InCRECA

Increasing Community Resilience in Climate Adaptation Process

KADIKÖY MUNICIPALITY

A GLANCE ON MEASUREMENT DATA

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Content

Urban Heat Island

The fact that air temperatures are higher in regions with intense urbanization compared to rural areas is called the urban heat island (UHI) (Oke, 1987). Since decreasing vegetation cover and dense construction affect the thermal heat capacity of cities, more heat is spread on city surfaces compared to rural areas, so urban heat islands emerge. Defining the temperature difference in the urban and rural areas, UHI can occur day and night throughout the year. The intensity of the urban heat island varies seasonally and is the most severe in the summer season in Istanbul. (Ünal et al.2020, Ünal et al, 2018).

Within the scope of the European Union project completed in Istanbul Technical University Meteorological Engineering Department in 2018, the UHI and heat wave intensities observed over Istanbul were revealed. In the study, the maximum and minimum temperature data of the measurement stations of the Turkish State Meteorological Service in six different regions (Göztepe, Kartal, Sarıyer, Florya and Şile) between 1960 and 2015 were used. When the temperature differences of Şile, which is defined as a semi-rural station according to the results of the research, are examined, it was determined that the highest values are seen in intense urbanized areas Göztepe and Kartal stations and it reaches a maximum of 3.01℃. (Ünal et al.2020, Ünal et al, 2018). These values are lower than other metropolises with the same population and size. The fact that the Bosphorus and the prevailing wind direction is north-east and urbanization is intensely located around the Bosphorus reduces the severity of the urban heat island.

Urban heat islands occur on the ground surface and in the atmosphere. On a hot sunny summer day, solar radiation is absorbed by roofs, sidewalks and paved areas, causing the surface to be warmer than the air above it. Rural area surface temperatures remain close to air temperatures. In cities, the surface heat island effect exists day and night and it tends to get stronger throughout the day with the effect of solar radiation. The atmospheric urban heat island is more effective due to the long-wavelength radiation emitted from the urban surfaces after sunset. In a city with a million and more population, the average annual air temperature is 1-3°C warmer than in the countryside. In a clear and calm night, the temperature difference can reach up to 12°C (EPA, 2003).

Selection of The Measurement Points

Intense urbanization is observed in Kadıköy district as in the general of Istanbul. In Kadıköy, the most crowded neighborhood is Göztepe, while the least populated neighborhood is Koşuyolu. The 20 temperature, humidity and air quality measuring devices provided within the scope of the project were distributed to the appropriate neighborhoods of the district and placed on the balconies of volunteer citizens. In this way, data is started to be collected for the Environmental Monitoring System (EMS), which will be implemented, by ensuring the participation of the citizens and their contact with science.

Different land use areas are very important in terms of determining the local distribution of the urban heat island intensity. Considering the literature, the importance of different buildings and street structures, roads, green areas and sea effect has been emphasized in the measurements to be made. For this reason, each neighborhood was examined one by one and the most correct points were selected. In order to reveal the effects of the urban heat island on the residents of the district, devices were placed in the land use areas that differ from each other as much as possible. Using the local climate zones study published by Stewart and Oke (2012), LCZ (Local Climate Zone) classes of the district were found on the basis of the district and their temperature characteristics were revealed. In Table 1, land use characteristics and approximate LCZ classes determined for the points where measurement devices are placed are given.

Table 1. Land use characteristics of the points where measuring devices are placed

Cevice code	Neighborhood	Land use class
5ddd	19 Mayıs	LCZ5 medium-wide street, medium-height buildings, impervious surfaces, trees
5aeb	Acıbadem	LCZ2 narrow street, adjacent medium-high buildings, no trees, impervious surfaces
7704	Bostancı	LCZ4 very wide streets, high buildings, impervious surfaces, few trees
3b0a	Caddebostan	LCZ1 very narrow streets, medium / high buildings, impervious surfaces, few trees
1505	Caddebostan	LCZ4 medium wide street, impervious surfaces, high buildings few trees
3153	Caferağa	LCZ2 very narrow street, adjacent medium-high buildings, impervious surfaces
6f8a	Dumlupınar	LCZ2 narrow street, medium-high buildings, impervious surfaces
545c	Eğitim	LCZ5 medium-wide street, medium-height buildings, few trees
4b10	Erenköy	LCZ5 medium-wide street, medium-height buildings, few trees
5123	Fenerbahçe	LCZ6 sea effect can be observed directly, the surrounding is open and green area
43f9	Göztepe	LCZ5B low-to-mid-rise buildings in Özgürlük Park
6e91	Göztepe	LCZ4-LCZ5 wide street traffic emissions can be observed
0b57	Koşuyolu	LCZ6 narrow street, 1-3 storey buildings, impervious surfaces, trees
0186	Kozyatağı	LCZ1 narrow street, high-rise buildings, few trees
3779	Merdivenköy	LCZ2 medium-width street, medium-rise buildings, few trees
65bf	Merdivenköy	LCZ4 wide street, high / medium buildings, impervious surfaces and green areas
1eff	Rasimpaşa	LCZ2 very narrow street, adjacent medium-tall buildings, no trees
284b	Suadiye	LCZ4 wide street, high-medium tall buildings, few trees
575d	Zühtüpaşa	LCZ5 wide street, low-rise buildings, dense impermeable surface, few trees
4cb5	Zühtüpaşa	LCZ2 very narrow street, medium-high buildings, few trees
Göztepe	Göztepe	LCZ2 narrow street, mid-rise buildings, few trees
Acıbadem	Acıbadem	LCZ5E large impervious surfaces, few trees, medium-height buildings

While selecting the measurement points, it was aimed to determine the extent to which the measurements will be affected by land use by determining the local climate zones. Kadıköy district can be divided into three main land use structures. These can be named as LCZ1 class dominated by high-rise buildings and impervious surfaces, LCZ2-LCZ4-LCZ5 classes with medium wide / narrow streets where high and medium-height buildings are found with few trees, and LCZ6 class with narrow streets where low-rise buildings are accompanied by trees. Although local climatic

zones (LCZ) categories contains much more detailed information such as building material properties, emissivity, albedo and heat capacity, it has been used as a scientific basis to determine the general land use profile of the district. Measuring devices have been distributed to represent each of the local climate classes within the boundaries of Kadıköy district. Table 1 shows the general characteristics of these classes and the neighborhood.

UHI Impact Analysis From Measurement Data

Temperature measurements taken between December 24, 2020 and January 13, 2021 were evaluated. Looking at the hourly temperature values, it is seen that the sensors placed on the exterior of the building are generally affected by the heat energy emitted by the building surface. Meteorological temperature measurements are made from a pole where they are mounted at a height of 2 meters with sensors that are prevented from receiving direct solar radiation in open measurement parks.

Table 2. Statistical information of measurement data

	Mean	Standard deviation	Maximum value	Minimum value
0b57	18.37	4.19	33.60	11.67
1eff	15.33	2.63	21.62	8.33
3b0a	17.68	3.51	33.40	10.00
4b10	16.24	2.13	22.39	10.27
4cb5	17.17	3.19	29.23	10.81
5aeb	18.96	4.10	40.51	11.91
5ddd	14.86	2.93	22.17	8.71
6e91	20.04	2.66	28.48	14.26
6f8a	17.80	3.16	26.02	12.08
43f9	15.50	2.47	21.65	9.46
65bf	17.08	2.44	21.45	9.89
0186	17.45	2.55	42.89	11.94
284b	15.77	2.79	21.55	8.34
545c	16.84	2.67	23.81	9.62
575d	17.48	4.30	31.68	10.86
1505	18.44	2.28	29.49	13.47
3153	16.99	2.16	20.69	10.23
3779	17.33	3.58	30.30	9.44
5123	15.99	2.48	25.76	9.22
7704	18.18	3.17	27.04	11.92
Acibadem	13.47	3.05	20.03	6.45
Goztepe	13.16	3.13	24.35	6.25

Sensors in this study, take measurements in residential buildings in direct contact with the building surface, and some devices are exposed to direct solar radiation. For this reason, it is quite normal

that the temperature values are higher than the measured air temperature. The sensors named Göztepe and Acıbadem, which take measurements by mounting on the pole in the open air, therefore measure the lowest temperature values. Table 2 contains the statistical information of the data of all devices collected between December 24, 2020 and January 13, 2021.

When different street structures are examined, the measurement points listed below draw attention because they have different land use characteristics.

- 545c (medium-height buildings, narrow street, few trees)
- 5123 (low-rise buildings, trees, sea and impervious surfaces)
- 5ddd (low-rise buildings, wide street and trees)
- 43f9 (low-rise buildings and green area in Özgürlük Park)
- 0b57 (low-rise buildings, wide street, few trees)
- 3b0a (tall buildings, very narrow street, few trees)

Results

The temperature differences were revealed by examining the 21-day data of the measurement points. Since the urban heat island effect was observed most prominently within a few hours after sunset, the maximum temperature measurements taken at 21:00 local time were compared. As can be seen in Figure 1, while 5ddd and 43f9 sensors have minimum temperature values, 0b57 and 3b0a sensors measured approximately 4 ℃ higher values. This situation reveals the effect of the presence of green space on thermal comfort. Since the sensor named 43f9 takes measurements in a low-rise building by the park, it is suitable for use for the urban heat island index to be calculated with the available data.

While calculating the urban heat island index, the difference between the rural station maximum temperature values and the urban station maximum temperature values are used. However, since there is no rural point specific to Kadıköy district, this approach has been updated. The maximum temperature values of the sensor located at the park edge and the maximum temperature values of the sensor in the average urban area are uset for calculating UHI index. Thus, the difference between the temperatures measured in a relatively green area and the temperatures measured in the city area can be revealed.

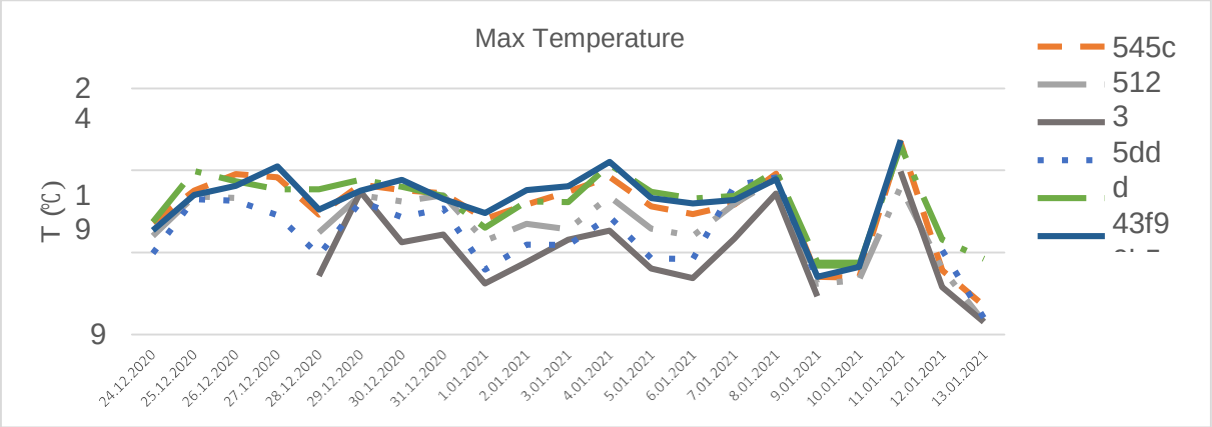

Figure 1. Maximum temperature values measured at 21:00.

The maximum temperature values for 14:00, which can be regarded as the hottest hour of the day, of the same measurement points have been compared.

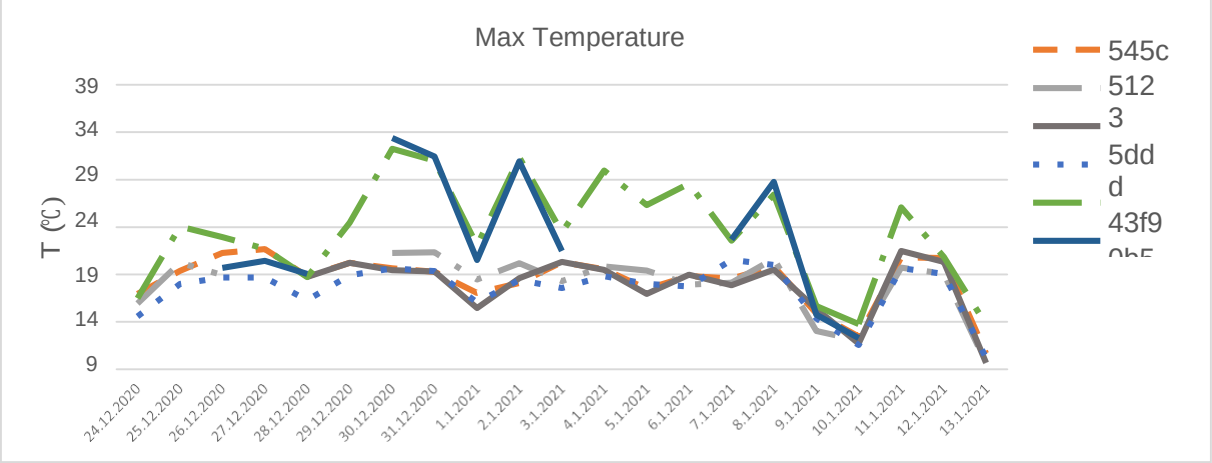

Figure 2. Maximum temperature values measured at 14:00.

As seen in Figure 2, devices named 3b0a and 0b57 measured warmer values than others. The dramatic differences between the maximum temperature values taken at the hottest hour of the day suggest that some sensors are exposed to direct solar radiation. On the other hand, temperature values above the seasonal norms that continue throughout December 2020 are also reflected in the devices called Acıbadem and Göztepe, which take measurements in the outdoor environment. Temperatures in these devices have reached a maximum of 23℃.

The 3b0a sensor was selected as well as the 43f9 sensor for the urban heat island index calculation. The main reason for this choice is that both devices take measurements on building surfaces and are located in different land use areas. The urban heat island index values calculated from the temperatures measured with identical devices in different urbanization structures for Kadıköy district are given in Figure 3.

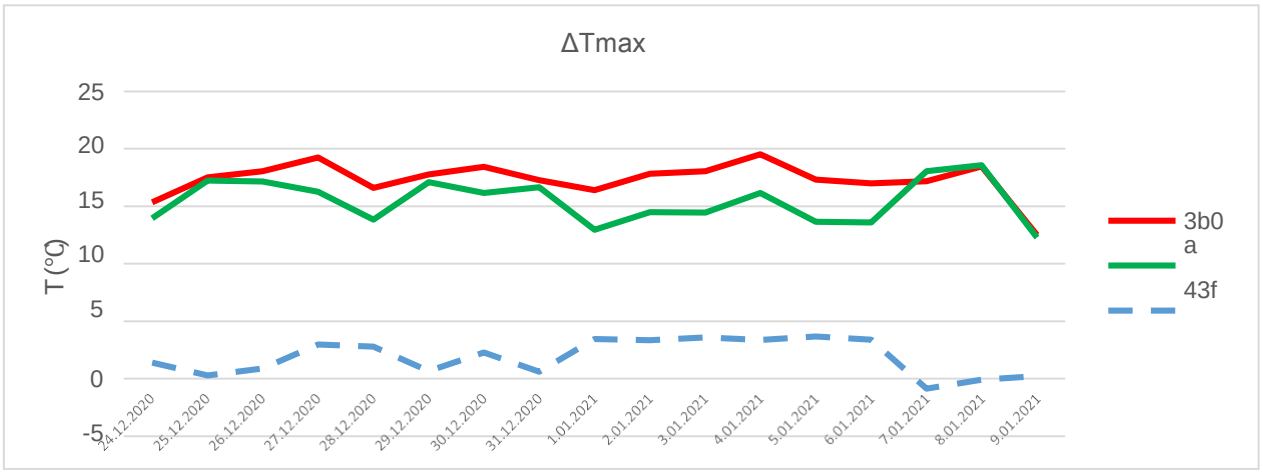

Figure 3.The 3b0a and 43f9 sensors maximum temperature differences and the UHI index

The maximum temperature difference between the two measurement points is calculated as 3.6 ℃ Although the UHI effect is evident especially during the summer months, an approximate urban heat island index is determined for Kadıköy district from the measurements evaluated between December 24 and January 9.

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