# "Fiery Sky: Exploring the Aerial Pathways of Fires"

(Measurement and Analysis of Fire Effects on the Atmosphere)

## Goal of the activity

The primary objective of this endeavor is to conduct a comprehensive inquiry into and quantification of diverse facets of controlled fires. These include assessing the effects of fire on air quality, determining the rate of fire propagation, evaluating the efficacy of fire suppression methods and firefighting teams, and conducting a meticulous analysis of statistical data. Moreover, it entails devising requisite measures for environmental preservation and safeguarding public health.

## Educational Year

The focus of this initiative targets students in the first and second years of secondary education.

## Student outcomes

The students will engage in the following activities:

- Investigating and analyzing the effects of controlled fires on air quality.
- Measuring and analyzing the rate of fire propagation under diverse conditions.
- Identifying and scrutinizing various sources of fire and assessing their efficacy.
- Simulating fire scenarios to evaluate the response time of firefighting brigades.

## Prerequisite knowledge

- In the field of **Biology**, students should possess prior knowledge encompassing an understanding of the biochemistry of combustion, the environmental ramifications of fires, and comprehension of the health implications associated with fires, particularly concerning air quality.
- Regarding **Chemistry**, students should be equipped with pre-existing knowledge regarding the various gases that may manifest in the atmosphere following a fire, along with an understanding of methodologies for their measurement and analysis.
- In **Physics**, students should possess foundational knowledge in principles of thermodynamics, heat transfer mechanisms, and techniques for quantifying heat fluxes, including the utilization of thermal imaging.
- In **Mathematics**, students should have a grasp of fundamental mathematical concepts for data measurement and analysis, as well as proficiency in statistical methodologies essential for analyzing data related to air quality and the efficacy of firefighting operations.

This prior knowledge serves as a framework for students to comprehend and appreciate the conceptual underpinnings and significance of fieldwork in executing the activities effectively.

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## DESCRIPTION OF THE ACTIVITY

**Activity 1: Assessing Post-Fire Air Quality:**

Employing a spectrophotometer to analyze changes in particle and gas composition in the atmosphere pre- and post-fire. This instrument discerns the spectral distribution of light absorbed or transmitted by diverse gases and particles, yielding insights into their concentrations.

Utilizing gas probes to measure key pollutants such as CO2, CO, and NO2. Gas probes offer precise readings of hazardous gas levels, crucial for gauging the fire's impact on air quality.

Quantifying concentrations of PM2.5 and PM10 particles, known for their adverse health effects. Aerosol monitors, typically leveraging laser diffusion reflection (LDR) technology, provide real-time measurements of particle densities.

**Activity 2: Evaluating Fire Spread Rates:**

Employing thermography to map heat distributions and pinpoint areas of heightened fire activity. This technique renders visual representations of heat flows, facilitating the identification of intense fire zones.

Experimenting with varying moisture levels, temperatures, and vegetative conditions to gauge the speed of fire propagation.

**Activity 3: Assessing Fire Source Efficiency:**

Conducting controlled experiments to assess the efficacy of different ignition sources, encompassing open flames, electrical, and chemical stimuli.

Employing specialized sensors to measure flame temperature and size, thereby evaluating the efficiency of diverse fire sources.

**Activity 4: Analyzing Fire Brigade Performance:**

Simulating a range of fire scenarios with varying intensities and locations to evaluate the responsiveness of firefighting teams.

Employing tachometers to measure response times and successful fire suppression efforts, thereby assessing the efficacy of firefighting operations.

**Activity 5: Statistical Analysis:**

Examining historical data on gas concentrations pre- and post-major fire incidents to discern patterns and ascertain the impact of fires on local air quality.

Utilizing statistical analyses to draw conclusions regarding requisite measures for environmental preservation and safeguarding public health.

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## MATERIALS

- **The following instruments and devices are indispensable for the successful execution of each activity and for ensuring the attainment of high-quality results:**

1. Spectrophotometer: Essential for analyzing particle and gas content in the atmosphere both before and after a fire event.
2. Gas probes: Vital for primary measurement of gas concentrations including CO2, CO, NO2, and other pollutants.
3. Aerosol monitors: Crucial for quantifying the concentration of PM2.5 and PM10 particles suspended in the air.
4. Thermography: Utilized to measure heat flows and identify areas of heightened fire activity.
5. Specific sensors: Employed to measure temperature and flame size, enabling detailed analysis of the efficiency of different fire ignition sources.
6. Processing units and software: Necessary for the comprehensive analysis and interpretation of data collected from various measurements.
7. Tachometers: Utilized for precisely measuring the duration required for fire brigade response and successful extinguishment of fires.

- **Student Sheet**

*Instruction Sheets for Recording Results from Investigations conducted within each of the listed activities will be provided.*

### Student Sheet: Air Quality Measurement Post-Fire

**Before proceeding, ensure thorough understanding of spectrophotometer operation for analyzing air particle and gas content. Familiarize yourself with the spectrophotometer's operation by reading the provided instructions before commencing fieldwork. On-site, adhere to usage guidelines meticulously and endeavor to measure gas and particle concentrations in the air before and after the fire incident. Carefully document and process all data obtained for subsequent analysis and discussion with peers and instructors.**

### Measurement of air quality after a fire

**Parameter: Gas Concentration (pre-fire)**
**CO2: _____ ppm**
**CO: _____ ppm**
**NO2: _____ ppm**
**Parameter: Gas Concentration (post-fire)**
**CO2: _____ ppm**
**CO: _____ ppm**
**NO2: _____ ppm**
**Parameter: Concentration of PM2.5 and PM10 particles (pre-fire)**
**PM2.5: _____ µg/m3**
**PM10: _____ µg/m3**
**Parameter: Concentration of PM2.5 and PM10 particles (post-fire)**
**PM2.5: _____ µg/m3**
**PM10: _____ µg/m3**

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## Student Sheet: Measuring Fire Spread Rate

**Prior to conducting measurements, review the thermography user manual to acquaint yourself with its functionality. In the field, follow the prescribed instructions for thermography usage and endeavor to measure heat flows while identifying areas of heightened fire activity. Conduct multiple experiments under varied conditions to assess fire spread rates in diverse scenarios. Present your findings and engage in discussions with peers and instructors.**

### Measurement of the rate of fire spread

**Experiment 1: Influence of Moisture**
**Conditions: Dry**
**Rate of fire spread: _____ m/min**
**Conditions: Moist**
**Rate of fire spread: _____ m/min**

**Experiment 2: Influence of Temperature**
**Conditions: Low temperature**
**Rate of fire spread: _____ m/min**
**Conditions: High temperature**
**Rate of fire spread: _____ m/min**

## Student Sheet: Testing Fire Source Efficiency

**Begin by acquainting yourself with the various fire sources to be tested, encompassing limited open flames, electrical, and chemical ignition sources. Familiarize yourself with safety protocols for handling these sources and adhere to established procedures for conducting controlled experiments. Execute a series of experiments to evaluate the efficacy of different fire sources, meticulously recording outcomes for subsequent analysis. Analyze gathered data to draw conclusions regarding the efficiency of each fire source type and their capacity to ignite and propagate fire.**

### Testing the effectiveness of fire sources

**Fire Source: Limited open flame source**
**Experimental Results: _____ (write them here)**

**Fire Source: Electrical ignition source**
**Experimental Results: _____ (write them here)**

**Fire Source: Chemical ignition source**
**Experimental Results: _____ (write them here**

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## Student Sheet: Analyzing Fire Brigade Efficiency

**Start by familiarizing yourself with firefighting techniques and methods employed for extinguishing fires. Before venturing into the field, review instructions for utilizing tachometers and grasp their operational principles. Simulate various fire scenarios with differing intensities and locations, measuring response times and successful fire extinguishments by fire brigades. Analyze experiment results to evaluate the efficiency of firefighting teams under varying conditions. Engage in discussions with peers and instructors to interpret findings comprehensively.**

### Analysis of the effectiveness of fire brigades

**Fire Scenario: Intensity: High, Location: Urban Center**
**Reaction Time: _____ minutes**
**Time required to extinguish the fire: _____ minutes**

**Fire Scenario: Intensity: Low, Location: Rural Area**
**Reaction Time: _____ minutes**
**Time required to extinguish the fire: _____ minutes**

**Fire Scenario: Intensity: Medium, Location: Industrial Zone**
**Reaction Time: _____ minutes**
**Time required to extinguish the fire: _____ minutes**

### ➢ "Air Fire Quiz"

The "Air Fire Quiz" game presents an engaging and interactive approach to reinforce students' understanding of the impact of fires on air quality. Here's how the game can be structured in detail:

**Question Categories:**

1. Pre- and post-fire air quality differences and the identification of primary gases and particles post-fire.
2. Factors influencing fire spread and methods to control and limit its propagation.
3. Various types of fire sources and methods for assessing their effectiveness in igniting and spreading fires.
4. Insights gained from simulating different fire scenarios regarding the efficiency of fire brigades.
5. The significance of analyzing historical measurements and statistical data in comprehending the impact of fires on air quality.

**Game Format:**

- Teams compete in rounds featuring questions from different categories.
- Each team has the opportunity to answer a question, earning points for correct responses.
- Rounds continue until all questions have been addressed.

**Bonus Rounds:**

- Bonus rounds offer teams the chance to earn additional points by solving extra tasks or questions.
- These rounds could involve practical demonstrations or problem-solving challenges related to fire science.

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**Finale:**

- The game culminates in a final round where teams have the opportunity to double their points by answering a challenging concluding question.
- The team with the highest total points at the end of the game emerges as the winner.

Through this game, students not only apply their knowledge but also foster teamwork, critical thinking, and communication skills in an enjoyable and stimulating environment.

## Prepared by


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