URBAN HEAT STRESS

MAKING COOL CITIES

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LESSON DESCRIPTION

In this lesson students will explore Urban Heat Islands and how to cool down their own cities or towns and use mathematical and geographical skills to estimate and predict the impact of their proposed solutions.

Students can focus on a micro-local level (their garden, schoolyard), or a more macro-level (village, town city), analyze the factors for urban heat stress, and propose and justify alternatives. They can evaluate and reflect on these alternatives in a critical way.

GOALS

At the end of the lesson students are able to

1. Describe how various solutions can affect urban heat stress and propose and justify alternative solutions
2. Analyze their local situation and determine the impact their proposed solution can have
3. Evaluate and reflect on the proposed alternatives

MATERIALS

- Attached PowerPoint
- Amsterdam map of UHI indices
- Strong 300W or greater lamp
- Different colored paper
- Thermometer
- Background reading:
    - https://www.epa.gov/heat-islands/
    - https://www.epa.gov/sites/default/files/2017-05/documents/reducing_urban_heat_islands_ch_1.pdf
    - https://sustainability-innovation.asu.edu/ecologyexplorers/teacher-toolbox/urban-heat-island/

TEACHING GUIDE

See also attached PowerPoint for images and resources

INTRODUCTION / BRAINSTORM:

Introduce the image (PPT slide 2) and have students determine their location and brainstorm how heat islands affect them. Prompting questions could include "Why is there such a difference between urban and rural areas?", "Why do nighttime

temperatures remain high?", etc. "What might help reduce temperatures in urban areas and why?".

DEMONSTRATION

The purpose of the demonstration is to show how different materials/colors can retain or reflect heat as well as have students reflect on effectiveness of UHI reduction solutions.

Gather black and white paper and place a thermometer behind each, shine the lamp at both. Check to see which has the highest temperature increase.

Alternatively, or further, you can also compare a dense material vs a less dense material (brick vs mound of soil) to show how heat can be retained over a longer period of time.

Extension: As an experiment for students, they can compare the heat capacities of different materials experimentally. They can compare stone/tile, dry/wet sand, water etc. They can determine specific heat capacities by adding thermal energy to the sample by means of a hot plate with a known power and use formula 1 to determine c. They can compare this to the recommended value.

$$Q = mc\Delta T \qquad (1)$$

Students can then use this data to critically compare how higher albedo surfaces like lighter concrete may still retain more heat over a day than lower albedo surfaces like dark vegetation.

TEACHING/ACTIVITIES

Show slides about mitigation and reduction efforts and you can choose the following activities.

Outside: groups of students have thermometers and find the temperatures of different areas/materials. They record data. For example, measuring the temperature of the air or ground in the shade vs in the sun. Of a black pavement surface vs. the grass. Depending on level, students may use data loggers or digital/analog thermometers. Can they find any microclimates? If white reflects really well, why not paint everything white? You can adjust based on level of students or turn this into a full-fledged lab investigation.

Discussion: Modes of heat transport: Discuss concepts of convection, conduction and advection, heat capacity.

Albedo: Discuss the concept of albedo and reflectance. Light objects reflect more solar energy, however if they have a high heat capacity, they can store more thermal energy.

Going further question: If water is darker (lower albedo) and as a high heat capacity, why are water areas generally cooler than urban areas (see also Map of UHI Amsterdam).

#TEGELSERUIT! (GET THOSE TILES OUT!)

In this activity students will look locally (their gardens, schoolyard, etc.) to see how small changes can have big impacts.

In this analysis activity students can do it in real life or virtually using google maps for example. They will analyze an area and determine how changing the surface from tiles to vegetation or another option can affect the urban heat island affect. They can extend this to take data and quantify the effect. If using google maps they can use the measure tool by right clicking and selecting measure. They can also estimate by measuring the size of a standard tile and extrapolating.

STEP 1: LOCATION ASSESSMENT

Have students choose a location where tiling, pavement, etc. is used in a garden / school yard etc.

Have them assess the situation – what is the total area? The albedo? The specific heat capacity of the materials?

STEP 2: ALTERNATIVES

Based on research (see further reading) how will planting vegetation (grass, trees, bushes) vs cool pavements address the situation? How can they quantify the impact?

STEP 3: ZOOM OUT

If they were to apply this situation to all similar gardens, how many tiles would be removed? How much pavement replaced by vegetation, cool pavements, or trees? How can they quantify this impact?

STEP 4: REFLECTION

It's not as simple as replacing tiles everywhere – students should critically analyze their solution – what are the social, economic, environmental and/or other factors which affect their solution? Some things to consider could be upkeep of grassy school fields which are played on by hundreds of students a day – how to prevent these from becoming mud pits?

MAP ANALYSIS- GOING FURTHER

Using the maps of Amsterdam's UHI as well as the proposed RES Plan, students can inquire into how and proposed efforts can affect the Urban heat stress of the city.

Some inquiry questions for students include:

How will adding green roofs or vegetation change how the city is designed?

How can a city balance it's climate goals with protecting its heritage?

How might changes in both 2D and 3D layout of the city affect the UHI?

Students can use Amsterdam as an example or use examples from their own city or town.