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A Study on the Impact of Changes in the Materials Reflection Coefficient for Achieving Sustainable Urban Design

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Abstract

A lot of geographers, scientists believe that the current climate has changed. Especially, since the rapid increment of world's population. Indeed, rapid urbanization led to an increased demand of basic facilities, such as public transport services, hospitals, housing &, etc. Accordingly; the urban areas of cities have been expanded compared to rural areas, and many modifications and changes have been happened on their surface's materials. These modifications made our cities hotter than the Countryside, UHI effect phenomenon now well-known. One of the main reasons behind these changes is construction materials in both buildings and urban spaces, which play a major role in affecting the urban temperatures, precisely near-surface air temperatures positively or negatively, which depend mainly on the behaviour of the surface with solar radiation and how the energy is reflected, emitted, and absorbed. Thus, the current study aimed to investigate the direct and indirect impacts of materials reflection coefficient on the environmental performance and external urban surface temperature; by using the SOLENE-microclimate model tool (developed by the laboratory CRENAU - ENSA Nantes); which is a direct effect on external air temperature in terms of sustainability in the urban context. This study applied on one of the most important residential complexes in Mosul city - Iraq as a case study. The results were proved that when used a material with high reflectivity; Comparing low albedo Scenario (1) with high albedo Scenario (3); it can improve the thermal behaviour of building and urban surfaces, where the surfaces temperature of rooftop, walls, urban spaces, road have been changed by, respectively, 25ºC, 18 ºC, 20ºC, and 18ºC. As well as changed the urban air temperature by 11°C. However, the results showed that in some cases the surface temperatures increased slightly even when reflectivity increased in the scene, (comparison scenario 3 and scenario 5) where the change of albedo value of external walls surfaces have affected increasing the average urban spaces & pavement temperature about 2°C. The tool that is used in this study (SOLENE-microclimate) has effectively helped in achieving all the analysis required successfully, which it represent the most specialized tool in this field.

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1. Introduction: Previous studies, Aims, Focus and Research Questions

Over the centuries, the world has witnessed a growth in its cities over different time periods. Although some cities now experience slow growth or decline, such as New York and London, still other Asian and African cities are suffering very rapid growth now and are expected to continue at this pace [1] & [2]. As reported by UN, today 54% of the world's population lives in urban areas [3]. This growth and increase in urban inhabitants have led to, sequentially, expansion the cities and presence of dark colored surfaces, absorption of solar radiation during daytime and its re-radiation as heat during the night by buildings' envelope and pavements, replacement of forests, natural soils and green spaces with natural vegetation by residential buildings, and increased commuting distances [4]. Therefore, the inevitable results of these changes are higher surface temperatures of buildings/urban spaces, and then higher near-surface air temperatures, increased energy consumption and induced emissions. Therefore, and finally our cities are warmer than rural areas, phenomenon now well-known as the urban heat island (UHI) [5]. UHI is gradually increasing in urban areas, changing their microclimate and increasing energy demand in summer [6]. All of these changes will harden the sustainability challenges on cities. The possibility to achieve sustainability in the urban context is still controversial [7]. Van Staden M. and Musco F (2010) said, "Any urban activity cannot be considered as sustainable if it satisfies only one area of sustainability (environment, economy, and society)" [7]. For example, any environmentally friendly project is not sustainable if needing high costs and limited to only a certain segment of population. Accordingly, this work represents an attempt to provide suggestions to change any project to be compatible with the basic principles of environmentally friendly (sustainable environment), the basic principles of energy efficiency (sustainable society) with minimum cost (sustainable economy).

1.1. Literature review

Numerous studies have been carried out regarding high reflective surfaces and how energy is reflected, emitted, and absorbed, which have varied approaches as summarized in table 2. From previous studies, it has been observed that there are differences in the results and final conclusions. They are due to differences in methods, regions' types and characteristics, performance standards, climatic conditions, and scales/type of the studied scenario, etc. Accordingly, it is difficult to extrapolate a certain result on all projects. This conclusion agrees with the findings of Yang Jiechi et al (2015) in their study, which summarized most of the literature related to the relationship between albedo value and surface temperature, air temperature, and energy consumption [8]. Therefore, we can conclude a range of important points as table 1.

In spite of all this awareness, the usage rate of low albedo materials is still higher than the usage of high albedo materials at the level of building and urban form in many cities. This is due to many reasons such as often the cost, lack of experience of the decision makers, and lack of awareness about the importance of using high-reflectivity materials on the thermal behaviour of building and energy needed [19].

Table 1. The general conclusion of previous studies.

Rooftop	Pavement and road	Building envelope
All previous studies confirm that high-albedo and high emissivity roof materials (white color material, or another material with another color after change their chemical composition) can play an important role in enhancing the thermal behaviour of a roof, indoor/outdoor air temperature, and energy consumption. The appropriate rooftop albedo value is 0.8 for all types of building.	Most of the studies explained the advantages of using high-albedo pavement and road, but still there are some visual problems. Therefore, many others studies proposed some alternative's ideas to reduce the brightness of high reflective pavement with sustain high level of reflectance. Studies showed that the pavements also can help to improve the urban thermal environment through their effect of the air temperature near ground surfaces. Studies did not propose optimum albedo values for pavements and roads, but they suggested some strategies to reduce the surface	Employing high albedo coatings on the building exterior wall is an active and effective approach to improve the urban buildings' micro-heat environment.