International Journal of Engineering Research
Volume No.7, Issue Special 4, pp : 462-463
ISSN:2319-6890 (online),2347-5013(print)
9,10 March 2018

Urban Heat Island: Causes, Effects and Mitigation Measures-A Review

Akshay Kumar Sharma[1], Anamika Gandhi[2], Ajay Bhatt[3]
[1]Department of Civil Engineering, Career Point University, Hamirpur, Himachal Pradesh, India
[2]Centre for Energy and Environmental Engineering, NIT, Hamirpur, Himachal Pradesh, India
[3]Department of Civil Engineering, Govt. Engineering College, Banswara, Rajasthan, India
Email: akshay.upmanyu01@gmail.com, gandhianamika99@gmail.com, ajaybhtt3@gmail.com

Abstract: Urban Heat Island effect is affecting peoples' lives very severely. The increased temperature in the urban areas is causing many ill effects which are related to man as well as to the rest of the ecosystem. It affects the quality of air as well as water which makes it difficult for humans. Other aquatic species have also been affected with respect to their metabolism and reproduction. In this paper we have tried to understand the concept of Urban Heat Island (UHI) and its causes, effects and mitigation measures like use of high albedo materials, green rooftop, green field development and low rise buildings.
Keywords : Urban Heat Island (UHI),

Introduction: Urban Heat Island (UHI) is becoming more and more evident now a days. The term heat island refers to an area which has a higher temperature than the surrounding rural areas. The first scientific observation of UHI was done by Luke Howard in 1833. He studied this effect for the city of London. Since then, this topic has gained quite an importance and various studies targeting different cities of the world and India as well have been carried out. However, it can be observed in all the cities; but the big cities with more population and high density have shown a greater increase in temperature which makes it more worrisome as more number of people are affected because a huge population resides in very small urban pocket which is affecting their quality of life very adversely. India is urbanising at a very rapid rate. According to census 2011, 31.16% of India's population resides in urban areas which according to World Bank has become 33% by the year 2016. UHI effect is more felt in the countries which are dominated by hot climate like India. It gives a sense of comfort if the temperature is low but if the temperature is high, it creates an environment which is unbearable due to its high temperature. The annual mean air temperature of a city with 10 lakhs people or more can be 1-30C warmer than the surroundings. In the evening, the difference can be as high as 120C. It necessitates more energy consumption for the cooling of our houses, buildings etc. which in turn would result in a higher release of greenhouse gases and the temperature will rise further. So, we need to understand this UHI effect and take the remedial measures accordingly.

Causes of UHI: Many of the human activities are responsible for the UHI effects which have been discussed here below:

1. **Decreasing Green Space:** Trees if present in adequate number can give a cooling effect. World Health Organization deals with green spaces, and it states that cities should provide with 9 m2 per capita within 15 minutes of walking distance from their home place. But Indian cities like Jaipur are lagging behind to fulfil this criterion by a huge margin which has per capita green space of only 2.30%.
2. **High Compactness:** The cities which have higher density of people tend to have more temperature difference between the urban and the rural areas. More the number of people mean more consumption of energy and thus more will be the greenhouse gases' emission. Nowadays, we see a number of tall buildings which are adding exponentially to the density and thus higher UHI effect.
3. **Concrete Jungle:** The usual building materials like concrete tend to absorb the heat energy from the atmosphere and thus make the environment hotter. The albedo of new concrete is 0.30-0.40 where as the albedo of aged concrete is 0.20 -0.30. It means that concrete absorbs around 60% to 80% of the total energy radiations incident on it. Therefore, the materials which have low albedo are responsible for the higher UHI.
4. **Air Pollution:** Industries and vehicles tend to produce very large quantity of greenhouse gases which are mainly responsible to trap the energy radiations and thus increase the urban temperature.
5. **Luxurious Life Style:** The more we rely on machines, the more energy we are consuming and hence adding hugely to the increase in temperature of the city. According to the 2008 World Bank development indicators, in 2005 the wealthiest 20% of the world accounted for 76.6% of the total private consumption. While the poorest 20% accounted for only 1.5%. More consumption will lead to more release of heat. The trend of using the air conditioners has become very common. These absorb the heat from inside of the building to outside environment leading to higher atmospheric temperatures.

Effects of Urban Heat Island: UHI tends to affect the lives of people and also the environment in a very drastic manner. These have been studied below:

1. **Discomfort to Humans:** The increased temperature, higher air pollution and greenhouse gases tend produce a sense of discomfort to the people and also have a negative impact on the human health as well. Children and old age people are likely to be affected more as they are more sensitive to any change in the environment. According to the Ministry of Earth Sciences of Govt. of India, in the years 2013-2016, 3402 number of people have lost their lives due to the heat wave conditions in the country.
2. **High Energy Requirement:** Increased summertime temperatures in cities increase energy demand for cooling. Electricity demand for cooling increases 1.5-2.0% for every 1°F (0.6°C) increase in the air temperatures, starting from 20 to 25°C. It increases the electricity demand by 5-10% due to the UHI effect. This effect increases the peak electricity demand during the summer time.

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3. Decreased Water Quality: The temperature of storm-water increases as the roof tops and pavements and heated up. According to the tests, pavements that are 100ºF (38°C) can elevate initial rainwater temperature from roughly 70ºF (21ºC) to over 95ºF (35ºC). This increased temperature in the water streams is dangerous to the aquatic life, as it affects the metabolism and reproduction of the aquatic species. Also, it decreases the level of dissolved oxygen in the water which makes it further more difficult for them.

4. Decreased Air Quality: As discussed earlier, since the energy requirement is higher due to the UHI effect, more greenhouse gases are released into the atmosphere which degrades the quality of air.

Mitigation Measures: It is very important to take the measures which can mitigate the effects of UHI. Some of them have been compiled here as:

1. Green Field Development: There should be more focus on the development if green fields. If the trees will be more, they will help to keep the city temperature low. Also, it is seen that the planned Indian cities have more green space per capita than the evolved cities. Planned city of Chandigarh which was built to replace Lahore has a green space of 55 m2 per capita. Gandhinagar which is a planned city and also the capital of Gujarat has a green cover of 160 m2 per capita. These both the cities have far more green space per capita than minimum requirement of 9 m2 as per World Health Organization. Thus, a solution to the UHI effect is to plan our cities well which have adequate green space to mitigate the increased temperature.

2. Low Rise Buildings: High rise buildings tend to increase the density of people residing per unit area, so if we go for low rise buildings then it would keep as check on the density and hence also on the increase of the urban temperature. These allow the heat to disperse easily as compared to the high rise buildings.

3. Use of High Albedo Materials: We should make use of the materials and paints which have a high albedo value. For example, white plaster and white pigment has albedo value of 0.93 and 0.85 respectively. If the albedo is high, the absorption of heat radiations will be less and subsequently, the temperature will be less. It will also result in the lower energy consumptions.

4. Green Roofs: A green roof or a garden on the rooftop is a layer of vegetation grown on a rooftop. These provide shade and don't let the heat penetrate into the building easily and thus makes them relatively cool when compared to the buildings which do not have any green roof. There will be savings in the overall energy consumption of the city also. Uninsulated rooftops provided with green roof reduce the flux of heat by 25% when compared to the building having uninsulated rooftop without green roof.

5. Cool Pavements: Pavements form a big pie of the land-use in the urban areas. If we use materials which do not absorb the radiations but reflect it, the temperature of the city can be brought down by good margin. The traditional concrete used has albedo value of 0.30 to 0.40 but white Portland cement concrete has albedo value of 0.70-0.80 which will reflect most of the radiations incident on it.

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