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Various Causes of Urban Heat Islands, effects and their Mitigation Measures for Urban Ecology – A Review

Aneesa S.[1] and Reshma J.K.[2]

Department of Environmental Sciences, All Saints' College, Thiruvananthapuram, Kerala, India

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ABSTRACT

Every human activity creates various adverse effects in our environment. Rapid urbanization and increased population lead to generation of urban heat islands. It adversely affects urban ecology and creates public health damage. The major causes of urban heat islands are destruction of trees, low albedo materials, urban canopy, human gathering. The increase of land surface temperature caused by urban heat island effect will definitely alters the urban ecological balance, atmospheric environment and their functions. Urban heat islands need to be addressed urgently. This review is an effort to understand how cities across the globe affect urban heat and their mitigation measurements. Green cover and cool pavements are the best method to reduce the temperature in urban areas. In this paper, we have analyzed major cause, effects and mitigation properties.

Key words: *Urbanization, Green cover, Mitigation, Urban heat islands, NDVI*

Introduction

Urban sprawl and the emergence of urban clusters are problems faced by any city. This in turn creates an impact on the micro-scale climate of that area. Generation of urban heat islands (UHIs), waning of urban green cover, an increase in carbon emissions and air pollution deteriorate the living environment thereby leading to a rise in urban temperatures and heat stress-induced problems. UHI which can raise the temperature in cities compared with rural areas. Pollutants in the air in urban environments create more precipitation and it leads to higher, temperature. Modification of infrastructure of buildings and land surfaces. The important factor is waste heat generated from energy consumption. UHIs also alters the air quality, public health and urban ecology. The most recent climate change pattern urban heat islands contribute to global warming. Literature surveys talked about the adverse effects of urbanization and heat exposure effects and the global impacts. And also, survey suggests the mitigation measures reduce the temperature in urban areas.

Review of Literature

Causes and effects of urban heat islands

Macarof and Statescu (2017) discussed about comparison of normalized difference built-up index (NDBI) and normalized difference vegetation index (NDVI) as indicators of surface urban heat island effects in Landsat-8 OLI imagery. They found about there was a strong relationship between LST and

([1]Research Scholar, [2]Assistant Professor & Head)

NDBI than the relationship between LST and NDVI. So, they put forward a suggestion NDBI is an accurate indicator of surface urban heat island effects. Chaithanya *et al.* (2017) reported about estimation of the relationship between urban vegetation and land surface temperature of Calicut city Suburbs. They noticed about the gradual temperature was raised from 2003 to 2015. They observed decrease in urban vegetation in landuse. A negative correlation was obtained by correlating NDVI with the temperature. Rapid urbanization was one of the factors of reduction vegetation in areas. The vegetated area was reduced in the year 2015 because of increasing the built-up areas.

Heaviside *et al.* (2017) discussed about the relationship between urban heat island and implications for health in a changing environment. The phenomenon of higher ambient temperature in urban, rather than rural or suburban environments, is largely explained by the differences between land surface and building geometry in urban and rural areas. They find out exposure to heat is associated with a range of adverse health effects, ranging from exacerbation of minor existing conditions to increased risk of hospitalization and death. The populations most likely to be adversely affected by heat are generally those in the older age groups and those with existing health conditions. In 2015 Nuruzzaman reported that major effects of UHIs are low albedo materials, human gathering, increased use of air conditioner, destruction of trees, urban canopy, wind-blocking and air pollutants. Owing to the excessive heat people with little enduring capability undergo heat stress and it causes illness as well as death (Voogt 2004). The heat causes many health effects problems like heat exhaustion, heat cramps, and heat stroke (Occupational safety and health administration, OSHA, 1999).

Mohajerani *et al.* (2017) reported that the increased use of man-made materials and anthropogenic heat production are the main causes of urban heat islands. They revealed about asphalt concrete pavements make a significant contribution to the UHI effects. Urban heat islands adversely affect the water bodies in the urban environment. It decreases the water quality of resources due to an excess amount of heat.

Aneesh *et al.* (2015) investigated about rapid urbanization leads to an increase in land surface temperature (LST) which is governed by surface heat fluxes and is an important parameter in global change. Normalized difference vegetation index (NDVI) and Enhanced vegetation index (EVI) have been used as an indicator for vegetation cover and Normalized difference built-up index (NDBI) for level of urbanization. They investigated about NDVI and EVI had negative correlation between land surface temperature in Ahmedabad city. It indicated that vegetation parameter reduce heat in urban areas.

Santamouris *et al.* (2015) reported the urban heat island and global warming increase significantly the ambient temperature. An increase in temperature leads to an impact on the electricity consumption of buildings. Besides it also leads to an increase in electricity demand. Their analysis of studies revealed that with each degree of temperature increase, the increase of the peak electricity varies between 0.45% and 4.6%.

Ilham (2012) discussed various causes of urban heat island in Kuala Lumpur (Malaysia), he found about the six factors contribute to the rapid increase of urban heat like urban fabric, artificial heat production, a unique property of the urban environment and urbanization, nature of the city structure and human activities. And also discussed five noticeable effects of the urban heat island human thermal comfort, human health, economics, pollution and climatological effects.

Rongbo *et al.* (2007) discussed urban heat islands effect can vary significantly from daytime to nighttime. They reported the main causes of urban heat are listed as heating emission from buildings, atmospheric pollution, urban morphology, absorption and radiation qualities of surface materials, reduction urban vegetation and local topography.

Akbari *et al.* (2009) reported that the pavements cover about 40 percent of the urban environment cities. Yavuzturk *et al.* (2005) reported asphalt concrete with higher volumetric heat capacity can store more heat, and hence, generally has a lower temperature. Takebayashi and Moriyama (2012) studied the comparison between asphaltic pavements and the grass. They revealed about the average daytime temperature of asphaltic pavements are higher (20 degree Celsius) than the grass surface.

Mitigation measures

The urban heat island effect is a kind of heat accumulation phenomenon within urban areas due to urban construction and human activities. Buscail *et al.* (2017) reported mapping techniques to identify

population risk from exposure to heat across a city make use of highly spatially resolved information from climate or meteorological modelling, satellite imagery to characterize variations in urban temperature.

Bevilacqua *et al.* (2017) discussed about green roofs have recently been regarded as useful tools to mitigate the Urban Heat Island phenomenon, being capable of substantially reducing the roof surface temperature. They analysed the surface thermal performance of both green and traditional roof through proper defined indices. The results of the analysis showed how the traditional roof in June reached a peak of 74.3 ^{o}C with a daily excursion of 51.5 ^{0}C whereas green roofs were able to produce a surface temperature from 0.57 to 0.63 times lower. Shafique and Kim (2017) reported about green blue roof is a new innovative low impact development (LID) practice that has exhibited an option to mitigate the heat island phenomena in urban area. The green blue roof is a modified form of green roof technology. It has ability to store rainwater in vegetation, soil layer and increases the evapotranspiration rate which decreases the temperature of area.

Mohajerani *et al.* (2017) revealed cool pavements are one of the reduction methods is to increase the prevalence of green spaces through the installation of street trees, city gardens. It leads to an increase in the cooling effect derived from rivers. Razzaghmanesh *et al.* (2016) revealed that green roofs reduce both the surface temperature and the air temperature of an urban area during the daytime.Getter and Rowe (2006) reported green roofs to absorb heat and filter the air, kept the temperature low, and also green roofs help to delay the runoff duration which will keep the cities cooler for a longer period. Green roofs absorb water and it helps to reduce the temperature.

Price *et al.* (2015) discussed about green roofs are another method employed to mitigate urban heat island intensity by introducing vegetation at roof level to increase evapotranspiration. Vertical 'green walls' can also carry out a similar function like evapotranspiration.

Yang *et al.* (2016) reported that the rivers and lakes could also separate urban thermal fields, reducing thermal radiation, alleviating thermal field circulation and eliminating urban heat island effects. It was observed in Bozhou, China. So, areas near to a river, lakes etc., with convenient traffic arebeneficial to the climatic environment.

Fallman *et al.,* (2016) reported that urban greenery and reflective surfaces can reduce the temperature and near-surface levels of ozone in an urban environment. Sodoudi *et al.* (2014) found three different strategies using ENVI-met to observe their usefulness to mitigate the UHI effect in Tehran, they are 1) High albedo materials 2) Vegetation and green roofs 3) a combination of both of them. All three measures show a higher cooling effect in the day time.

Proper urban planning can also play a vital role in the mitigation of the urban heat island effect. Yamamoto (2006) described an urban planning approach situated on the bank of the river. He suggested some measures to build the buildings. To build the buildings, the creation of a winding path is one of the factors for cool airflow from the river into the city. Yamamoto (2006) suggested if the buildings are built parallel to the direction of the river, no airflow will happen in the city and if the buildings are perpendicular to the river, the airflow will occur. He suggested it is one of the mitigations to UHI effect.

Other studies like Theeuwes *et al.* (2012) reported the impact of vegetation and water surfaces in the urban areas. They measured and found that vegetative cover can reduce the temperature (each 10% vegetative cover reduces the temperature 0.6 k). They revealed about the water bodies does not increase the temperature in urban areas. Susca *et al.* (2011) reported that the high surface of albedo decreases the usage of energy and positively influences the environmental assessment, especially on the roofing system. Use of phase change materials integrated into the mass of the paving surfaces, these materials permit to achieve a lower surface temperature during the day time and reduce the heat amount (Santamorious, 2013).

Other studies like (Santamorius, 2013) reported various methods to reduce urban heat islands that include increasing the permeability of the pavements, it enhances the evaporation process. Other studies like (Santamorius, 2013) reported various methods to reduce urban heat islands that include increasing the permeability of the pavements, it enhances the evaporation process. Demuzere and Coutts (2012) reported about the water bodies have been widely used to regulate the urban heat, due to the contribution of the enhanced evaporation. Hathway and Sharples (2012) found river proximity is reduced urban air temperature and they also discovered the cooling power is strongest in early spring and already reduces June.

Heaviside (2017) suggested quantification of the UHI impact on health is necessary to increase the understanding of policy makers of the present and future risks to health of urban populations, particularly in the context of climate change. Care should be taken to consider multiple exposure in urban environments, which may compound or modify the direct impacts of heat on health. Ilham (2012) discussed various mitigation steps to reduce urban heat islands. These recommendations and five strategies that should be used by urban planners, political leaders and engineers. Recommendations are land management and plant cover, roof tiles of buildings are manufactured with high albedo and reflectivity, awareness and understanding of environmental effects.

Urban heat island is a matter of great importance. Policy makers need to pay immediate attention to matters related to urban heat islands. Green roofs are mandatory in homes or Flats built in urban areas. Care should be taken to consider multiple exposure in urban environments. Officials should take steps to make people aware of urban heat related health impacts and other issues.

Conclusion

Rapid urbanization is the major cause of urban heat islands. Increased use of man-made materials, anthropogenic heat production, destruction of trees in urban areas, air pollutants are adversely affected urban environment. So, the implementation of mitigation measures is needed to reduce urban temperature. Mitigation measures include green roofs, increasing the permeability of the pavements, high albedo materials and land management. The global land and ocean surface temperature of March 2020 was 1.16^0C. Urban heat is one of the factors to increase of global temperature.We must move forward to reduce the urban heat islands and people need to be made aware of the impacts of this.

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