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Transport Impact on the Urban Heat Island in Lebanon

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ABSTRACT *The replacement of natural areas by artificial surfaces and the anthropogenic heat released from different human activities such as the transportation and industrial sectors are the main contributors to Urban Heat Island (UHI), a phenomenon that can be dangerous on both the human and wildlife as well as on the environment in general. The focus of this paper is to study UHI effects in Lebanon due specifically to the oversaturated transportation sector in Lebanon's highly populated Beirut city and its surroundings. The busy main street of Zalka, located at the Mount Lebanon Governorate, is selected to investigate UHI effects. Four different scenarios are studied in ENVI-met software as form of simulations. Three assessment parameters: the air temperature T_{air} , the surface temperature $T_{surface}$, and the emitted CO₂ concentration are investigated. The results show that the usage of public transportation in its different forms is considered as solution to mitigate the UHI effect in the city.*

Keywords: Beirut, ENVI-met, Mitigation, Transportation

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INTRODUCTION

Urban Heat Island, referred to as UHI, is a phenomenon that occurs when the temperature experienced in urban areas is higher than the temperature in the surrounding non-urban areas. [1]. UHI effects impose a great threat on the environment, the society, and the economy [2].

Transportation, specifically road transport, is a major source of air pollution leading to the UHI formation in both developing and developed countries [3]. The concentration of particulate matter (PM10 and PM2.5) is a key indicator for air pollution since it has both short- and long-term health implications [4].

This paper proposes four different traffic scenarios to be simulated in ENVI-met software in a selected street located in the capital of Lebanon, Beirut. The objective is to study and compare the impact of each scenario on the mitigation of UHI due to the transport sector [5]. The assessed parameters are the surface temperature $T_{surface}$, the air temperature T_{air} and the concentration of emitted CO₂.

METHODS

In order to study the effect of the transportation sector on the mitigation of UHI, a real case study is conducted in Lebanon, Beirut. The selected geometric area is chosen as Zalka’s busy main street (100m x 100m). Coupling field visits with

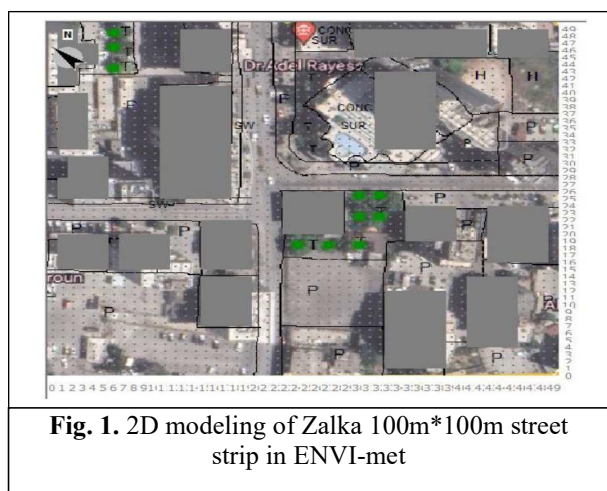


Fig. 1. 2D modeling of Zalka 100m*100m street strip in ENVI-met

google maps, the area of interest was well examined and the ensuing street geometry is

modeled in ENVI-met software. Figure 1 below illustrates a 2D representation of the selected street in ENVI-met.

To study the traffic status in the Zalka street, “MetroCount Traffic Executive” was used on site as a traffic counter for 7 hours on the 5th of September 2022. This instrument was able to record the count, type and speed of vehicles passing through two pneumatic tubes set across the road. The study is divided into four different mutually exclusive traffic scenarios. Each of these scenarios is executed through a simulation in ENVI-met. Table 1 below shows the definition of each of the four studied scenarios.

Table1 Transportation Scenarios

Scenario (S0)	The null scenario: No Traffic
Scenario (S1)	Basic Traffic as it is
Scenario (S2)	Replacement of cars with Public Transport
Scenario (S3)	Introduction of Electric Buses

Table 2 below shows the composition of traffic for each scenario. The values vary according to the percentage incorporation of UB and EB in the total traffic. For instance, in scenario 2, 0.17% of the total traffic was given to UB while in scenario 3, this percentage was assigned to EB instead.

Table2 Contribution of Vehicle Category to overall traffic in percent

	Scena rio 0	Scena rio 1	Scena rio 2	Scena rio 3
LDV (Light Duty Vehicles)	0%	5.30%	5.39%	5.39%
HDV (Heavy Duty Vehicles)	0%	2.30%	2.34%	2.34%
MC (Motorcycles)	0%	7.40%	7.50%	7.50%
UB (Urban Bus)	0%	0%	0.17%	0.00%
Coaches	0%	0%	0%	0%
PC (Passenger Cars)	0%	85%	84.60 %	84.60 %
EB (Electric Bus)	0%	0%	0%	0.17%

RESULTS

In order to assess and compare the difference between these four scenarios, three assessment parameters are taken into consideration throughout the day: the air temperature denoted as T_{air} , the surface temperature denoted as $T_{surface}$ and the concentration of emitted CO_2 denoted as $[CO_2]$. Simulations were run continuously and the obtained results, showcased as thermal maps and concentrations of emissions were taken.

DISCUSSION

Figure 2 below represents a comparison between S2 and S3 relative to S1. All three assessment parameters are considered simultaneously.

The straight line represents the variation of the range of recorded T_{air} between all three scenarios. The recorded percentages are given in comparison with the values from S1. It is clear that T_{air} drops by an average of 0.71% with the use of public transport (S2) and reaches a drop of 0.74% with the inclusion of Electric Buses. The pointed line represents the variation of the range of recorded $T_{surface}$ between all three scenarios.

The recorded percentages are given in comparison with the values from S1. It is clear that $T_{surface}$ drops by an average of 0.04% with the use of public transport (S2) and reaches a much more pronounced drop of 3.49% with the inclusion of Electric Buses. The dashed line represents the variation of the range of recorded emitted $[CO_2]$ between all three scenarios. The recorded percentages are given in comparison with the values from S1. It is clear that $[CO_2]$ drops by an average of 0.82% with the use of public transport (S2) and reaches a much more pronounced drop of 2.17% with the inclusion of Electric Buses. As a result, the changes incorporated in each scenario showed an improvement in the UHI.

CONCLUSION

Lebanon suffers from UHI and intense air pollution due to its transportation sector. The following paper presented four different transportation scenarios in order to try to mitigate UHI. Three assessment parameters were studied: the air temperature T_{air} , the surface temperature $T_{surface}$, and the emitted CO_2 concentration. The results showed that the second-best scenario was scenario 2 (inclusion of public transport), with reductions of 0.04% in $T_{surface}$, 0.71% in T_{air} and 0.82% in CO_2 as compared to the status-quo

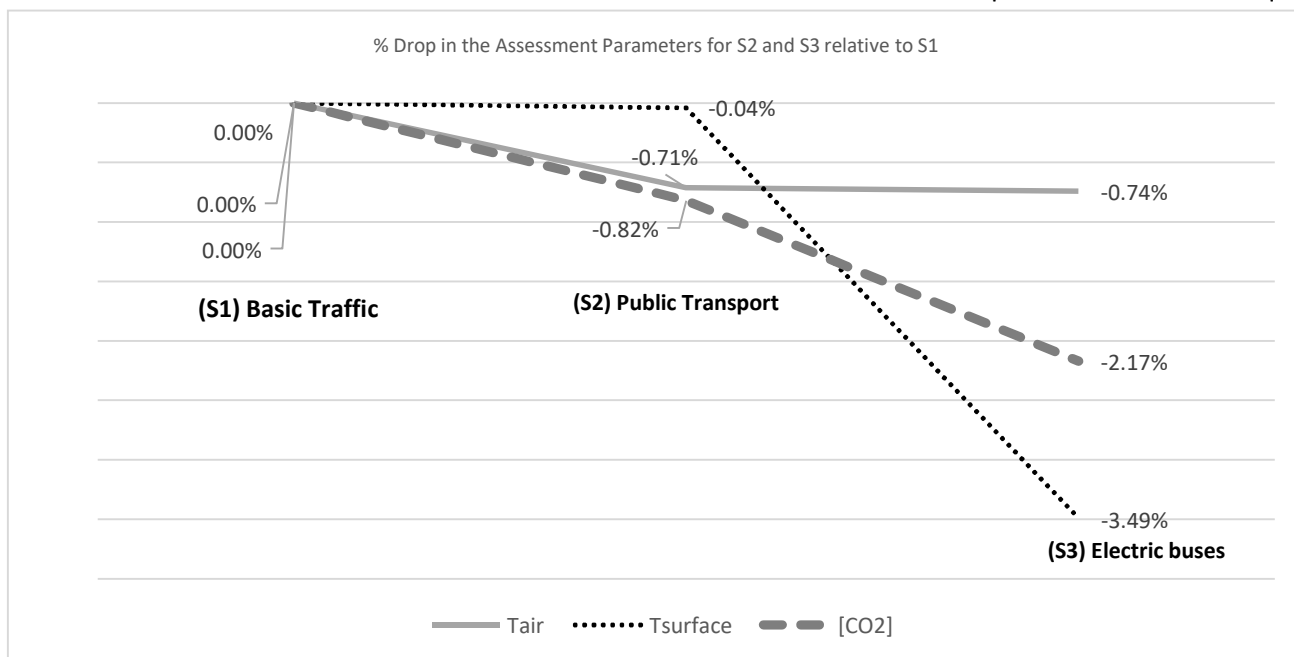


Fig. 2. % Drop in the Assessment Parameters for S2 and S3 relative to S1

(scenario 1). The best possible scenario was scenario 3 (inclusion of electric buses) with reductions of 3.49% in $T_{surface}$, 0.74% in T_{air} and

2.17% in CO₂ as compared to the status-quo (scenario 1). It is to be noted that the authors plan to conduct further studies where these impacts would be optimized and other parameters would be incorporated.

Declaration of Competing Interest

The authors report no declarations of interest.

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