Proving the Effects of Surfaces on Urban Heat Island Effects

Audrey Kelm and Shannon McCain

Ottawa Hills High School

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Abstract

Understanding Urban Heat Islands is very important to understanding urban planning in city life. Understanding this subject is not only important to science, but everyday life for the majority of people. In this study, we tested surface temperatures of natural and unnatural objects/areas to find what emits more heat, and why. This study was conducted using surfaces of grass, asphalt, concrete, and brick. Our independent variable was the surface type, while the dependent was surface temperature. Our results indicated that more natural surfaces, like grass, emit less heat as it cools down easier. The procedures of the study results in the idea of natural surfaces being able to emit less heat, while non natural ones emit more.

Research Question

- Our research questions is important because in provides an input on urban heat islands surfaces, and gives knowledge about which surface emits more or less heat, letting people know which is more beneficial for the environment and people.
- Urban Heat Islands are very prominent in the world, and knowing which surface emits more heat is beneficial and allows for improvements and revisions of surfaces.
- Some other investigations did not test the specific surfaces in which we did, so with our research an output of said surfaces is given.
- Throughout our experiment, we put much time and effort into looking at other sources, along with revising our own to give us further knowledge on the subject.
- Our questions is "How do different surfaces affect urban heat island effects?"
- Yes, our question and research is testable using a infrared thermometer and taking in the surrounding weather, along with cloud formations.

Introduction

- Everyday, people continue to take in pollutants while disregarding the harmful effects they carry.
- This is caused by highly studied effects such as urban heat island where urban areas continue to be increasingly harmful to the environment, encroaching on animal's natural habitats.
- But not as much is known about the effects of specific colors and surfaces have on these pollutants and exactly why they are emitted.
- This experiment will dive into the specifics of how separate surface areas affect urban heat islands by either amplifying or reducing the effects.
- The urban heat island effect is where temperatures tend to stay higher in cities compared to that of rural areas. In urban areas, the surfaces tend to hold and absorb more heat, this is due to their unnatural nature whereas in rural areas much of the surface is greenery allowing transpiration to occur.
- That being said, in urban areas which tend to have more infrastructure than biodiversity, there is no natural way to cool the area causing higher temperatures overall(NASA).
- As waste heat and carbon emissions can cause the effects to be amplified as well as calmer weather which allows more solar energy to reach the surface area.
- Furthermore, two different kinds of this effect exist, surface heat islands, different surfaces emitting more heat, and atmospheric heat islands, warmer air in urban areas.
- In concern to the environment, this poses an issue as it increases energy consumption, carbon emissions, compromises health, and leads to a decrease in water quality(United States Environmental Protection Agency).
- Surfaces tend to absorb heat differently than each other, this can be due to the sensing of temperature, whether on its surface or back. The rate of heat transfer through surfaces is based on time variables and other factors such as weather, conditions, and temperature surrounding the material.
- Some factors in surface absorption include specific heat capacity, thermal conductivity, color, and density.
- Additionally, the inverse relationship between surface temperature and wavelengths of light makes it so as surface temperature increases, wavelengths will decrease(BYJUS).
- Furthemore, different surfaces are found to absorb and trap heat more efficiently such as lightning streets used to cool down urban areas or asphalt streets with reflective gray coating(NASA).
- As well as, many building materials known as impervious surfaces, meaning water cannot flow through them, trap heat while natural organisms such as plants uptake water cooling themselves down.
- As shown in the research above, urban heat island effects are due to the absence of greenery and an increased amount of infrastructure causing heat to be absorbed rather than released.
- Different surfaces and their differences in absorption of heat or conversion of heat also play a major role, along with urban cities' cooling and absorbing heat factors. This is of importance as the environment is increasingly dying as temperatures increase and substances pollute the environment.
- From effects such as acid rain and dying ecosystems, pollution caused by urban heat island negatively affects populations and their surroundings.
- For this experiment, certain surfaces are to be tested over a course of a week at peak sunlight to test their surface temperature and in turn how much heat they have absorbed and are emitting. With the hypothesis being, if a surface is more natural then it will not emit as much heat as it is able to evaporate water and cool the air better.

Research Methods

Question: How do different surfaces affect urban heat island effects?

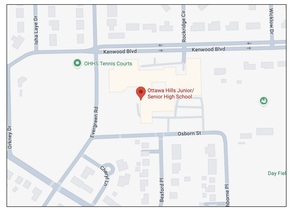
Hypothesis: If a surface is more natural then it will not emit as much heat as it is able to evaporate water and cool the air better.

Materials:
- Infrared Thermometer
- Weather Rite Tech System
- Cloud Data Sheet
- Surface Temperature Data Sheet

Procedure:
1. Gather your materials, an infrared thermometer and your cloud and surface temperature data sheets at about 11:00 am to 12:00 pm.
2. Record the temperature outside and the relative humidity using the Weather Rite.
3. Go outside to the area near the bus parking at Ottawa Hills High School.
4. Record the surface temperature of brick, asphalt, concrete, and grass.
5. Record the clouds using the cloud data sheets.
6. Repeat over the course of a week or more keeping time of day, thermometer, and areas constant throughout.

Independent Variable: Surface Type
Dependent Variable: Surface Temperature
Constants:
- Time of day
- Thermometer
- Area being tested

Data Collection and Analysis:
- Data is collected by using the infrared thermometer, and scanning the surfaces to collect the surface temperature.
- We then collect data on the clouds, and calculate how the sky and weather for the day is affecting surface temperature.
- There was about 8 trials/days where data was collected, so N=8.



GLOBE Badges

Be a **Data Scientist**
The report includes in-depth analysis of students' own data as well as other data sources. Students discuss limitations of these data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from other databases.

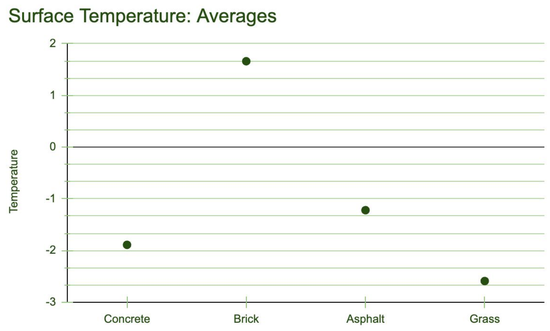
Results

In the graphs, asphalt and brick tended to emit more heat and fall higher on the graph while concrete and grass stayed on the lower side, usually occupying the negatives and low tens. However, the asphalt and brick were most likely on the high side due to their colors while concrete was probably due to its color as well, grass most likely tended on the lower side to to its composition and processes as a living organism. Some anomalies which occurred happened first on 12/3 when brick was significantly lower than the other surfaces, this does not have a good explanation due to weather and could simply be human error. This anomaly also happened the next day which could also mean there was something different going on as well. After this, most of the graphs stayed relatively the same with only slight changes between what was hottest and coldest. Though, on 12/9 grass did read as emitting more heat than asphalt though this can be assumed to be due to the amount of snow recorded on asphalt, 11mm, was greater than that of the grass, >10mm, causing the asphalt to trap in and emit less heat.

Figure #1

Surface Type	Concrete	Brick	Ashphalt	Grass
12/3	-1.8	-6	-5.2	-2.4
12/4	-2.7	-8.1	-7.5	-3.4
12/5	-1.9	9.9	-1.4	-5.4
12/6	0.2	4.3	5.4	-0.2
12/9	-10.7	-3.1	-9.3	-8.6
12/10	0.2	2.9	1.6	0.3
12/11	-0.8	-0.1	7.1	-0.1
12/12	2.4	13.5	-0.5	-0.9
Average Temp	-1.89	1.66	-1.23	-2.59
STD	3.9	7.52	5.88	3.11
SEMS	1.38	2.66	2.08	1.1
2 SEMS	2.76	5.32	4.16	2.2

Figure #2



Discussion

- The results of our experiment have garnered similar results to those conducted in other parts of the world by other citizen scientists though some differences between these studies may be season, location, and cloud coverage.
- Overall, our hypothesis was supported as on average natural surfaces like grass tended to emit less heat, read as colder, than unnatural surfaces such as concrete, brick, and asphalt.
- This most likely occurred not only due to the fact that grass is able to take in water cooling down it's surfaces while the other surfaces are unable to do so as well as grass having more snow sticking to it due to it's colder temperature.
- Though, these data sheets only account for the reasoning in different temperatures between days to show the causes of why the ground temperatures may change in a short period of time.
- Some possible experimental errors could be the thermometer not being the same distance from the ground per measurement, not tracking the cloud and sky patterns, or not recording accurate snow measurements.
- Some solutions could be to redo the temperature measurements, estimate the error using error bars on a graph, calculate the difference between measurement errors, or re-track data.
- Our hypothesis was backed by our data, however there may not be enough statistical differences between the concrete and grass to show a link between the naturality of a surface and it's surface temperature.
- Though, the hypothesis is still technically supported by our statistical averages, just not if you look day to day.

Conclusions

- To end, our hypothesis was supported by our data as the results show that natural surfaces such as grass tended to emit less heat, while less natural surfaces such as concrete, brick, and asphalt tended to emit more.
- There is not enough statistical difference between grass and concrete, which could be due to its lighter color making the low difference between the two, as lighter colors absorb less heat.
- Some changes that could be made if this experiment were attempted again is to do a different array of places around the city. As well as, testing different surfaces such as different plants or soils and testing objects like gravel or rocks.
- For further investigation, we could test during snow storms, rain, or during the multitude of seasons and weather patterns throughout the year for a more thorough investigation.
- This research is important to our and others understandings of urban heat island effect, and can help give a better understanding of separate urban surfaces and how they emit heat and help with urban planning in the future.

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