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DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

River effects on microclimate

Modules: **Impacts of human intervention on river ecosystem**

Total duration: 4 hours
Field work: Yes
List of materials:
- Air thermometer (and hygrometer)
- Questionnaire
- Map of the town

Worksheets: 3
Students' age: 15-18
Use of apps/software: Google

Brief disciplinary introduction

Water flowing through urban rivers and streams can moderate the local climate by creating "cool islands" within an otherwise overheated city. The basis for this cooling effect can be understood based on the energy balance between the body of water and the surroundings, which includes energy exchanges by radiation, convection and evaporation. The radiative cycle of a river is dominated by solar absorption during the day and long-wave emission at night –but the river modifies these fluxes in several ways. The albedo of the water surface varies with sun angle more than it does for most other types of ground cover, as the river becomes highly reflective at shallow sun angles (for instance in the early morning and late afternoon) and this large effective albedo limits the rate of heating. In addition, because flowing water is a dynamic rather than a static medium, heat absorbed during the day at one point (such as in the city center) will ultimately be re-radiated during the night at another point downstream (possibly outside the built-up area). If the surface of the river is cooler than the air flowing over it, a sensible cooling effect may be noticeable.

In practice, though, convection cooling will be amplified by evaporative cooling which increases the latent heat content of the air but reduces its temperature. The magnitude of this reduction depends on a number of interconnected factors, including the temperature of the water, the humidity of the ambient air, the wind speed and direction and the properties of the river itself. Although observational data in European cities is scarce, Hathway and Sharples (2012) found cooling effects of up to 2°C at the riverbank in a UK case study. An important question is to what extent the cooling provided by an urban river penetrates into the city fabric and moderates thermal discomfort over a broader area of the city. This depends heavily on the density of building and the wind regime, among many other factors that would be particular to each location.

Hathway EA, Sharples S (2012) The interaction of rivers and urban form in mitigating the Urban Heat Island effect: A UK case study. Building and Environment 58:14-22.

Objective of the learning unit

To learn about:

- ✓ Meteorological parameters
- ✓ Climate vs. microclimate
- ✓ Soil-atmosphere interaction
- ✓ Land cover
- ✓ Effects of land cover on microclimate
- ✓ Thermal comfort
- ✓ Urban planning

To be able to:

- ✓ Work in groups
- ✓ Plan a scientific investigation
- ✓ Use a data management software
- ✓ Data acquisition
- ✓ Use informatics software
- ✓ Orienteer by using georeferenced information

Introduction (orientation)

Time estimated: 5 minutes
Where the activity takes place: in the classroom, using PC, beamer and Internet
Method (how the students have to work): class brainstorming
Instructions for the teacher:
Ask students

"Where do you usually go in a hot summer day in town? Why?" or "Where did people use to go before air conditioning? Why?"

Answers might include: swimming pools, river, forest mountain.. why? Because these places are cooler than the town.

Show a video on the urban heat island:

Urban heat Islands https://youtu.be/s_apVv7dbMQ (2:11 min)

Then you can ask students "*what do they think it might reduce the temperature in town*".

Conceptualization

Time estimated: 5 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work, use worksheet 1.
Instructions for the teacher:
In the classroom, the students are divided in 4 groups. They formulate the hypothesis about

"Which types of areas are the hottest in your town? And the coolest ones?"

(They should indicate the totally sealed areas as the hottest, and the green and blue areas as the coolest).

Investigation

Time estimated: 2 hr 30 minutes
Where the activity takes place: in the classroom and outdoor
Method (how the students have to work): group-work, use worksheet 1, 2.
Instructions for the teacher:
In the classroom, the students are divided in 4 groups (2 groups will deal with mapping and 2 groups with the definition of the methodology for investigating the thermal comfort).

1) Planning

Time: 30 minutes

Ask students *"How would you investigate the effect of the river on climate conditions and thermal perceptions?"* (worksheet 1)

Give two groups of students a map of the town.

- Students should select a route on the map where they want to perform the investigation

Give the other two groups the task to decide how to perform the investigation

- Students should come out with an investigation plan (materials, methods) on human thermal perceptions.

Time: 15 minutes
The groups present their plans (methods and routes on the map) and reach an agreement. The teacher shows students the Worksheet 2 (questionnaire for the thermal comfort investigation) to compare it with their plans. They can decide the tools to use.

Expected result:
Students mark a route on a map, like a transect perpendicular to the river and identify 4-5 "Stops" for taking measurements (meteorological parameters) and thermal perception data. The "Stops" should be different in terms of distance from the river, presence vs. no-presence of vegetation, shade vs. sun. Ask students how they would analyze the thermal comfort. They can use their own questionnaire, or compare it with worksheet 2. The questionnaire can be transferred on an online google form and used on site using mobile devices, in order to make easier data digitalization and elaboration.

2) Performing

Students perform a 45 minutes walk along the agreed route.

At each stop, they record environmental variables using a digital air thermometer and hygrometer and fill in the questionnaire (their version or that one in worksheet 2) on thermal comfort and climate perceptions by human body.

If the questionnaire are prepared as online version, students can use their mobile devices to record the data. Each student should answer the questionnaire.

3) Concluding

Time: 60 minutes

In the computer lab or at home, students report the data of the filled-in questionnaires into an Excel file (template available). They can elaborate the questions in terms of:

- ✓ At each stop, characterize the climatic conditions
- ✓ At each stop, calculate the frequencies of each scale point regarding thermal comfort
- ✓ Make comparisons between stops
- ✓ Make comparisons between different nationalities (if any) and genders.

Conclusion

Time estimated: 20 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work, use worksheet 3.
Instructions for teacher:
The different groups (or the whole class) report their conclusions from the activities following worksheet 3.
They compare their findings with the formulated hypothesis or check if they answered the generated questions in the conceptualization phase.
The conclusions lead to understand the benefits of rivers and streams but also unsealed surfaces for the urban community, in terms of thermal mitigation.
They also help to identify the services for citizens connected to the rivers.

Discussion

Time estimated: 30 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group work, use worksheet 3.
Instructions for teacher:
This phase aims to transfer students' acquired knowledge in practice.
"In urban planning, what kind of areas are important to provide the best thermal comfort?"

Design on the map of your town where you would include green or blue infrastructures for improving the thermal comfort.