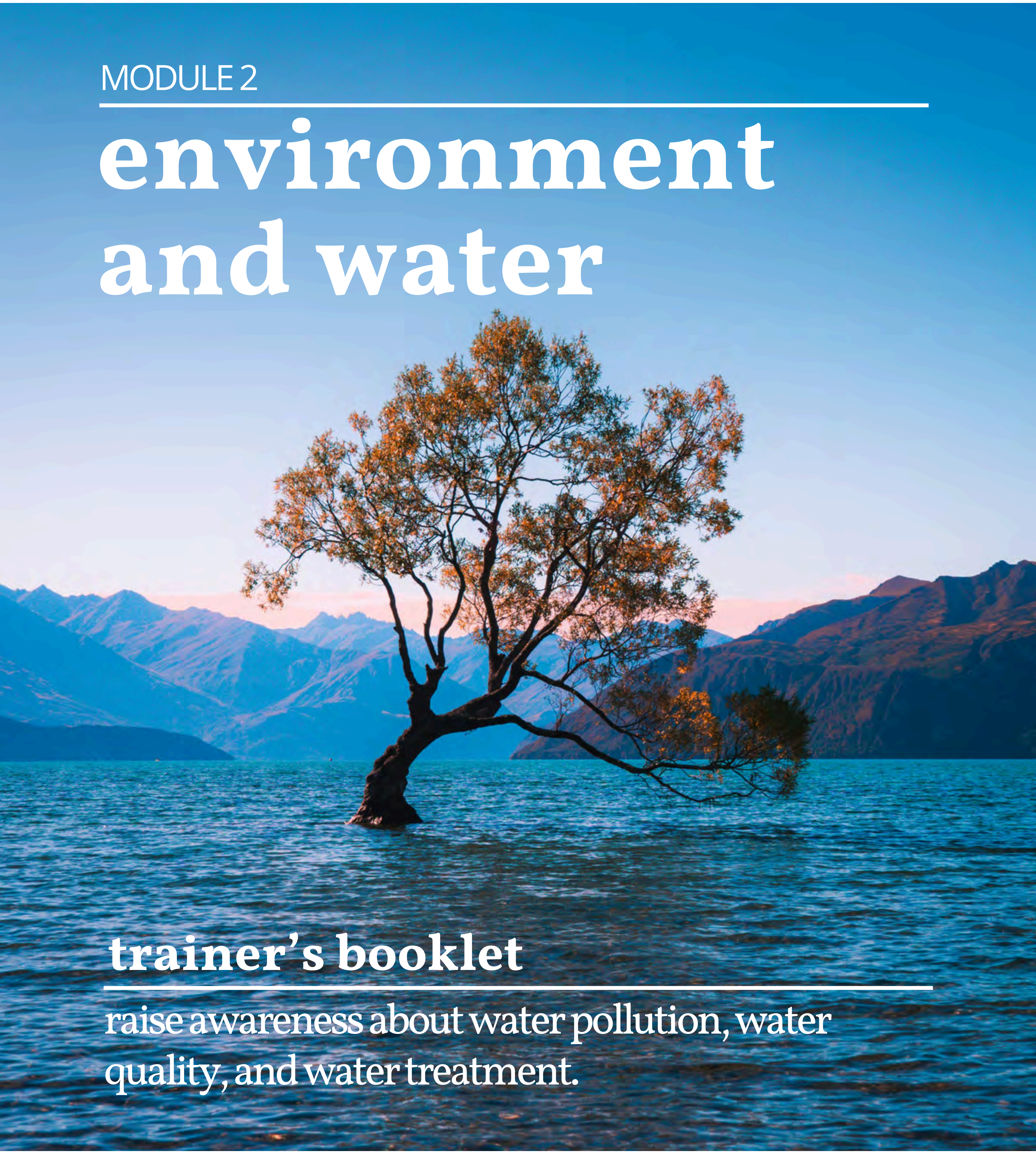
Interreg NEXT Black Sea Basin

Co-funded by the European Union

ecosystem

MODULE 2

environment and water



trainer's booklet

raise awareness about water pollution, water quality, and water treatment.

IDEA Universal (Turkey)

DUTH (Greece)

UABSC (Ukraine)

İO-BAS (Bulgaria)

ENVIRONMENT AND WATER

NO	ACTIVITIES	STATUS
1	Let’s Design a Water Filter!	80 minutes
2	Aquaponics: A Self-Sustaining Food System	80 minutes
3	Every Drop Counts: Rainwater Harvesting	80 minutes
4	Oil Spill Cleanup Challenge	80 minutes
5	Investigating Water Quality	120 minutes

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

LET'S DESIGN A WATER FILTER!

Ages 8-15

Environment and Water

80 minutes

Key Concepts

- Water Pollution
- Water Quality
- Water Filtration
- Sustainable Solutions

Purpose: In this activity, it is aimed for students to raise awareness of the importance of clean water and the impacts of water pollution, design and test a functional water filter, and enhance their skills in applying STEM-based approaches to analyze data, solve real-world problems, and develop sustainable solutions.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Learning Outcomes

By the end of this activity, students will be able to:

- Understand the importance of clean water for human life and ecosystems.
- Disccuss the causes and effects of water pollution.
- Identify key properties of potable water.
- Apply the engineering design process to create a functional water filter.
- Evaluate the environmental and economic implications of their designs.
- Enhance collaborative problem-solving and critical thinking skills.

Materials

For Building the Filter: Water design kit (includes pre made components for filter structure), activated carbon, zeolite, cotton balls, filter paper, sand, gravel, gloves; **For Testing Water:** pH meter, conductivity sensor, beaker, stopwatch; **For Simulating Polluted Water:** Plastic bottle (2.5 L), water, food coloring, vinegar, sand, dust and small debris (e.g., dust, leaves etc.); worksheets, markers and pencils.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

EDUCATOR GUIDELINES

1- Introduction (5 minutes)

- Begin by discussing the importance of clean water for life and provide real-world examples of water pollution.
- Ask the following questions to engage students:

o Why is clean water essential for life?
o What are the main causes of water pollution?
o What solutions have you heard of to combat water pollution?

- Briefly explain the principles of water filtration systems and highlight the properties of the materials commonly used in filtration.

2- Problem Identification and Research (15 minutes)

- Divide students into teams of three to five members and assign each team the challenge: designing an effective and portable water filtration system that meets the criteria for clean drinking water.
- Encourage teams to research the properties and functions of filtration materials using available resources to better understand the problem.
- Teams should identify the key criteria and constraints for their designs and document their initial ideas for further development.

3- Designing and Prototyping (20 minutes)

- Provide teams with the materials and ask them to design their water filters.

Materials like activated carbon, zeolite, sand, and gravel should be rinsed and dried in advance to ensure they are clean and ready for use.

- Encourage them to answer the following questions during the design process:

o Which materials will you use, and why?
o In what order will you layer the materials?
o What criteria will determine the success of your filter?

- Ask each team to draw their design on a worksheet and explain the key features of their filter.

4- Testing and Data Collection (20 minutes)

Safety Reminder: Before testing, remind students that the water filtered during this activity is not safe for drinking and should never be consumed.

- *Teams test their filters by using the provided polluted water samples, which consist of:*

o 2 L of water
o 200 ml vinegar
o 100 ml sand
o Food coloring
o Small debris (e.g., dust etc.).

- *Ask students to record the following measurements:*

o pH, coductivity, turbidity, color, and odor before and after filtration.
o The filtration time and the volume of filtered water.

- *Teams organize their findings in a data table for comparison.*
- *Emphasize that failures during the prototyping or testing process are a natural part of the engineering design process. Students should analyze what went wrong and suggest improvements.*

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

5- Analysis and Discussion (15 minutes)

- *Teams present their findings, highlighting the strengths and weaknesses of their designs.*
- *Guide the discussion with questions like:*

o Which materials were most effective in improving water quality?
o What design modifications could improve your filter's efficiency?

6- Reflection and Application (5 minutes)

- Conclude the activity by promting students with reflective questions:

o What was the most surprising thing you learned?
o What challenges did you face during the filtration process?
o How does this activity connect to global water pollution and purification challenges?

- Discuss how water filtration systems contribute to sustainable water management, ecosystem health, and resource conservation.
- Finally, summarize the key points and emphasize the role of engineering design, data analysis, and problem-solving in addressing water sustainability challenges.

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

BACKGROUND

Water Pollution

Water pollution refers to the degradation of water quality caused by the introduction of harmful substances, making it unsuitable for living organisms and detrimental to their health. Diseases associated with water pollution include diarrhea, cholera, dysentery, typhoid, and polio. Consuming contaminated water or coming into contact with polluted water can lead to the spread of these diseases and other serious health issues.

Moreover, water pollution disrupts the natural balance in aquatic ecosystems, threatening aquatic life. Polluted seas, lakes, and rivers negatively impact industries like fishing, tourism, and other economic activities. The decline in aquatic species due to pollution can reduce fishery productivity and lead to economic losses in tourism. Additionally, water pollution limits the usability of water resources and makes access to clean water more challenging.

Common causes of water pollution include agricultural activities, such as fertilizers and pesticides washing into surface and groundwater due to rainfall; untreated wastewater from industrial facilities, mines, thermal power plants, and households; soil erosion that transports sediment into water bodies; atmospheric pollutants settling into water sources; and oil spills or land-based oil leaks contaminating surface and groundwater.

Water Quality

Water quality is assessed by scientists using various methods and indicators. For example, water samples are tested for the presence of coliform bacteria, such as Escherichia coli, which are found in the intestines of humans and animals. For water to be considered drinkable, no coliform bacteria colonies should be present in a 100 ml sample.

Another indicator of water quality is the level of dissolved oxygen (DO). Oxygen in water originates from aquatic producers or the atmosphere. As temperature and pollution increase, DO levels decrease. DO levels below 3 mg/L can be fatal for many marine organisms.

Scientists also perform chemical analyses to identify and quantify specific pollutants in water. To monitor water pollution, indicator organisms are used. For instance, aquatic plants from polluted ecosystems are analyzed for contaminants in their tissues. Similarly, filter-feeding benthic species, such as mussels, are examined to determine water quality.

The quality of drinking water is evaluated based on criteria such as color, odor, turbidity, pH, conductivity, and the presence of total coliform bacteria, as shown in the following table.

Some Characteristics of Drinking Water

ATTRIBUTES	IDEAL VALUES
Color	Colorless
Odor	Odorless
Turbidity	Clear, <5 NTU (Nephelometric Turbidity Unit)
pH	6.5–9.5
Conductivity (at 20°C)	<2500 µS/cm (microsiemens/cm)
Total coliform bacteria	0/100 ml

Source: *Official Gazette of the Republic of Turkey (February 17, 2015)*

Water Filtration

Water filtration is a process used to remove impurities, suspended solids, and harmful contaminants from water, ensuring it is safer and more suitable for both human use and environmental sustainability. This process is vital for improving water quality and addressing challenges such as pollution, limited access to clean water, and ecosystem protection.

The materials used in a water filtration system are key to its success. Each material is selected based on its ability to target specific contaminants, such as organic pollutants, heavy metals, or suspended particles. For example, some materials excel in reducing turbidity, while others are effective in removing harmful chemicals or odors. The right combination of materials ensures that the filtration process is efficient and meets the required standards for water quality.

The following table provides an overview of commonly used filtration materials, their unique properties, and their specific roles in improving water quality. Understanding these properties helps in designing effective filtration systems that can address diverse water contamination issues.

Common Filtration Materials and Their Functions

FILTRATION MATERİALS	KEY FUNCTIONS
Gravel/Stone	• Serves as a preliminary filter, trapping larger particles and debris. • Improves water clarity by reducing turbidity. • Provides structural stability for other filtration layers.
Activated Carbon	• Absorbs organic compounds, heavy metals, and chlorine. • Eliminates unpleasant odors and colors. • Highly effective due to its porous structure, which traps contaminants.
Zeolite	• Absorbs ammonia and harmful chemicals through its porous channels. • Neutralizes bad odors. • Enhances the chemical quality of water by reducing contaminants.
Sand	• Removes smaller suspended particles and solids. • Reduces turbidity effectively, making water clearer. • Serves as an essential layer in multi-stage filtration systems.
Filter Fiber / Cotton Balls	• Filters out fine and small solid particles. • Functions as an additional barrier in the filtration process. • Needs regular replacement to maintain filtration efficiency.

WORKSHEET

Dear Team Members,

Clean water is essential for life, yet millions around the world lack access to it. Water pollution is a critical global issue that affects ecosystems, public health, and economic stability. This highlights the urgent need for innovative solutions to transform polluted water into a safe and usable resource.

In this activity, you will design and test a water filtration system. Your task is to create a portable, efficient, and cost-effective filter that meets essential water quality standards. Through this experience, you will explore how science and engineering can address real-world problems and improve lives.

To guide your design process, ensure that your water filtration system meets the following criteria and constraints:

- The filtered water must meet drinking water quality standards, including appropriate levels for pH, conductivity, turbidity, color, and odor.
- The filtration process should not exceed 15 minutes for 200 ml of water.
- The design must be portable and suitable for use in various settings.
- Filtration should be manual and should not require electricity. Advanced option: Electrical systems may be used, but energy efficency and cost-effectiveness should be considered.
- The entire task must be completed within the specified time frame.

Let's take on this challenge together and make a meaningful difference in creating a more sustainable future!

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 1: Identify the Problem

What challenge is your team addressing? Write down the criteria and constraints that your water filter must meet. How do these requirements influence your design approach?

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

Step 2: Conduct Research

Consider the materials provided. What are their properties, and how can they contribute to water filtration? Materials like activated carbon, zeolite, and sand each play a unique roles. What do you think those roles are? Record your findings and discuss them with your team to develop strategies for an effective design.

Step 3: Generating Solutions

What are your possible ideas for the water filter? Collaborate with your team to sketch different prototypes and decide how to arrange the materials. What features make each design practical, portable, and effective? Explain your decision-making process in detail.

Step 4: Choose the Best Possible Solution

The fifth environment you experienced belongs to which biome? Provide information about the animals and vegetation that have adapted to this biome. Compare the animals and vegetation you observed with those in other biomes. What similarities and differences do you notice?

Step 5: Build the Prototype

The fourth environment you experienced belongs to which biome? Provide information about the animals and vegetation that have adapted to this biome. How do the animals you observed survive in this biome? What behavioral and physical adaptations have they developed? What types of plants can survive in this biome? What common characteristics do these plants have?

Step 6: Test and Evaluate

To test your prototype, use the polluted water samples provided. Begin by measuring the key water quality parameters such as pH, conductivity, turbidity, color, and odor before and after filtration. Record the filtration time and the volume of clean water your filter produces. Ensure all data is organized systematically into the following table. This will allow you to analyze and compare the effectiveness of your filtration design.

Water Quality Evaluation

Team Name	Filter Design Features			Pre-Filtration Observations				Post-Filtration Results			
	Materials Used (Layer Order)	Amount of Each Material	Filtration Time (Minutes)	Volume	pH	Conductivity	Color Odor Turbidity	Volume	pH	Conductivity	Color Odor Turbidity
				200 ml							
				200 ml							
				200 ml							
				200 ml							
				200 ml							

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 7: Share Results

Present your water filter design, the testing process, and the results to the class. Emphasize which criteria were successfully met and discuss the strengths and weaknesses of your prototype. Compare your results with other teams to evaluate the most effective design and identify areas for further improvement.

Step 8: Redesign

Reflect on your initial design and the results of your tests. Consider what aspects of your design worked well and what could be improved. Based on your observations, propose changes that could enhance the effectiveness and efficiency of your water filter.

Step 9: Final Reflection

Think about what you have learned through this activity about water filtration and the engineering design process. Reflect on how this knowledge can be applied to address global challenges related to water pollution, water scarcity, and access to clean water.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

AQUAPONICS: A SELF-SUSTAINING FOOD SYSTEM

Ages 8-15

Environment and Water

80 minutes

Key Concepts

- Aquaponic Systems
- Nitrogen Cycle
- Water Quality
- Sustainable Agriculture

Purpose: In this activity, it is aimed for students to understand the role of water quality, the nitrogen cycle, and sustainable agriculture practices in an aquaponic system. Students will investigate how water parameters affect plant and fish health and, additionally, they will engage in engineering design and mathematical modeling to optimize the system's efficiency.

Learning Outcomes

By the end of this activity, students will be able to:

- Explain the concept of sustainable agriculture.
- Explore the nitrogen cycle in real life.
- Understand the principles of aquaponic systems.
- Collect and interpret real-life data related to water quality.
- Develop critical thinking and problem-solving skills by troubleshooting system issues.
- Apply engineering design principles to improve the aquaponic system.
- Use mathematical modeling to analyze plant growth and water quality trends.

Materials

Temperature probe, pH probe, dissolved oxygen probe, ammonia, nitrite, and nitrate test kits, worsheets, markers and pencils.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

EDUCATOR GUIDELINES

1- Introduction (5 minutes)

- Begin by discussing the importance of sustainable food production and aquaponics.
- Ask the following questions to engage students:

o Why is sustainable agriculture important for the future?

o How does aquaponics compare to traditional agriculture?

o What are the advantages and challenges of aquaponics?

- Introduce the nitrogen cycle and its relevance to aquaponic systems.

2- Problem Identification and Research (15 minutes)

- Divide students into teams of three to five members and assign each team the challenge: Designing an optimized aquaponic system that balances plant and fish growth while ensuring stable water quality parameters.
- Encourage teams to research the properties of different aquaponic system components and materials.
- Teams should identify the key criteria and constraints for their designs and share their initial ideas for further development.

3- Designing and Prototyping (20 minutes)

- Provide teams with materials to visualize their aquaponics system design.
- Ask teams to create a model representation or detailed schematic of an aquaponic system.
- Encourage discussion on:

o What components are essential for a functioning system?
o How will they monitor water quality and plant growth?
o What potential challenges might arise, and how can they address them?

- Each team sketches their design and prepares an explanation of their system's features.

4- Testing and Data Collection (20 minutes)

- Discuss how nitrogen moves through the system before data collection.

o Fish produce waste containing ammonia (NH_3).
o Nitrite bacteria convert ammonia into nitrite (NO_2^-).
o Nitrate bacteria convert nitrite into nitrate (NO_3^-).
o Plants absorb nitrate as nutrients.

- Teams collect water quality data from the aquaponic system available at the center.
- Measurements should include: temperature, pH, dissolved oxygen ammonia, nitrite, and nitrate.
- Encourage students to think about how their measurements relate to nitrogen cycle.
- Students document their observations and record the collected data in tables on their worksheet.
- Have students create a flowchart or diagram illustrating the nitrogen cycle in an aquaponic system.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

5- Analysis and Discussion (15 minutes)

- Teams analyze their findings and evaluate the efficiency of the aquaponic system
- Guide discussion with questions such as:

o Which water parameters are within the ideal range? Which parameters need adjustment? What might be the possible reasons?

o If ammonia or nitrite levels are high, what actions would you take to restore balance? How does maintaining optimal water quality benefit both fish and plants in the aquaponic system?

o What would happen if pH levels were too high or too low? How would it affect nutrient absorption?

o Based on your measurements, what adjustments could optimize the system's performance and efficiency?

- Students use their worksheet to organize, visualize, and interpret the recorded data, identifying key patterns and trends.

6- Reflection and Application (5 minutes)

- Conclude the activity by asking reflective questions:

o What was the most surprising thing you learned?

o How could the knowledge from this activity be applied to real- world sustainable agriculture solutions?

- Discuss how aquaponics contributes to food security, water conservation, and promotes sustainable agriculture.
- Summarize the key points and emphasize the importance of system design, data analysis, and problem-solving in optimizing aquaponic systems.

BACKGROUND

What is Aquaponics?

Aquaponics is an integrated system that combines aquaculture (fish farming) and hydroponics (soilless plant cultivation). It mimics a natural ecosystem where fish waste provides essential nutrients for plants, while plants filter and clean the water for the fish. The nitrogen cycle plays a crucial role in maintaining the system's balance, ensuring that toxic ammonia from fish waste is converted into nitrates, which plants utilize for growth. This system supports sustainable agriculture by reducing water use, minimizing chemical fertilizers, and increasing food production in areas with limited arable land.

Historically, aquaponics-like systems have been used for centuries. The Aztecs developed a method called Chinampas, which consisted of artificial floating islands on lakes where they grew crops. These islands were supported by nutrient-rich water channels, creating an early form of aquaponics. Today, modern aquaponic systems use controlled environments and technology to maximize efficiency and sustainability.

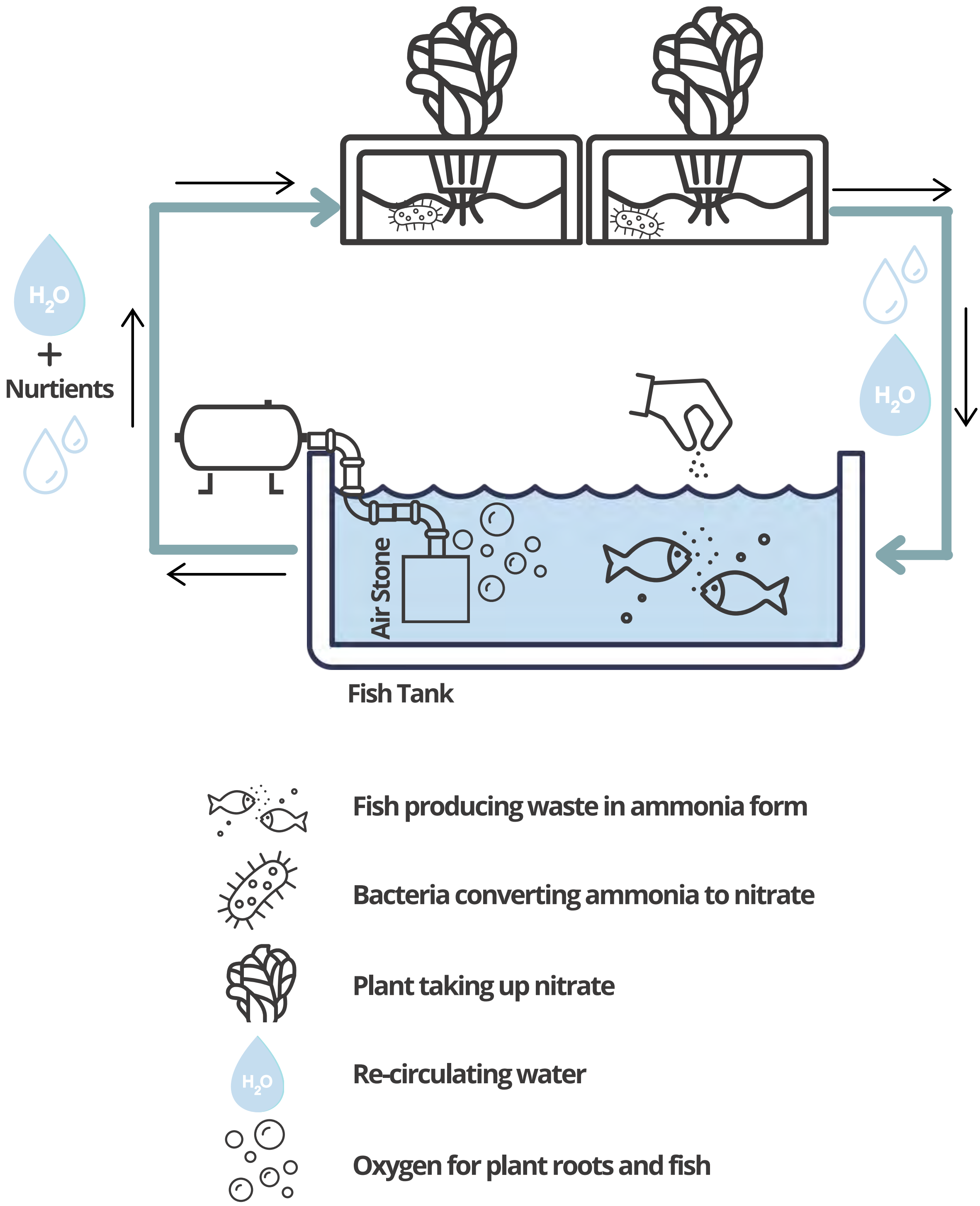


Figure 1. Aquaponic System

Source: *Someville, Cohen, Pantanella, Stankus, & Lovatelli (2014)*

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

The Nitrogen Cycle in Aquaponics

The nitrogen cycle ensures that fish waste is transformed into usable plant nutrients.

Steps of the nitrogen cycle:

- Fish produce waste containing ammonia (NH_3).
- Nitrite bacteria (Nitrosomonas) convert ammonia into nitrite (NO_2^-).
- Nitrate bacteria (Nitrobacter) convert nitrite into nitrate (NO_3^-).
- Plants absorb nitrate, utilizing it as a nutrient for growth.
- Clean water is recirculated back into the fish tank.

This cycle enables an efficient, waste-free system that mimics natural aquatic ecosystems.

Benefits of Aquaponics

Aquaponics is gaining popularity due to its environmental, economic, and social benefits:

- Water efficiency: Uses 90% less water than traditional soil-based farming.
- No chemical fertilizers: Fish waste serves as a natural nutrient source.
- No soil required: Ideal for urban farming, deserts, and non-arable land.
- Higher yields: Maximizes space with continuous crop production.
- Sustainable food production: Provides both fish protein and fresh vegetables.
- Eco-friendly: Prevents pollution by recycling nutrients within the system.

Types of Aquaponic Systems

Different aquaponic designs exist, depending on scale, resources, and goals:

- Media bed system: Uses gravel or clay pebbles as a growing medium. Best for small-scale units.
- Nutrient film technique (NFT): Water flows in thin layers over plant roots. Common in commercial systems.
- Deep water culture (DWC): Plants float on rafts over water. Best for large-scale leafy green production.

Water Quality Parameters for Aquaponic Systems

For aquaponic systems to function optimally, several water quality parameters must be monitored:

Water Quality Parameters for Aquaponic Systems

PARAMETERS	IDEAL RANGES	PURPOSE
Temperature	18–30°C (species dependent)	Regulates fish metabolism, plant growth, and bacterial activity
pH	6.0–7.0	Supports bacterial, fish, and plant health.
Dissolved Oxygen	>5 mg/L	Essential for bacteria, fish, and plant health.
Ammonia (NH_3)	<1 mg/L	Prevents fish toxicity and supports bacterial conversion.
Nitrite (NO_2^-)	<1 mg/L	Avoids harmful accumulation for fish and bacteria.
Nitrate (NO_3^-)	5–150 mg/L	Optimal for plant growth while maintaining safe levels for fish.

Regular testing ensures system stability and prevents imbalances that can harm fish and plants.

Challenges and Considerations

While aquaponics offers many advantages, challenges include:

- **High initial costs:** Setting up the system requires an investment in equipment.
- **Technical knowledge:** Operators must understand fish care, water chemistry, and plant nutrition.
- **Energy use:** Pumps and aeration require consistent electricity.
- **System maintenance:** Regular monitoring of water quality is essential.

Applications of Aquaponics

Aquaponics is used globally for food security, education, and commercial farming:

- **Urban farming:** Rooftop and indoor aquaponic systems.
- **Sustainable agriculture:** Reduces reliance on chemical inputs and conserves water.
- **Education and research:** Used in schools to teach STEM principles.
- **Disaster relief and food security:** Provides fresh food in crisis areas.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

WORKSHEET

Dear Team Members,

Sustainable food production is one of the greatest challenges of our time. Traditional farming methods require large amounts of water and extensive land, whereas aquaponic systems offer an innovative solution by combining fish farming (aquaculture) and soilless plant cultivation (hydroponics).

In this activity, you will examine how aquaponic systems function, analyze water quality nd investigate the role of the nitrogen cycle in maintaining system balance., aBy evaluating the data you collect, you will develop recommendations to enhance system efficiency.

The key questions to begin your research:

- How do fish, plants, and bacteria interact in an aquaponic system?
- What role does the nitrogen cycle play in maintaining water quality?
- How do water quality measurements help assess system efficiency?

Let's explore the world of aquaponics and contribute to a more sustainable future!

Step 1: Problem Identification and Research

Research different aquaponic system components and their functions. Identify key criteria and constraints for designing an optimized system. Discuss the challenges of maintaining balance between fish, plants, and water quality. Document your findings and initial ideas in the table below:

COMPONENTS	FUNCTION IN THE SYSTEM	SYSTEM NEEDS	HOW IT MEETS ITS NEEDS	HOW IT HELPS OTHER ORGANİSMS	POTENTIAL CHALLENGES
Fish					
Plant					
Bacteria					
Water					

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 2: Designing and Prototyping

Sketch a schematic of an optimized aquaponic system. Label the essential components and explain their roles. Discuss: *How will water quality be monitored and maintained? What design improvements could enhance plant and fish growth? What external factors could affect the system's performance?*

Draw your design here:

Step 3: Observing the Aquaponic System

Visit the aquaponic unit at the center. Record your initial observations about the system's appearance and function. Take notes on the structure, water clarity, fish activity, and plant health. Answer the following: *How does the real aquaponic system compare to your prototype design? What unexpected features or challenges did you notice? How does environmental variation (e.g., temperature, light) affect the system?*

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

Step 4: Understanding the Nitrogen Cycle

Draw a simple flowchart to explain how nitrogen moves through the system, starting with fish eating food. Below are the labels you should correctly place in your flowchart:

D	Nitrate is absorbed by plants.
A	Fish produce waste containing ammonia (NH_3).
C	Nitrate bacteria convert nitrite into nitrate (NO_3^-)
B	Nitrite bacteria convert ammonia into nitrite (NO_2^-)

Step 5: Testing and Data Collection

Record the provided data from water quality measurements:

DATE/TIME	TEMPERATURE (°C)	PH	DISSOLVED OXYGEN (MG/L)	AMMONIA (NH3) (MG/L)	NITRITE (NO2–) (MG/L)	NITRATE (NO3–) (MG/L)
OBSERVATIONS						

Compare your measurements with the ideal ranges:

PARAMETERS	IDEAL RANGE	YOUR MEASUREMENT	EVALUATION
Temperature (°C)	18–30°C (species dependent)		☼ Excellent / ▮ Good ! Needs Attention / ⊠ Critical
pH	6.0–7.0		☼ Excellent / ▮ Good ! Needs Attention / ⊠ Critical
Dissolved Oxygen (mg/L)	>5 mg/L		☼ Excellent / ▮ Good ! Needs Attention / ⊠ Critical
Ammonia (NH_3) (mg/L)	<1 mg/L		☼ Excellent / ▮ Good ! Needs Attention / ⊠ Critical
Nitrite (NO_2^-) (mg/L)	<1 mg/L		☼ Excellent / ▮ Good ! Needs Attention / ⊠ Critical
Nitrate (NO_3^-) (mg/L)	5–150mg/L		☼ Excellent / ▮ Good ! Needs Attention / ⊠ Critical

Step 6: Identifying and Solving Problems

Examine the system for possible inefficiencies. Use the "Aquaponic System Troubleshooting Guide" to determine potential solutions. Fill in the table below by specifying clear steps to restore balance to the system.

ISSUE OBSERVED	POSSIBLE CAUSE	SUGGESTED SOLUTION

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 7: Reflection and Discussion

Based on your findings, discuss: *What surprised you the most about the aquaponic system? How can aquaponics contribute to global food security? What modifications could improve the system's efficiency?*

Water Quality Issues

Issues	Possible Causes	Effects	Solutions
Ammonia and nitrite levels > 1 mg/L	• Insufficient bacterial activity. • Biological filter capacity too low or too many fish. • Organic waste accumulation (uneaten feed, dead fish, solid waste).	• Fish experience stress and may die.	• Immediately replace 1/3 to 1/2 of the system water with fresh water. • Remove any uneaten food or accumulated waste from the tank. • Stop feeding the fish until levels decrease. • Ensure pH and temperature are suitable for nitrifying bacteria. • Optimize biological filtration capacity and feeding regimen.
Nitrate levels > 150 mg/L (for several weeks)	• High feeding rate (excessive daily feed per square meter of plant area).	• No immediate threat, but continuous nitrate buildup can harm fish over time.	• Test ammonia, nitrite, nitrate, and pH levels. • Identify and eliminate the stressor (e.g., poor water quality, oxygen deficiency, organic pollution, or disease). • Perform a partial water change to reduce toxin buildup. • Improve aeration and water circulation.

Fish Health Issues

Issues	Possible Causes	Effects	Solutions
Fish are gasping at the water surface.	• Low dissolved oxygen levels. • High water temperature reducing oxygen solubility.	• Fish experience severe stress and may die due to oxygen deprivation.	• Ensure the air pump is working properly. • Increase aeration or add additional air stones. • Reduce water temperature by providing shade or using cooling techniques.
Fish are not eating.	• Low oxygen levels. • High ammonia, nitrite, or nitrate levels. • Extreme pH fluctuations. • Disease or stress.	• Fish stop feeding, weakening their immune system and increasing the risk of disease.	• Test ammonia, nitrite, nitrate, and pH levels. • Identify and eliminate the stressor (e.g., poor water quality, oxygen deficiency, organic pollution, or disease). • Perform a partial water change to reduce toxin buildup. • Improve aeration and water circulation.
Water temperature is too high (>33°C) or too low (<15°C).	• Seasonal temperature fluctuations.	• At high temperatures, fish stop eating, and plants may wilt. • At low temperatures, nitrifying bacteria slow down, and some fish refuse to eat.	• For high temperatures: Provide shade to keep water cool. • For low temperatures: Insulate the system and use a heater if necessary. • Adjust fish species to match the climate conditions.

Plant Growth Issues

Issues	Possible Causes	Effects	Solutions
Plants are not growing or leaves are discolored.	• Nutrient deficiency. • Excessive temperature stress. • Root disease.	• Plants show stunted growth, yellowing leaves, and reduced yield.	• Ensure water quality is optimal for plant uptake. • Check nitrate levels; if too low, gradually increase fish feed. • Inspect for root and stem diseases.
Nitrate levels are high, but plant leaves are turning yellow.	• pH imbalance affecting nutrient uptake. • Deficiency of essential micronutrients.	• Plants fail to grow properly and may not produce fruit.	• Adjust pH to a range of 6.0-7.0 for optimal nutrient absorption. • Supplement with aquaponics-safe fertilizers such as seaweed extract or compost tea.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Electrical, Air Pump, and System Issues

Issues	Possible Causes	Effects	Solutions
Pump is not working, but electricity is available.	• Pump failure or clogging.	• Oxygen levels drop, and system balance is disrupted.	• Check for blockages in the pre filter or pipes. • Replace the pump if it is malfunctioning.
Pump is not working, and there is no electricity.	• Power outage.	• Water circulation and oxygen levels decrease.	• Consider using a backup power system (UPS, generator). • Manually stir water every hour until power is restored.
Water is accumulating under the unit, and tank water level is dropping.	• Leak or crack in the system.	• Water loss leads to stress and potential death of fish and plants.	• Immediately identify and repair the leak. • Regularly monitor water levels and refill as needed.
Water appears green.	• Algae bloom.	• Oxygen levels drop, and system balance is disrupted.	• Reduce direct sunlight exposure to the system. • Physically remove algae and consider adding shade covers.

EVERY DROP COUNTS: RAINWATER HARVESTING

Ages 8-15

Environment and Water

80 minutes

Key Concepts

- Rainwater Harvesting
- Water Conservation
- Sustainability

Purpose: In this activity, it is aimed for students to raise awareness about the importance of rainwater harvesting as a sustainable water management solution. By analyzing the efficiency of an existing rainwater harvesting system, students will explore the potential of this method to conserve water resources, meet irrigation demands, and contribute to environmental sustainability.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Learning Outcomes

By the end of this activity, students will be able to:

- Understand the principles and importance of rainwater harvesting, including its role in addressing water conservation.
- Calculate the amount of rainwater collected using real-life data.
- Evaluate the efficiency of rainwater harvesting systems in fulfilling specific water demands.
- Conduct analysis using mathematical and engineering disciplines and propose improvements for sustainable solutions.
- Enhance collaborative problem-solving and critical thinking skills.

Materials

Tablets with Internet access, calculator, local weather data (digital or printed), worksheets, markers and pencils.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

EDUCATOR GUIDELINES

1- Introduction (5 minutes)

- Begin by discussing the global water crisis and its impact on human life, agriculture, and ecosystems.
- Introduce rainwater harvesting as a sustainable solution to mitigate water conservation issues.
- Ask the following questions to engage students:

o Why is water conservation important in combating climate change?
o How does rainwater harvesting reduce the strain on traditional water supplies?
o Can you think of any examples of rainwater harvesting systems in your community or elsewhere?

2- Problem Identification and System Overview (30 minutes)

- Introduce the rainwater harvesting system built at the Center.
- Explain its components (e.g., rooftop catchment, filtration unit, storage tank).
- Describe its purpose: providing irrigation water for the Center's green spaces.
- Challenge students with the following tasks:

o Calculate the total rainwater collected and evaluate the system's efficiency in meeting irrigation needs.

- Provide the necessary data for calculations:

o Catchment Area: Real value from the Center
o Annual Rainfall: Localized data
o Roof Runoff Coefficient: 0.8
o Filter Efficiency Coefficient: 0.9

3- Research and Redesign (20 minutes)

- Divide students into teams of three to five members and ensure that they design their system while considering the key criteria and constraints.
- Encourage teams to explore rainwater harvesting principles, focusing further on:

o Innovative features such as dual storage systems, advanced filtration methods, and smart technologies (e.g., sensors).
o System efficiency improvements for optimal rainwater collection and usage.

- Assign teams to:

o Design an improved version of the rainwater harvesting system.
o Create sketches of their proposed designs, including explanations for each component and its purpose.

4- Presentation, Discussion, and Reflection (25 minutes)

- Teams present their designs to the class, emphasizing:

o Strengths and weaknesses of their proposed systems.
o The expected impact of improvements on water collection and usage.

- Facilitate a class discussion with guiding questions:

o Which features make the design more efficient?
o What challenges might arise during implementation?
o How could this system be adapted for different locations or scales?

BACKGROUND

Rainwater Harvesting

Rainwater harvesting is the practice of collecting and reusing rainwater for various purposes. This practice plays a significant role in supporting environmental sustainability at both individual and societal levels. Rainwater is typically collected from roofs, open surfaces, or specially designed storage areas and can be used for irrigation, cleaning, and, when properly treated, even as drinking water. This method has historical roots in ancient civilizations like the Romans, Chinese, and Egyptians, who recognized its importance. In modern times, it addresses increasing water demand and climate change induced droughts, making it a cornerstone of sustainability.

Types of Rainwater Harvesting Systems

Rainwater harvesting can be implemented through various systems. One of the most common methods is rooftop rainwater harvesting. In this system, rainwater is collected from rooftops via gutters, passed through filters, and stored in tanks. The stored water can then be used for irrigation, toilet flushing, or vehicle washing. On a larger scale, surface-based systems collect rainwater from open areas and store it in reservoirs. Additionally, subsurface systems channel rainwater underground, contributing to the replenishment of aquifers and supporting groundwater reserves.

Benefits of Rainwater Harvesting

Rainwater harvesting offers environmental, economic, and social benefits. Environmentally, it reduces the demand on freshwater resources, prevents soil erosion, and aids in the replenishment of groundwater reserves. Economically, it lowers water bills and provides a reliable water source during emergencies such as droughts. Socially, it offers a solution for communities with limited access to water, reduces health risks, and fosters awareness of water conservation among individuals.

Scientific Aspects of Rainwater Harvesting

Scientifically, the efficiency of rainwater harvesting depends on several key factors. The intensity and frequency of rainfall directly impact the amount of water collected. Additionally, engineering design factors, such as the type and slope of the roof surface, influence system efficiency. Parameters like the roof runoff coefficient and filter efficiency coefficient are critical for maximizing the quantity and quality of harvested rainwater. Furthermore, filtration and disinfection systems are essential to ensure the water is safe for various uses.

Rainwater harvesting provides a sustainable solution for both individuals and communities. When implemented correctly, it can enhance resilience against water scarcity, reduce the risk of flooding, and contribute to the preservation of natural resources. As such, rainwater harvesting plays a crucial role in addressing contemporary environmental challenges, including climate change and the depletion of water resources.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

WORKSHEET

Dear Team Members,

Drought is an increasingly urgent environmental challenge, impacting ecosystems, agriculture, and access to clean water. As climate change intensifies these effects, developing innovative strategies for water conservation and management is crucial to ensuring a sustainable future.

Rainwater harvesting—the practice of collecting and storing rainwater for reuse—provides a practical and sustainable approach to water conservation. By utilizing this natural resource, we can reduce dependence on conventional water supplies, particularly in regions facing water scarcity.

In this activity, your task is to examine the existing rainwater harvesting system at our Center. Using the system's current layout and provided criteria, you will calculate the potential amount of rainwater collected and analyze how effectively it meets the irrigation needs of the green spaces in the center. Additionally, you will propose innovative improvements to optimize the system's performance.

Your system must adhere to the following criteria and constraints:

- The system must collect rainwater from a specified catchment area.
- A filtration stage must be included to ensure the quality of the collected water.
- The collected rainwater should primarily support irrigation needs.
- The system must function efficiently under the environmental conditions of your local area.

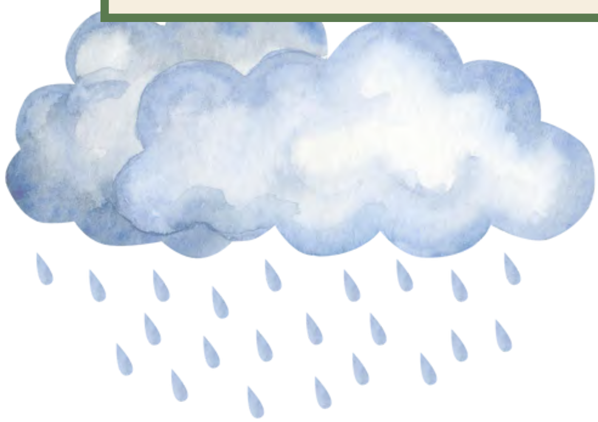
Let's contribute to water conservation and develop solutions for a greener and more sustainable future!

Step 1: Identify the Problem

What is the primary purpose of the existing rainwater harvesting system at the Center?

What are the main components of a rainwater harvesting system?

What data do you need to calculate the system’s rainwater yield?



Step 2: Calculate Rainwater Yield

Rainwater Yield Formula:
Rainwater Yield (liters) = Catchment Area (m²) × Annual Average Rainfall (mm) × Roof Runoff Coefficient × Filter Efficiency Coefficient
Rainwater Yield Formula Terms:

- **Catchment Area (m²):** The total area (e.g., a roof) where rainwater is collected.
- **Annual Average Rainfall (mm):** The average amount of rainfall a location receives over a year.
- **Roof Runoff Coefficient:** The percentage of rainwater that can be collected.

o Standard Value: 0.8 (as specified by the German Institute for Standardisation, 2002).

- **Filter Efficiency Coefficient:** The percentage of water passing through the filter.

o Standard Value: 0.9 (as specified by the German Institute for Standardisation, 2002).
Rainfall Data for Istanbul (1991–2020):
Monthly Total Rainfall Averages in Istanbul (mm)

Month	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Rainfall(mm)	80.2	75.2	62.9	50.0	36.4	33.3	24.0	24.1	45.1	75.2	67.2	99.2	672.8

Source: Turkish State Meteorological Service (2025)

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

What is the total annual rainwater yield for the roof area of the Center? *(Use the given formula, rainfall data, and standard coefficients.)*

How much rainwater could be harvested during the driest month of the year? *(Use the formula and rainfall data for the month with the lowest value to calculate the yield.)*

How much rainwater could be harvested during the month with the highest rainfall? (*Use the formula and rainfall data for the month with the highest value to calculate the yield.)*

Compare the rainwater yield for the two months with the highest and lowest rainfall. What conclusions can you draw about seasonal variability and its impact on rainwater harvesting?

What would happen to the total annual rainwater yield if the roof area of the Center is expanded by 25%?

Assume that a filter clog reduces the filter efficiency coefficient from 0.9 to 0.8. How does this affect the total annual rainwater yield?

How many days can the collected rainwater sustain the irrigation needs of the Center's green spaces if they require 50 liters of water daily?

Calculate the total annual financial savings based on the harvested rainwater. Research the average cost of water (per cubic meter) in your area and use this value in your calculations.

Interreg NEXT Black Sea Basin Co-funded by the European Union | ecosystem

Step 3: Analyze the System

Based on your calculations, what are the potential inefficiencies in the system?

How do these inefficiencies impact the system's ability to meet irrigation needs?

Step 4: Propose Improvements

Work as a team to propose and refine improvements for the rainwater harvesting system. Brainstorm and discuss how the system can be improved to maximize water collection and usage.

Propose new features or technologies that could make the system more sustainable.

Create a detailed sketch of your improved system. And, label each component and explain its purpose.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 5: Present, Discuss, and Reflect

Present your team's improved system and reflect on the overall process. In your presentation, be sure to include:

- The challenges your team identified during Step 3.
- How your improved design addresses these challenges.
- The strengths and weaknesses of your proposed system.
- Use clear visuals or sketches to support your explanation and ensure all team members contribute to the presentation.

During your presentation, discuss and answer these questions:

- What features make your design more efficient?
- What challenges might arise during implementation?
- How could this system be adapted for different locations or scales?

Step 5: Present, Discuss, and Reflect

Finally, reflect on your experience as a team. Summarize:

- The key insights gained from your analysis and design process.
- How your improved system and learnings can be applied to real-world water conservation challenges.
- What you would do differently if you were to redesign the system again.

OIL SPILL CLEANUP CHALLENGE

Ages 8-15

Environment and Water

80 minutes

Key Concepts

- Oil Spill
- Environmental Pollution
- Environmental Disasters
- Nature’s Balance
- Sustainability

Purpose: In this activity, it is aimed to draw attention to the environmental and economic impacts of oil spills and emphasize the importance of preventing such disasters. By engaging in the engineering design process, students will develop innovative solutions for cleaning up oil spills and gain a deeper understanding of the delicate balance between human activities and natural ecosystems.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Learning Outcomes

By the end of this activity, students will be able to:

- Recognize the widespread uses of oil in daily life.
- Understand the properties and environmental impacts of oil spills.
- Evaluate different cleanup techniques and their limitations.
- Design and test innovative methods for oil spill cleanup.
- Calculate cleanup efficiency using data and mathematical formulas.
- Reflect on their solutions and propose improvements based on test results.
- Collaborate effectively within a team to solve a complex environmental challenge.

Materials

Measuring cylinder, plastic spoons, pasteur pipettes, pipettes, absorbents (cotton balls, cotton swabs, cotton pads, acrylic fabric pieces, wood shavings, cat litter, polypropylene foam sheet, sponges etc.), styrofoam plate, dispersants (dishwashing liquid or similar), thin cookie sticks, bird feathers rubber bands, syringe(various size), string, scissors, tape, paper towels, wet wipes, ruler, precision scale, stopwatch or timer, calculator, tablets with internet access, worksheets, markers and pencils, gloves, safety googles, aprons or lab coats.
For Simulating Seawater: Aluminum tray, water, blue food coloring;
For Simulating Oil Spill: motor oil

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

EDUCATOR GUIDELINES

1- Introduction (5 minutes)

- • Begin by discussing the importance of clean water and a healthy environment for life.
- Use the following questions to engage students and activate prior knowledge:

o Why is oil important, and where is it used?
o What is an oil spill? Have you heard about such an event before?
o What are the environmental and economic impacts of oil spills?

- Share real-world examples of oil spills, such as recent oil spill in the Black Sea. Use relevant visuals or videos to grab students' attention and ask for their observations and thoughts.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

2- Problem Identification and Research (10 minutes)

- Divide students into teams of three to five members and asign each team the challenge:

"Design an effective and innovative solution to clean up oil spills in water."

Encourage students to research using the following guiding questions:

o How do oil spills happen?

o What are the environmental and economic consequences of oil spills?

o What methods are currently used to clean up oil spills, and how effective are they?

- Teams should consider key criteria and constraints for their designs and take notes on their findings and initial ideas.

3- Designing and Prototyping (20 minutes)

- Provide teams with the materials.
- Ask teams to create their designs and address these questions during the process:

o What materials will you use, and why?

o How will your design remove oil efficiently?

o How will you measure the success of your design?

- Each team sketches their design on the worksheet, explaining its key features and the expected results.

4- Testing and Data Collection (15 minutes)

- Safety Reminder: Emphasize that the water used in this activity is for simulation purposes and must not be consumed.
- Each team tests their designs using a polluted water simulation that includes:

o 800 ml of water, 50 ml of oil, 10 grams of sand, and 5 drops of blue food coloring.

Teams measure and record the following data:

o Amount of initial oil volume, oil removed, and oil remaining (ml).

o Time taken for cleanup (minutes).

o Observations about remaining pollution or residue.

- Teams organize their findings into a data table for analysis.

5- Analysis and Discussion (15 minutes)

- Teams present their findings, highlighting the strengths and weaknesses of their designs.
- Facilitate a class discussion with these guiding questions:

o Which materials were the most effective for removing oil?

o What challenges did you encounter during the process?

o What changes could improve the design's efficiency?

- Encourage students to reflect on how their designs could be applied in real-world scenarios.

6- Refining the Design (10 minutes)

- Ask students to revisit their designs and address these questions:

o How could the cost of your design be reduced?

o Are there more sustainable materials that could be used?

o How could the cleanup process be made faster?

- Allow teams to sketch improved designs and discuss their changes.

7- Concluding Activity (5 minutes)

- Summarize the activity with reflective questions:

o What was the most surprising thing you learned today?

o How can your design or ideas be applied to address real-world oil spill challenges?

- Highlight the importance of collaboration, innovation, and the engineering design process in solving global environmental problems.
- Congratulate students on their creativity and encourage them to think about how they can contribute to environmental solutions.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

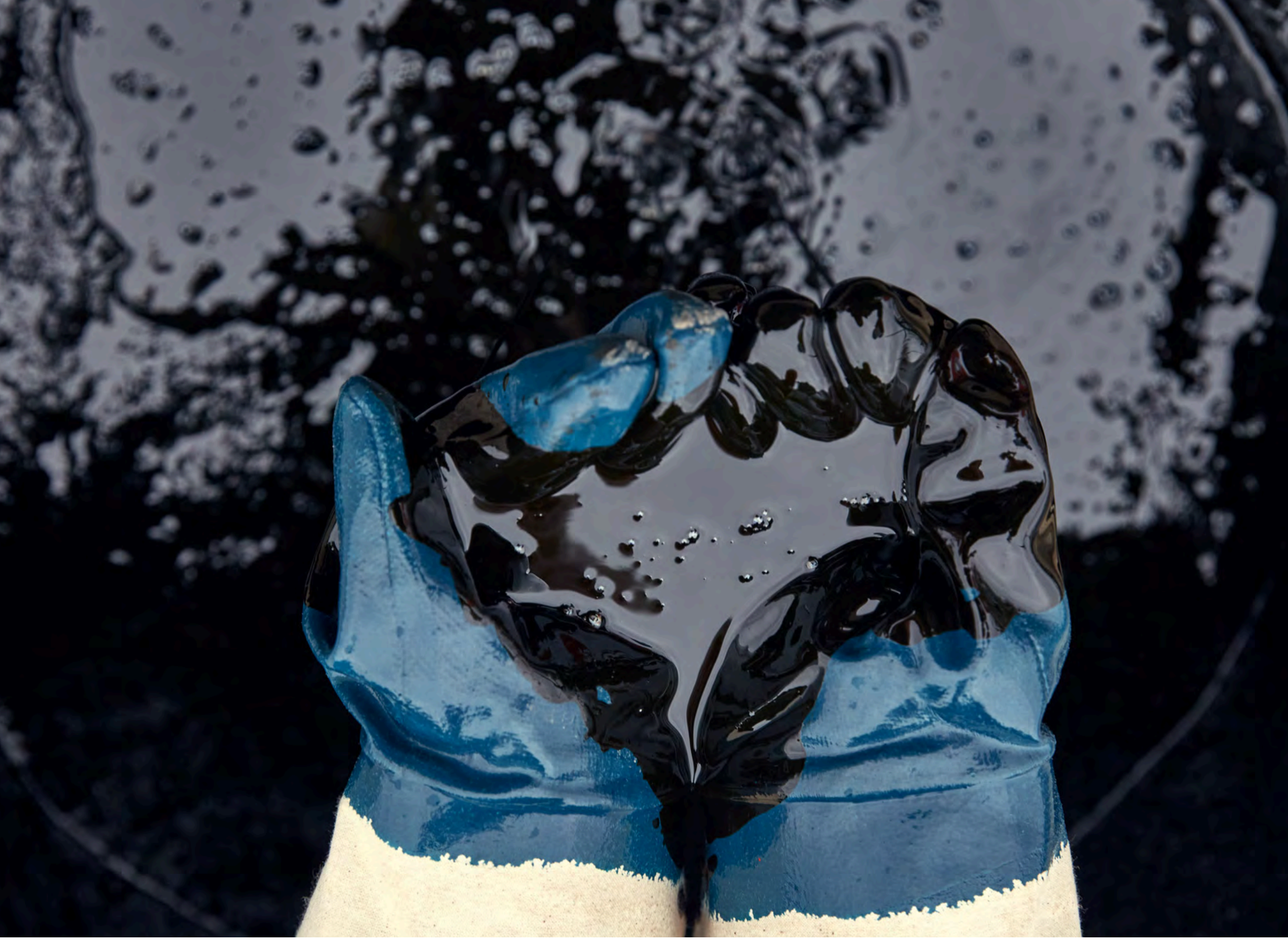
BACKGROUND

What is an Oil Spill?

An oil spill is the unintentional release of crude oil or refined petroleum products into the environment. These spills often occur during extraction, transportation, or storage processes. For example, the 2010 Deepwater Horizon spill released approximately 5 million barrels of crude oil into the Gulf of Mexico. This incident caused significant ecological damage, harming marine life and coastal ecosystems, while also leading to substantial economic losses for local industries reliant on fishing and tourism.

What Happens When Oil Spills into Water?

Oil and water typically do not mix due to differences in their densities. Most types of oil, being less dense than water, float on the surface, forming a layer that blocks sunlight and oxygen, thereby disrupting aquatic ecosystems. However, some oils, like heavy fuel oil (e.g., M100-grade), can solidify, adhere to sediments or organic materials, and sink to the seabed, where they persist and cause long-term damage. Unlike lighter oils that spread on the surface, heavy oils can form dense clumps, making cleanup more challenging and impacting both the water surface and seabed ecosystems.



Impacts of Oil Spills

Environmental Impacts:

- Oil covers bird feathers, reducing their ability to stay warm or fly.
- Marine mammals like dolphins and whales face breathing difficulties as oil clogs their blowholes.
- Sunlight blocked by oil reduces photosynthesis, harming aquatic plants.

Economic Impacts:

- Declines in fish populations harm fishing industries.
- Contaminated beaches reduce tourism revenue.
- Cleanup efforts are costly and time-intensive.

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

How Can Oil Spills Be Cleaned?

Cleaning up oil spills requires a combination of methods tailored to the type of oil, the environmental conditions, and the affected area. Here are some commonly used techniques:

- **Booms and Skimmers:** Barriers contain the oil, while skimmers physically remove it from the water. These are widely used for surface spills.
- **Dispersants:** Chemicals break oil into smaller droplets, making it easier for natural processes and microbes to degrade the oil. However, their use may harm marine ecosystems in some cases.
- **Bioremediation:** Microorganisms are used to break down oil naturally. This method is eco-friendly but requires optimal conditions for microbial activity.
- **Absorbents:** Materials such as sponges, cotton, or specialized pads absorb oil. They are effective for small-scale spills and localized cleanup efforts.
- **Burning:** Controlled burns are used to remove oil on the water's surface. While efficient, this method produces air pollution and is limited to specific conditions.
- **Vacuum and Centrifuge Systems:** Advanced machinery separates oil from water. These systems are effective but costly and require proper infrastructure.
- **Manual Cleanup:** Workers physically remove oil from shorelines using tools such as shovels and rakes. This method is labor-intensive and slow.
- **Natural Attenuation:** Allowing natural processes like evaporation, sedimentation, and wave action to degrade or disperse the oil. This is often used for spills in remote areas.

Each cleanup method has its limitations and potential impacts. For example, dispersants may be effective for breaking up oil but could harm marine life. Similarly, bioremediation requires specific conditions to succeed. Combining multiple techniques is often necessary to address the diverse challenges posed by oil spills. By considering these factors, engineers and scientists design customized solutions to mitigate the environmental and economic impacts of spills. Understanding the strengths and weaknesses of each method is crucial for effective decision-making and environmental protection.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Common Uses of Oil

- Fuel: Powers transportation vehicles, including cars, ships, and airplanes.
- Plastics: Used in the production of synthetic materials and packaging.
- Medicines: Many pharmaceuticals are petroleum-based.
- Energy Production: Powers electricity plants and industrial processes.

While oil is vital for modern industries, its extraction, transport, and use come with significant environmental risks.

Key Questions to Explore

The Gulf War oil spill of 1991 released an estimated 240 million gallons of oil into the Persian Gulf, marking it as the largest accidental spill in history. Its impact still serves as a reminder of the long-term consequences of oil spills.
•How does oil impact marine and coastal ecosystems?
•What methods work best for cleaning up oil spills?
•How do engineers design tools and techniques for oil spill cleanup? These questions will guide your exploration as you develop innovative solutions to address the challenges posed by oil spills.

Eco-friendly Facts

- Certain naturally occurring bacteria, such as Alcanivorax borkumensis, degrade oil efficiently in marine environments, offering a potential eco friendly cleanup approach.
- Advances in technology, including nanotechnology and biodegradable dispersants, are revolutionizing oil spill responses. These innovations aim to minimize environmental harm while increasing cleanup efficiency.
- Heavy fuel oils, like M100-grade fuel, are particularly challenging as they can sink to the seabed, making traditional cleanup methods less effective and requiring innovative engineering solutions.
- Sustainable practices, such as the development of reusable absorbents, contribute to reducing the ecological footprint of oil spill responses

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

WORKSHEET

Dear Team Members,

On December 15, 2024, a strong storm in the Kerch Strait of the Black Sea caused catastrophic damage to two Russian oil tankers, Volgoneft-212 and Volgoneft-239. The incident resulted in the release of approximately 5,000 tonnes of heavy fuel oil into the sea, causing one of the region's worst environmental disasters. This spill severely affected marine ecosystems and coastal habitats, particularly in areas such as the Kerch Strait and Anapa.

Natural habitats were irreversibly damaged, with oil covering an estimated 400 km^2 of sea surface. Local communities relying on fishing and tourism suffered substantial economic losses. Wildlife was heavily impacted, with over 6,000 birds delivered to rehabilitation centers and many marine species severely affected. Despite extensive cleanup efforts, the environmental and economic consequences of this disaster persist, with oil residues continuing to harm ecosystems.

The spill, consisting of heavy M100-grade fuel oil, has proven especially damaging due to its ability to solidify and sink to the seabed, where it can take decades to biodegrade. Experts predict that this disaster will have long-term implications for both regional and neighboring ecosystems.

In this activity, your task is to design, test, and evaluate an efficient solution to clean up the oil spill. Your design should meet the following criteria and constraints:
Your system must adhere to the following criteria and constraints:

- Your solution must remove 70-80% of the oil from the water.
- The cleanup process must be completed within 4-6 minutes.
- No residual materials should remain in the water after cleanup.
- The total cost of materials should not exceed 50 units (local currency)

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Through this challenge, you will explore how science, technology, and engineering can work together to address real-world problems. Your mission is to create an innovative, efficient, and eco- friendly method to clean up the spill and protect our ecosystems.

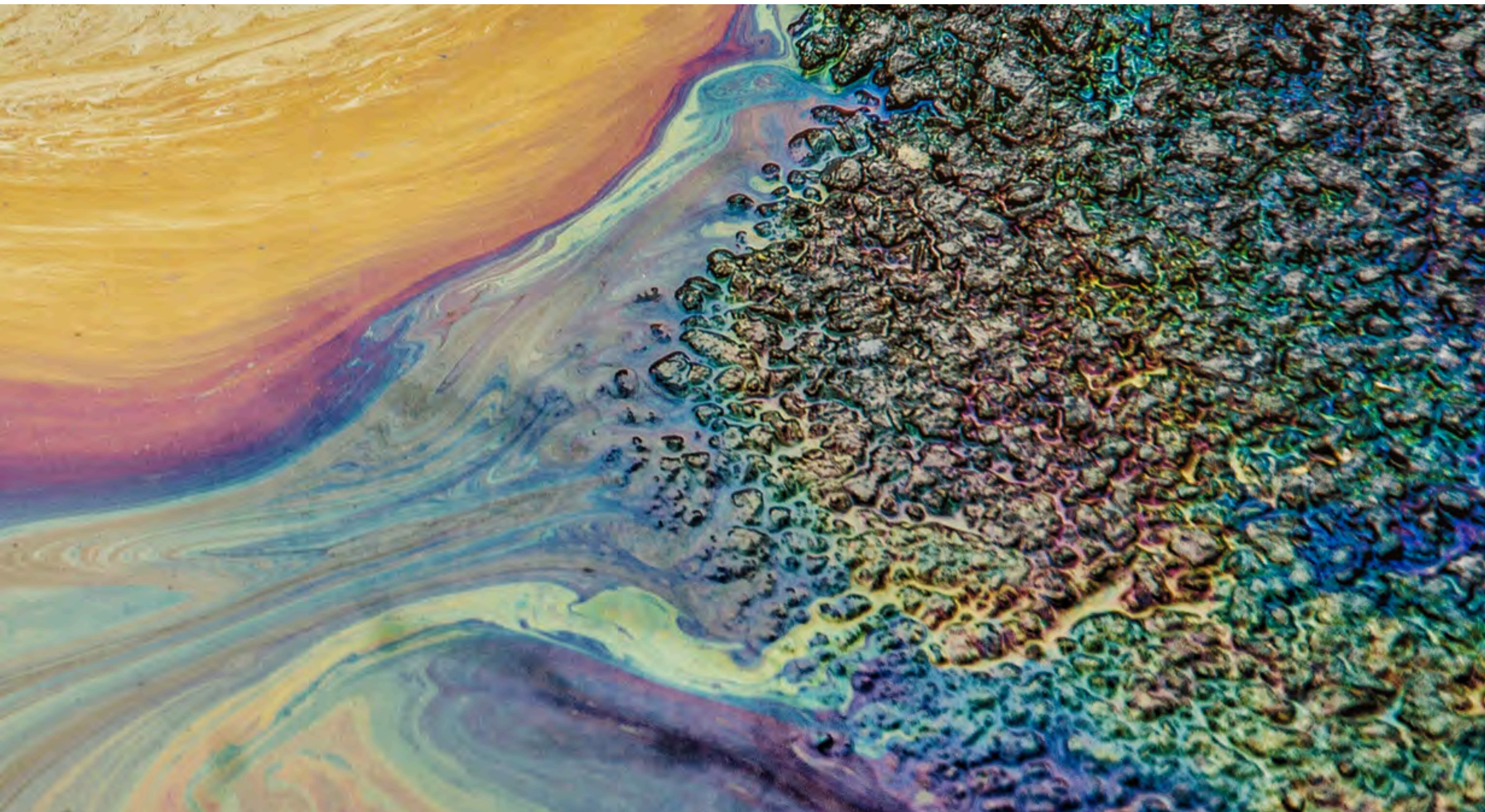
Let's take on this challenge and work towards building a cleaner and more resilient future. By participating in this activity, you will not only gain valuable skills but also contribute to promoting sustainability!

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 1: Identify the Problem

What are the challenges of cleaning heavy oil spills that sink versus those that remain on the water's surface?

Why is it essential to address the environmental and economic impacts of oil spills?



Step 2: Conduct Research

Investigate existing methods used for cleaning oil spills: *What techniques are used for surface cleanup? What methods are effective for addressing submerged oil?*

Review the properties of heavy fuel oil (e.g., density, viscosity). How do these properties influence cleanup strategies?

Step 3: Generating Solutions

Based on your research and brainstorming, sketch or describe three potential solutions. Combine or refine ideas to create your final solution.
List the materials needed for your prototype: *Why are these materials chosen? How do they function in your design?*

Step 4: Build and Test Your Prototype

Using your chosen materials, construct your prototype. Document the steps taken during construction.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Test the prototype using the following criteria:

- Percentage of oil removed from the water (target: 70-80%).
- Time required for cleanup (4-6 minutes).
- No residual materials left in the water.

Test Solutions

Solution 1: Surface Cleanup

Test No	Initial Oil Vol (ml)	Oil Removed Vol (ml)	Oil Remaining Vol (ml)	Efficiency (%)	Cleanup Time (min)	Residual Materials? (Yes/No)
Test 1	50 ml					
Test 2	50 ml					
Test 3	50 ml					
Average						

Solution 2: Subsurface Cleanup

Test No	Initial Oil Vol (ml)	Oil Removed Vol (ml)	Oil Remaining Vol (ml)	Efficiency (%)	Cleanup Time (min)	Residual Materials? (Yes/No)
Test 1	50 ml					
Test 2	50 ml					
Test 3	50 ml					
Average						

Solution 3: Combined Cleanup

Test No	Initial Oil Vol (ml)	Oil Removed Vol (ml)	Oil Remaining Vol (ml)	Efficiency (%)	Cleanup Time (min)	Residual Materials? (Yes/No)
Test 1	50 ml					
Test 2	50 ml					
Test 3	50 ml					
Average						

Formula for Efficancy Calculation:

- Efficiency (%) = $\frac{[(\text{Initial Oil Volume} - \text{Remaining Oil Volume})] \times 100}{\text{Initial Oil Volume}}$

Key Terms and Explanations:

• **Initial Oil Volume (ml):** The starting amount of oil (e.g., 50 ml, should remain constant for all tests). This value should remain consistent across all tests to ensure comparability.

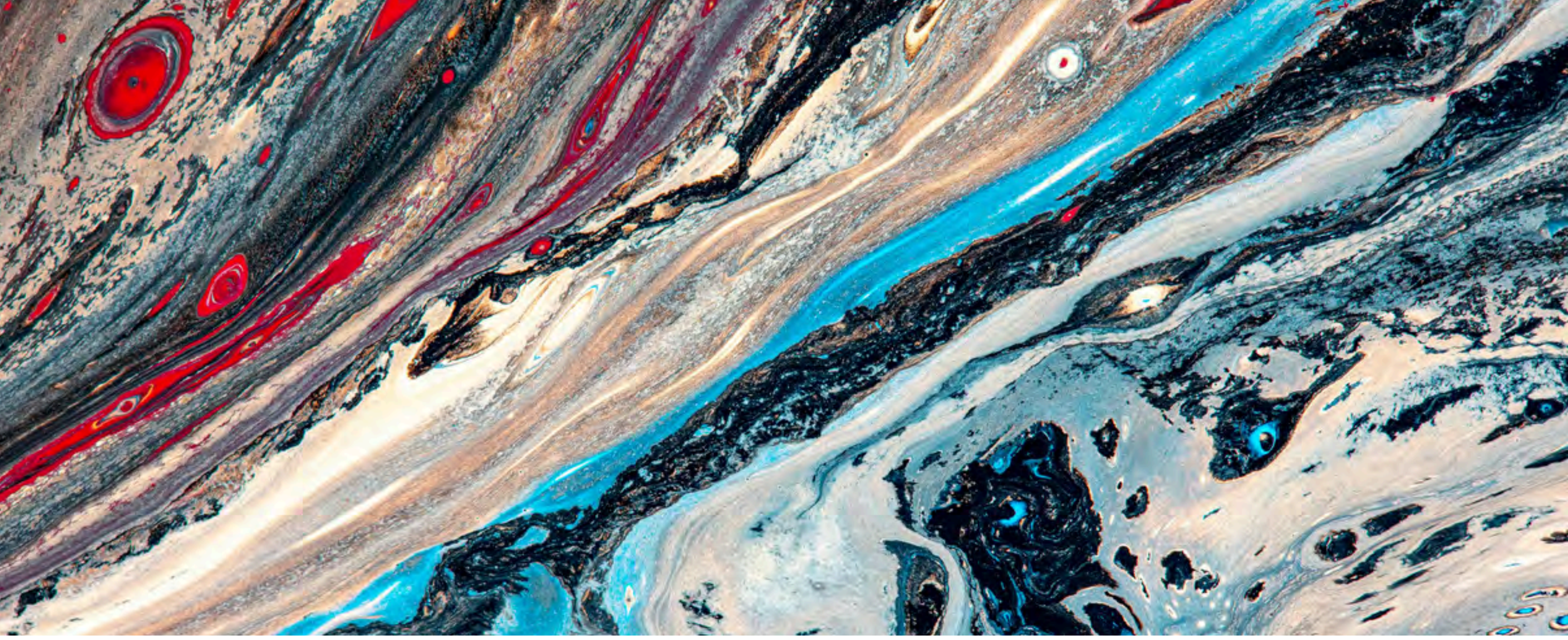
• **Oil Removed (ml):** The amount of oil removed during cleanup, calculated as: Oil Removed = Initial Oil Volume - Remaining Oil Volume

• **Oil Remaining (ml):** The amount of oil left in the water after the test has beeb completed.

• **Efficiency (%):** The percentage of oil successfully removed from the water during the cleanup process. This metric evaluates the effectiveness of the solution.

• **Cleanup Time (min):** The total time required to complete the oil spill cleanup process.

• **Residual Materials (Yes/No):** Indicates whether any debris or materials were left in the water after the cleanup.



Step 5: Analyze and Evalute

What are the strengths of your design? What area need improvement? How can you refine your design? Compare your test results. Did your solutions meet the criteria? Why or why not?

Step 6: Share and Reflect

Present your solutions and findings to the class. Your presentation should include:

✓ The problem you addressed.

✓ Your design and ow it works

✓ Test results and areas for improvement.

Reflect on your experience: *What skills did you develop during this activity? How might these skills be applied to other real-world challenges?*

INVESTIGATING WATER QUALITY

Ages 8-15

Environment and Water

120 minutes

Key Concepts

- Water Quality
- Water Quality Indicators
- Water Pollution
- Human Impact
- Sustainability

Purpose: In this activity, it is aimed for students to analyze the physical, chemical, and biological properties of water samples collected from natural water bodies. By engaging in hands-on investigations and observations, students are expected to learn about water quality indicators, identify potential pollutants (including microplastics and coliform bacteria), and evaluate their environmental impact. This activity is designed to foster scientific inquiry and critical thinking regarding freshwater ecosystems, human influences, and waterborne contaminants.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Learning Outcomes

By the end of this activity, students will be able to:

- Explain water quality indicators and their physical, chemical, and biological significance.
- Detect and classify different types and sizes of microplastics in freshwater samples.
- Conduct coliform bacteria tests to assess biological contamination in water sources.
- Analyze the impact of microplastics and coliform bacteria on human health and aquatic ecosystems using scientific data.
- Develop sustainable, evidence-based solutions to improve water quality and reduce pollution.

Materials

Water sample, water quality testing kit, coliform bacteria test kit, incubator, sample bag, petri dish, gloves, thermometer, microscope, magnifying glass, tweezers, filtration paper, filtration system, waterproof boots and waders, sterile dropper or pipette, labels, worksheets, markers and pencils.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

EDUCATOR GUIDELINES

1- Pre-Field Trip Preparation (15 minutes)

- Encourage students to reflect on the importance of clean water and sustainability.
- Introduce physical, chemical, and biological water quality indicators and pollutants.
- Provide information on the classification and environmental impacts of microplastics.
- Explain the significance of coliform bacteria in water quality assessment.
- Teach students proper water sampling techniques and guide them through the sampling process.
- Divide students into teams of three to five and assign roles (sample collector, tester, data recorder).

2- Field Study: Water Sampling and Testing (30 minutes)

- Guide students in collecting water samples from different locations.
- Assist them in observing the physical properties of the water samples, including temperature, turbidity, and color.
- Support students in measuring pH, dissolved oxygen, ammonia, nitrite, and nitrate levels using chemical test kits.
- Direct students through the filtration process for microplastic analysis.
- Facilitate the use of coliform bacteria test kits for rapid testing.

3- Data Collection and Analysis (30 minutes)

- Encourage students to record their measurements in the provided data sheets.
- Guide them in assessing the health of the water source based on collected data.
- Ensure that they compare their results with clean water standards.
- Lead discussions on identifying and analyzing pollution sources based on test results.

4- Solution Development (15 minutes)

- Encourage students to identify the primary pollution sources based on collected data.
- Guide discussions on potential solutions to improve water quality.
- Help students develop sustainable solutions, such as pollution prevention strategies, natural filtration techniques, or policy recommendations.
- Lead students in creating a plan to test the effectiveness of their proposed solutions in real-world applications.

5- Presentation and Evaluation (20 minutes)

- Encourage teams to present their findings and proposed solutions.
- Facilitate discussions on the practical applications of their solutions.
- Guide students in reflecting on what they learned about water quality.

6- Evaluation of Incubation Results (10 minutes)

- Encourage students to analyze the results of coliform bacteria test kits.
- Guide them in evaluating bacterial contamination based on color changes or result indicators.
- Lead discussions on how the collected data can be incorporated into water quality assessments.
- Ensure students understand the impact of coliform bacteria on human health and ecosystems.

7- Concluding Activity (5 minutes)

- Summarize the key takeaways from the field investigation.
- Encourage students to think critically about how they can contribute to reducing water pollution.
- Discuss long-term sustainability strategies for protecting freshwater ecosystems.

WORKSHEET

Dear Team Members,

Water quality plays a critical role in maintaining the health of ecosystems and human communities. Pollution from industrial waste, agricultural runoff, and plastic contamination can severely impact water bodies. Among these pollutants, microplastics have become a major concern. These particles enter water sources from personal care products, synthetic clothing fibers, and degraded plastic waste. Additionally, the presence of coliform bacteria in water indicates possible contamination from sewage or animal waste, which can pose risks to human and environmental health.

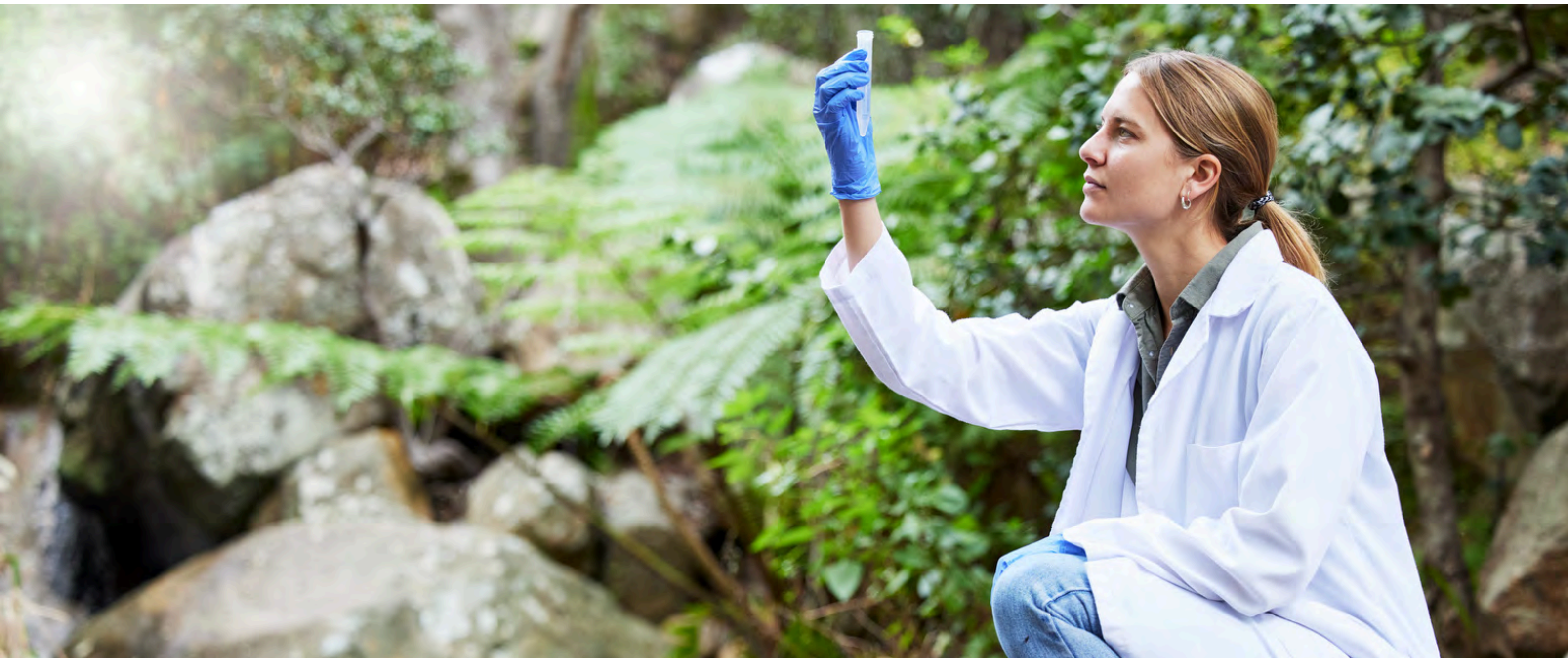
In this investigation, you will collect and analyze water samples to assess key water quality indicators, detect microplastics, and test for coliform bacteria. Using scientific methods and engineering principles, you will develop innovative solutions to improve water quality and reduce pollution.

Let's dive into this exploration and discover how we can protect our water resources for a cleaner, healthier future!

Step 1: Identify the Problem

Describe the site where you are collecting water samples. *What type of freshwater body is it (river, lake, pond, or stream)? Are there visible signs of pollution, such as litter, chemical waste, or unusual coloration? Are there nearby human activities that could contribute to pollution (factories, agriculture, urban areas)?*

Develop a hypothesis: *What are your initial expectations about the water quality at this site? What types of pollutants do you predict will be present in the water? How might different factors such as weather conditions, land use, or human activity affect water quality?*



Step 2: Research and Explore

Examine your water source and surroundings: *Observe and note any floating or suspended particles in the water. Identify any visible sources of contamination, such as wastewater discharge or agricultural runoff. Document the types of vegetation and wildlife near the water source.*

Collect a water sample following these steps:

- Use a clean collection bottle or container.
- Wear protective gear, such as gloves and waterproof boots, if needed.
- Submerge the container below the water surface to avoid debris floating on top.
- Label your sample with the location, date, and time of collection.

Investigate water quality indicators: What parameters (e.g., pH, dissolved oxygen, turbidity) are most important for assessing water quality? How do these factors help determine the presence of pollution? How will you record and analyze your findings?

Interreg NEXT Black Sea Basin Co-funded by the European Union ecosystem

Step 3: Conduct Water Quality Test

Use the Water Quality Data Sheet below to record your observations and measurements:

WATER QUALITY DATA SHEET Investigate your waterway by recording te following information.						
Date & Time				Team Name		
Waterway				Location		
Weather Condition	Sunny	Cloudy		Windy	Raining	
Rainfall estimate (past 48 hours)	*mm*	Stream		Depht	cm/m (approx)	
				Width	cm/m (approx)	
Water Temperature	°C			**Air Temperature**	°C	
Water Quality Tests **(Use your rating sheet in your kit)**	Parameters		Measurement		Comments	
	Turbidity		NTU			
	pH					
	Electrical Conductivity		µS/cm			
	Dissolved oxygen		mg/L | %			
Water Flow (Please circle one)	Permanent	Stagnant		Pools	Dry	
	Low	Medium		High	Flood/overbank	
Water appearance	Clear			Scummy	Smelly	
	Foamy/Frothy			Stained Green	Stained Brown	
	Muddy			Oily	Other:	

Is there a drain with water flowing?	**YES**	**NO**	**COMMENTS**
Coliform test	+	-	
Microplastics Presence	+	-	

Step 4: Analyze and Interpret Data

Compare your data with standard water quality guidelines: *Are the measurements within acceptable limits? What do your results indicate about pollution levels? How do the test results support or challenge your hypothesis?*

Identify patterns and relationships in your data: *Are certain pollution indicators correlated with specific pollution sources? Were any unexpected findings observed?*

Step 5: Generating Solutions and Propose Actions

Brainstorm potential methods to reduce pollution in this freshwater system: *Could filtration techniques or natural purification methods be implemented? What role do policy changes, conservation efforts, or education play in improving water quality?*

Design a solution based on your research: *Describe how your method addresses the specific pollutants detected in your water sample. List materials needed for a prototype or strategy implementation.*

Explain how your proposed solution could be tested and improved.

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

Step 6: Presentation and Reflection

Prepare a short presentation on your findings: *Explain your hypothesis and key test results. Describe your proposed solution and why it is effective.*

Reflect on your investigation: *What challenges did you encounter, and how did you overcome them? How might this investigation inform real-world environmental decisions?*

Step 7: Conclusion Activity

- Summarize the key takeaways from the field investigation.
- How can individuals and communities contribute to preventing water pollution?
- What long-term sustainability strategies can be applied to protect freshwater ecosystems?

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

REFERENCES

Abay, E. G. (2024, December, 26). Russia declares emergency over oil spill off Black Sea coast. *Anadolu Agency,* Retrieved from https://www.aa.com.tr/tr/dunya/rusya-karadeniz-sahilindeki-petrol sizintisi-nedeniyle-acil-durum-ilan-etti/3435228

Cheetham, J., Robinson, O., & Murphy, M. (2025, January, 24). Russia suffering 'environmental catastrophe' after oil spill in Kerch Strait. *BBC News.* Retrieved from https://www.bbc.com/news/articles/c23ngk5vgmpo

German Institute for Standardisation. (2002). DIN 1989-1: R*ainwater harvesting systems – Part 1: Planning, installation, operation and maintenance.* German Institute for Standardisation

Kuvaç, M., & Koç, I. (2019). E-STEM: *A middle school activity book on environmental topics for STEM teachers* (2nd ed.). Anı Publishing.

Kuvaç, M., & Koç Sarı, I. (2019). STEM applications in environmental topics. In B. Akçay (Ed.), *Approaches to science learning and teaching* (pp. 347-379). Nobel Academic Publishing.

Somerville C., Cohen M., Pantanella E, Stankus, A. and Lovatelli, A. (2014). *Small-scale aquaponic food production: Integrated fish and plant farming.* FAO Fisheries and Aquaculture Technical Paper No: 589.

Taylor, M. R., Simon, E. J., Dickey, J. L., & Hogan, K. (2022). C*ampbell biology: Concept connections* (10th ed.). Pearson Education.

Tema (2025). *Protecting water: Rain harvest.* Retrieved from https://sutema.org/yagmur-hasadi

Tema (2025). *The world of water.* Retrieved from https://sutema.org/suyun dunyasi

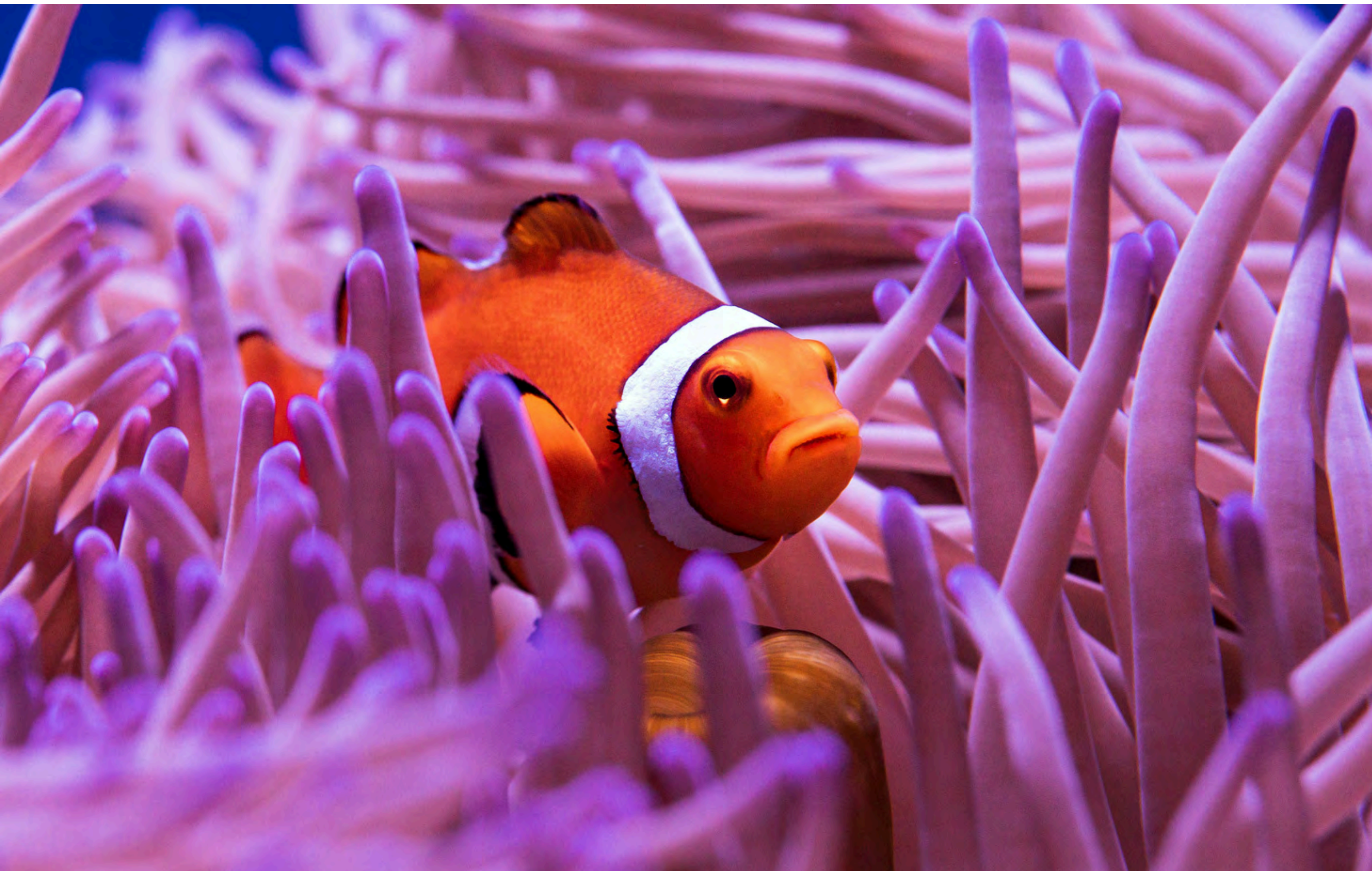
Turkish State Meteorological Service. (2025). Istanbul annual rainfall data. Retrieved from https://www.mgm.gov.tr/veridegerlendirme/il-ve ilceler-istatistik.aspx?k=undefined&m=ISTANBUL

Interreg NEXT Black Sea Basin
Co-funded by the European Union
ecosystem

United Nations Environment Programme (UNEP). (2022). Water resource management strategies. Retrieved from https://www.unep.org/topics/fresh-water/water-resources management

World Wide Fund for Nature (WWF). (2025). Rain water harvesting. Retrieved from https://www.wwf.org.tr/kesfet/gida/yagmur_suyu_hasadi/

Yalılı-Kılıç, M., & Abuş, M. N. (2018). Rainwater harvesting in a residential area. International Journal of Agricultural and Wildlife Sciences (IJAWS), 4(2), 209–215.



Proje Adı / The Title of The Project
E-STEM ile Çocukların Çevresel Sürdürülebilirlik için Güçlendirilmesi / Empowering Children for Environmental Sustainability through E-STEM

Proje Ortağının Adı / Name of The Project Partner
Uluslararası Kalkınma ve Çevre Derneği – IDEA Universal / International Association for Development and Environment – IDEA Universal

Proje Ortağının İletişim Bilgileri / Contact Details of The Project Partner
e-mail: info@ideauniversal.org
phone: +90 216 606 10 64
ideauniversal.org

Basım Tarihi / Date of Publising

24.03.2025