Causes, Effects and Solutions To Urban Heat Island

On many occasions, you have probably noticed there is so much heat in your city. What's more, if you pay attention to the local weather channel news, you won't miss noticing a queer tendency of temperature variations within and around the city areas. Cities or metropolitan areas are typically warmer with slightly higher temperatures compared to their adjacent rural areas. This temperature difference is due to the unusual state known as the urban heat island (UHI).

The name implies that cities or metropolitan areas are transformed into islands of heat. Temperatures in these regions can get as much as 10 degrees Fahrenheit higher compared to the adjacent rural areas. So, urban heat island (UHI) means any urban area which is significantly hotter than the neighboring area. Urban heat island is highly noticeable during winter and summer periods, and the temperature difference is often greater at night than in the daytime.

According to EPA,

"The term "heat island" describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C). Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water quality."

Causes of Urban heat island

1. Low Albedo Materials

According to Bouyer, Albedo is the ratio of the reflected solar energy to the incident solar energy. It depends on the arrangement of surfaces, materials, pavements, coatings, etc. Albedo has a direct impact on the formation of the microclimate.

The albedo of a city varies according to various factors like the surface arrangement, i.e., orientation, heterogeneity, materials for roofs, pavements, etc. If the albedo of the urban surface is low, it will store more solar energy, and the effect will be an increase of urban temperature, i.e., the creation of the urban microclimate.

2. Paved and Impermeable Surfaces

Paved over surfaces, such as roads and parking lots, can absorb solar radiation as heat, and these surfaces are typically impermeable, which means that water runoff is redirected to the stormwater system rather than being absorbed by plants or water bodies that help cool the area through evapotranspiration and evaporation.

3. Thermal Mass

Buildings contain a lot of thermal mass, which means they store a lot of heat during the day and are slow to release the heat overnight.

4. Dark Surfaces

Dark roofs absorb more energy into the building as heat, hence the boom in cool roof adoption. But it's not just roofs absorbing the heat, but blacktop absorbs the sun rays just as well, and neither surface reflects much solar radiation, so they get hotter than lighter-colored surfaces.

5. Lack of Vegetation

Plants and trees provide shade and cool the air through evapotranspiration. But areas that are dominated by paved surfaces have little room for green space. Forests are wiped out on a massive scale to meet the demand of various urban facilities. Lesser trees mean less cooling efficiency.

Trees intercept the solar heat and absorb carbon dioxide for their own photosynthesis to cool the environment. With the destruction of plant life, the efficiency of the cooling system goes radically down, causing the creation of the process.

6. Climate Change

The more extreme heatwaves in urban areas, mainly in northern regions, are a factor that contributes to urban heat island formation. Urban heat islands also exacerbate the changes in the climate, so the problem feeds on itself.

7. Increased Use of Air Conditioner

We use air conditioners massively with a rising trend for comfort. Air conditioners keep a building cool inside but absorb heat from inside, releasing it to the atmosphere. Mechanical air conditioning exhausts heat into the environment around the building, directly adding to the problem. As a result, the outside environment is warmed, leading to increasing atmospheric temperature.

8. Urban Canopy

In urban areas, there are multilayer buildings. The heat reflected by a building is trapped by the nearby taller buildings, which is known as the urban canopy. UHI is exacerbated by the formation of the urban canopy.

9. Wind Blocking

Due to the presence of densely situated buildings, the velocity of wind is reduced, and it lessens the cooling effect by convection. So, the trapped heat intensifies the effect.

10. Air Pollutants

In urban areas, especially in city centers, air pollution is a major issue. Exhaust gases from vehicles, industrial pollutants released in the atmosphere, trap solar radiation, causing an increase in temperature, and the microclimate effect becomes stronger.

11. Human Gathering

As human gathering is huge at the city centers owing to the availability of various facilities, the emission of CO2 is also huge in these areas. CO2 stores heat, causing enhanced atmospheric temperature. The ultimate effect is that it assists in the formation of heat island to a great extent.

Effects of Urban Heat Island

1. Increased Energy Consumption

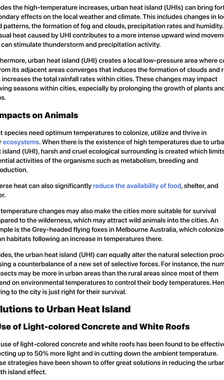
Increased temperatures during summer in cities amplify energy demand for air conditioning. Studies reveal that electricity demand for air conditioning or cooling increases in the ranges of 1.5 to 2 percent for every 1°F (0.6°C) increase in air temperatures (ranges of 68 to 77°F (20 to 25°C), implying that the community requires about 5 to 10 percent more electricity demand to cater for the urban heat effect.

This means the increased demands for cooling or air-conditioning during summer contribute to higher energy bills. Also, during exacerbated periods of urban heat islands, the resulting demand for air conditioning can overload systems, which can lead to power outages and blackouts.

2. Elevated Greenhouse Gas Emissions and Air Pollution

As explained earlier, urban heat island (UHI) raises electricity demand during summer. As a result, power plants have to supply the needed extra energy, and since they rely on fossil fuel for energy production, there is an increase in greenhouse gas emissions and air pollutants. The main greenhouse gases and pollutants include carbon monoxide (CO), carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter and Mercury (Hg).

Increased greenhouse gases cause global warming and climate change, while the pollutants negatively impact human health as well as the decline of air quality. Sometimes the UHI can also lead to the formation of ground-level ozone and acid rain. Research shows that high UHI correlates with increased levels and accumulation of air pollutants at night, affecting the next day's air quality.



3. Poses Danger to Aquatic Systems

High temperatures within the urban areas mean elevated temperatures for pavements and rooftops. Accordingly, these surface temperatures can heat stormwater runoff. Trials have demonstrated that pavements with temperatures of 100°F (38°C) can increase initial rainwater temperately from about 70°F (21°C) to over 95°F (35°C).

This heated stormwater is the runoff that flows into storm drainage systems and raises water temperatures as it is discharged into ponds, streams, rivers, lakes and oceans, resulting in thermal pollution. As a result, the increased water temperature affects the aquatic system, especially the reproduction and metabolism of aquatic species and can be even fatal to aquatic life.

4. Discomfort and Danger to Human Health

Higher air pollution reduced nighttime cooling, and increased temperatures as outcomes of urban heat island can adversely affect human health. Human health is negatively impacted because of increased general discomfort, exhaustion, heat-related mortality, respiratory problems, headaches, heat stroke and heat cramps.

Because urban heat islands can also worsen the impacts of heatwaves, abnormal weather periods can arise, which can seriously affect the health of sensitive and vulnerable populations such as older adults, children, and those with weather-responsive health conditions.

Exacerbated heat events or sudden temperature increases can result in higher mortality rates. Research by the Center for Disease Control and Prevention indicates that between 1997 and 2003, more than 8,000 premature deaths were registered in the United States owing to excessive exposure to heat.

5. Secondary Impacts on Weather and Climate

Besides the high-temperature increases, urban heat island (UHIs) can bring forth secondary effects on the local weather and climate. This includes changes in local wind patterns, the formation of fog and clouds, precipitation rates and humidity. The unusual heat caused by UHI contributes to a more intense upward wind movement that can stimulate thunderstorm and precipitation activity.

Furthermore, urban heat island (UHI) creates a local low-pressure area where cool air from its adjacent areas converges that induces the formation of clouds and rain. This increases the total rainfall rates within cities. These changes may impact growing seasons within cities, especially by prolonging the growth of plants and crops.

6. Impacts on Animals

Most species need optimum temperatures to colonize, utilize and thrive in their ecosystems. When there is the existence of high temperatures due to urban heat island (UHI), harsh and cruel ecological surrounding is created which limits the essential activities of the organisms such as metabolism, breeding and reproduction.

Adverse heat can also significantly reduce the availability of food, shelter, and water.

The temperature changes may also make the cities more suitable for survival compared to the wilderness, which may attract wild animals into the cities. An example is the Grey-headed flying foxes in Melbourne Australia, which colonized urban habitats following an increase in temperatures there.

Besides, the urban heat island (UHI) can equally alter the natural selection process, causing a counterbalance of a new set of selective forces. For instance, the number of insects may be more in urban areas than the rural areas since most of them depend on environmental temperatures to control their body temperatures. Hence, moving to the city is just right for their survival.

Solutions to Urban Heat Island

1. Use of Light-colored Concrete and White Roofs

The use of light-colored concrete and white roofs has been found to be effective in reflecting up to 50% more light and in cutting down the ambient temperature. These strategies have been shown to offer great solutions in reducing the urban health island effect.

Black and dull colors absorb copious amounts of solar heat, resulting in warmer surfaces. The use of light-colored concrete and white roofs can as well reduce the overall air conditioning demands.

2. Green Roofs and Vegetation Cover

Green roofs present a great method of lessening the impacts of urban heat islands. Green roofing is the practice of planting vegetation on a roof, just like they are planted in a garden. Plants on the roof are excellent insulators during summer and decrease the overall urban heat island effect. Plants also cool the surrounding environments, thereby reducing air conditioning demands.

Furthermore, air quality is improved as the plants absorb carbon dioxide and produce fresh air. Other practices that can be used include open space planting, street trees and curbside planting. All these practices produce a cooling effect within the urban areas and lower the costs of temperature reduction.

3. Planting Trees in Cities

The practice of tree planting within and around cities is an incredible way of reflecting solar radiation while at the same time decreasing the urban heat island effect. Trees provide shade, absorb carbon dioxide, release oxygen and fresh air, and provide a cooling effect. Deciduous trees are the best for urban areas because they provide a cooling effect in summer, and they don't block warmth during winter.

4. Green Parking Lots

Green parking spaces utilize green infrastructure strategies to limit the impacts of urban heat island effect. In precise, it cushions against the elevation of pavement temperatures which can considerably prevent thermal pollution resulting from stormwater runoff. With this in place, the danger posed to aquatic systems is reduced.

5. Implementation and Sensitization of Heat Reduction Policies and Rules

The state implementation of environmental policies such as the Clean Air Act, Low carbon fuel standards, uses of renewable energy, and clean car rule standards can impressively regulate the anthropogenic inducers of urban heat island effect.

With fewer emissions, the level of greenhouse gases in the atmosphere can be reduced, thus decreasing the effects of climate change and global warming. Education and outreach can also be done to ensure communities are aware of the economic and social benefits of planting trees and eco-roofing.