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Analysis of water pond in mitigating the effect of Urban Heat Island in Hyderabad Sindh

Halar Ahmed Bhatti [ab], Rizwan Ahmed Memon [b] ,Abdul Ghafoor Memon [b] , Abdul Rehman Soomro [a b]
[a] Post Graduate Student, Energy Systems Engineering, Mehran university of engineering and Technology, Jamshoro,76062, Pakistan
[b] Department of Mechanical Engineering, Mehran University of Engineering and Technology Jamshoro, 76062, Pakistan
Government of Pakistan
Corresponding author email: halarbhatti@gmail.com
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Abstract **- Urbanization leads to increasing heat stress in the hot and humid climates, therefore the formation of a concentrated original microclimate within municipal environs is seen as crucial. The megacity of Hyderabad has experienced heat, but the cooling impact of the water bodies in the megacity has received little attention thus far. While the evaporative action of water is thought to be acting on its own to lower the temperature of the surrounding medium. The microclimate of the girding area is cooled by rivers. Other researchers refocused on the fact that the most efficient non-resisting method of cooling buildings or public spaces is evaporative cooling via water bodies or features. A simulation tool called Envi- met was used to analyze the impact of water bodies on microclimates.**

The software's application is to analyze the temperature distribution of a typical urban layout with and without water. According to our analysis of the research, bodies of water may effectively lower city temperatures by 0.5 to 4.0 °C. Based on the results, it can be inferred that increasing evapotranspiration in cities, which results in water bodies, may successfully reduce the impact of civic heat islands.

Index Terms— ENVI-MET, Pond evaporation, heat mitigation, urban heat island,

I. INTRODUCTION

Urbanization-related rises in air temperature have an impact on how energy-efficient and comfortable buildings are outside. Urban microclimate research utilizing numerical simulation techniques are receiving a lot of scholarly attention as they aim to build adaptation methods[1] [2]. Several scholars debate whether there is a gradient between urban and rural areas or if these regions have unique traits that set them apart from both urban space and the countryside [3] [4] [5]. This dissertation discusses the technological advancements made to the ENVI-met microclimate simulation between 2007 and 2010 and provides examples of how ENVI-met may be used to aid with solving common microclimatic problems in urban settings [6], [7]. The microclimate model ENVI-met, which has more than 1500 registered users worldwide and has been in operation for more than 10 years, is getting a significant upgrade in the upcoming Version 4.0.[8] [9] A completely redesigned 3D editor, improved calculations of wall temperatures and radiation, and the ability to specify the diurnal fluctuation of the climatic boundary conditions of the model area are among the key changes [10] [11] [12] . The purpose of this study is to estimate how well the program ENVI- met predicts the thermodynamic performance of yards by differing field data from the concurrent monitoring of two yards with the issues of the software simulations [13] [14]. Using the three-dimensional civic microclimate model ENVI- met, this study examined the impact of variations in the physical and geometrical characteristics of the civic fabric on the civic microclimate and out-of-door thermal comfort. According to the anticipated issues, a 3 K reduction in air temperature can be achieved by adding the number of passable pavements [15] [16] . The thermal impacts of the primary GBI forms, Similar as trees, green roofs, perpendicular greenings, and water bodies, have been the subject of several exploration. The resulting heat impacts may vary depending on the individuals' physical attributes, planting strategies, and local urban fabric features. A key tool in GBI research is ENVI-met, a comprehensive three-dimensional modelling program that can accurately mimic the outside microclimate[17]. In particular, the study demonstrates how a yard can achieve an respectable position of thermal comfort for the tropics and be used by its druggies for a significant portion of the day, indeed during the noon, depending on design parameters like the structure height rate and an cornucopia in the quantum of area of pond and vegetables [18] [19]. A variety of mesh cell sizes were taken into account while analyzing the data the software produced. Still, because substantial disagreement couldn't be detected, the $2m^2$ cell- sized model was named as a fair middle ground between computation time and accurate findings. The disquisition of the measure of determination, Root Mean Square Error, and Willmott's indicator of agreement for air temperature and mean radiant temperature further attested to the software's prophetic power [20] [21] . The ENVI-met model is utilized to evaluate and compare hot summer day. For the daylight hours of 06.00–20.00 (14 h), software simulations of microclimate and outdoor thermal comfort conditions are run at a height of 1.8 m [22] [23] . For their modelling, validation, and scenario simulation processes, the results of 79 peer-reviewed papers were examined and synthesized [24] [25] [26].An emphasis was placed on closely investigating their data sources, assessing indicator choices, analyzing key analytical tenets, and condensing suggestions to enhance the research workflow [27]

[28]. Temperature comfort may be severely impacted by climate change and cooling degree days, which are the causes of increased heating and cooling energy consumption. High energy use to maintain comfort causes environmental deterioration, depletes traditional energy supplies, and may be costly to the entire economy. Therefore, cost reduction is achieved by using energy wisely and managing environmental problems associated with energy consumption better [29] [30].

METHODOLOGY

The goal of the study that is being presented is to quantitatively investigate how a water body affects the distribution of temperature in a typical megacity region. Envi-met V, a simulation tool, is used to read the microclimatic changes in the urban terrain. The atmosphere's state is (temperature, moisture, wind speed, and wind direction). Different configurations are disassembled to probe the excellent water and determine how much of the research area's water body is made out of water. To gain a better understanding of how the Hyderabad water body's evaporative cooling from adjacent aqueducts may differ from its surroundings, the study case region is being investigated. The paper also aims to discuss the potential impact of evaporative cooling on water on the surrounding temperature as a function of Area.

Flow Chart

Research Methodology → Literature Review → Collection of Data → Analysis of Dajta → Simulations in ENVI-MET 5 → Analyzing Results → Discussions, Results and Conclusion.

METHODOLOGY
Simulation software and settings

• The effort started by developing a simulation model utilizing ENVI- met V software that is capable of simulating the microclimatic conditions of municipal settings, with the goal of reading the microclimatic variations within civic terrain. In the context of fluids and thermodynamics, it must also be capable of determining the complex heat exchange procedures of various shells and faking the influx around structures. The municipal environment and water body of the Hyderabad megacity center serve as the work's initial case study (see Fig 1). Since they were the days with the greatest temperatures, June 21st was a good day to run the simulations. A numerical model needs initialization time, which cannot occur at noon since the model would not be able to "predict" the proper launch circumstances, according to ENVI- met 5. The simulations began and ended at 6 am and lasted for 24 hours. While wind speed and the initial air temperature were categorized as fixed factors, layout was not. Point Hyderabad, 25° 25' 20" N–68° 19' 57" E, Simulation Day 19 of July are the point-specific input data for the programme. The mean values of the rainfall data obtained by the Hyderabad Meteorological Department by sites like Google and are used to set the air temperature, wind speed, and relative moisture for ENVI-met 5 Simulations.

According to Lambert- Beer's law, the remaining energy, primarily visible radiation, is absorbed in the water subcase.

$$Q^{*}_{sw}(z) = Q^{*}_{sw,trans}(0)\, e^{-E(z)}$$

Where Q_{sw}^{*} (z) (Wm-2) denotes the amount of shortwave radiation that has reached the top of subcase z, and $Q_{sw,trans}$*(0) denotes the amount of shortwave radiation that has passed through the actual upper water subcase and contains the remaining 55% of the shortwave radiation that has been absorbed. The extermination measure is also (m^{-1}). Also provided is the heating rate at depth z (m) caused by immersion of shortwave radiation, Qw (z) (Ks^{-1}).

$$Q_w(z) = \frac{1}{\rho C w}\frac{\partial Q sw(Z)}{\partial z}$$

The heat capacity of water is given by Cw = 4.2 x 103 (J kg^{-1} K^{-1}), its viscosity by = 1000 (kg m^{-3}), and the amount of solar radiation (W m^{-2}) that is absorbed in the subcase at z by $Q_{sw}(z)$. The extermination factor & in (1) is a crucial metric for a water body's thermal gestor. In older ENVI- met performances, this measurement's fixed dereliction value ranged from 0.5 to 0.6 m^{1}, reflecting the turbidity of the water. Since the turbidity of different water bodies varies greatly, a modified interpretation of ENVI-met has been devised in which the stoner can adjust the value of to take into account particular light immersion properties.

Fig: 1 Hyderabad Area

Employed Settings

Temperature	38°c
Wind Speed average	2 mph
Wind Direction	90°
Height of buildings	5m and 10m
Min to Max Relative Humidity	45% - 75%
Roughness Length	0.010m

Evaluated scenarios

Two scripts were presented to exhaustively probing the goods of water ponds around Hyderabad.

Scenario 1- Scenery with effect of Pond

This scenario illustrates the situation in which the research area's current microclimate and its surroundings are reproduced with the help of a pond.

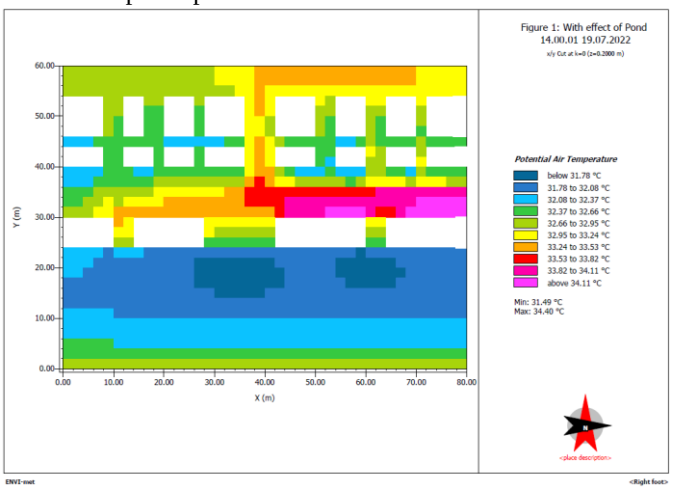

Fig. 2 Results of Simulation area with effect of Pond

Scenario 2- Scenery without any effect of Pond

In this case, Pond is taken out of the picture. The replacements' and the replacements' microclimates and Following that, its adjacent areas were examined under comparable environmental conditions.

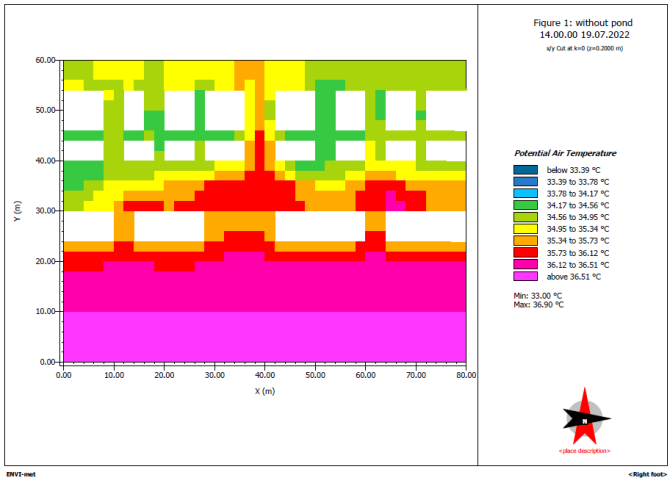

Fig. 3 Results of Simulation area without effect of Pond

4. Results and Discussions

Figs. 4 and 5 compare the average temperatures of the two scripts (Fig 2 and Fig 3) as determined from July 19. Comparing the two scripts reveals that water bodies are effective in lowering the temperature of the medium air.

Simulations were used to validate the cooling effects of water. Additionally, it was shown that the distance between the water bodies with the region in question is closely connected with the effects to tackle heat effect on the surrounding areas.

POND was found to have the great cooling effect to tackle heat the surrounding. Quantitative analysis demonstrates that the greenery scenario is 3° C cooler than the other scenarios. When the pond is replaced with a road or red brick, this effect goes away.

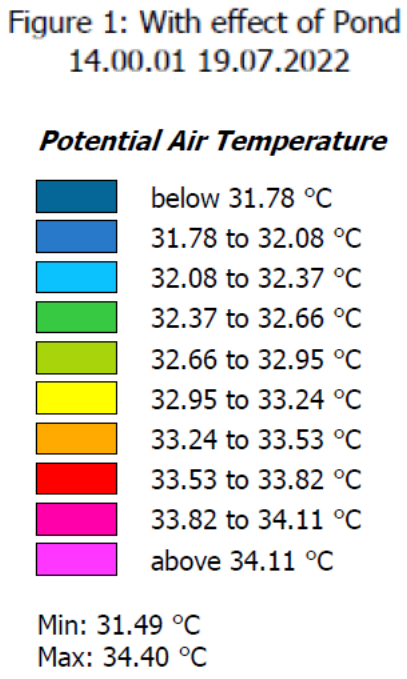

Fig 4

Results of Fig 1 Simulation of Area with effect of Pond

According to the average temperatures for the two situations, a region's temperature decreases the closer it is near water. At locations near water, there was an average temperature difference of 1-2 °C. Blue regions contributed to this differential, which eventually resulted in a reduction in cooling energy and resident thermal comfort.

The results handed by the simulation from Envi-met should support the results acquired from the observed area dimension crusade. Envi- simulation met farther demonstrated how the loss of blue space might lead to inimical thermal conditions both in the original region and its environs, particularly when blue area is replaced by hard shells or structures. In conclusion, simulations in tropical climates were used to demonstrate the significance of water. Water bodies in cities should be given more attention rather than being replaced by urban.

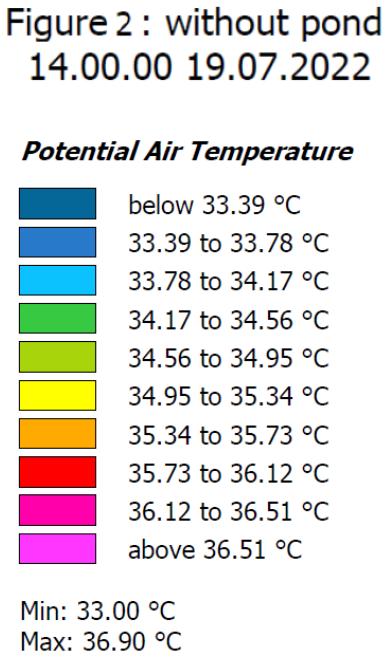

Fig 5

Results of Fig 2 Simulation of Area without effect of Pond

Simulation has been done on an area of Hyderabad in its natural conditions with effect of Pond and without any effect of Pond. The input parameters include input data which is extracted from online resources Google and Envi-Met. Whereas output parameters include Temperature variation of Area with effect of Pond and without any pond effect. Observed difference is of $2^{o}C$ – $4^{o}C$ respectively. Use of pond to tackle heat effects of urban areas is a wise choice.

V. CONCLUSIONS

Estimated the hot days for summer are of July with help of ENVI-MET we observed great effect of ponds in Hyderabad to mitigate heat effect of urban island. Hyderabad district is a hot urban island with great pollution, and usage of Electronics to decrease room Temperature e.g Air Conditioner. Here results show us usage of ponds to tackle heat effects is a wise choice. For the specific research, ENVI-met worked well, proving that it is feasible to transform cities into smarter, more advanced models. This idea enhances urban resilience and livability while offering substantial promise for reducing the effects of climate change and adapting to it.

Pakistan has experienced unprecedented growth in recent times, and many of its major cities are expanding quickly and unplanned, which is having negative effects on their economies. The growth of other-league cities like Hyderabad, Karachi, and many others has been extraordinarily rapid during the past ten years. Similar Pakistani metropolises are likewise experiencing problems relating to the rise in facial temperatures. The suggested investigation is a step toward better understanding the UHI and the causes of it. The study aids in quantifying how much of an impact water features have on UHI. The suggested exploration has assisted in providing a scientific instrument to help plan the growth of a megacity in the most effective way. Such that the impact of UHI is reduced by providing eye-catching mitigating measures like water bodies, etc. This investigation shows that, in addition to other considerations, water bodies have a substantial role in

It can be concluded that by analyzing the estimation of cooling degree days better and proper energy management can be easily done. Furthermore, by considering the cooling degree hours monthly as well as annual power requirement to maintain thermal comfort can be easily determined, and it will also make us able to utilize the appropriate power which will results in reduction of energy wastage.

It is thus concluded that ponds have direct impact on fighting heat effect of urban island and energy consumption of building.

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