

연구논문

Air Temperature Decreasing Effects by Restored Urban Stream

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복원된 도시 하천에 의한 기온저감효과

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Abstract

자연형 하천으로 복원된 도시하천의 기온저감 효과를 파악하고자 2007년 6월 1일부터 2008년 5월 31일까지 10분 간격으로 서울시 강남구의 양재천 및 그 주변지역의 기온을 관측하였다. 관측 값은 관측지점의 일중 기온변화와 관측 자료들 중에서 연 평균 기온이 가장 높은 숙명여고 (SM)와 양재천 주변 두 지역(YW와 YT)의 기온차를 비교 분석하였다. 그 결과 2007년 6월 15일 22:50에 숙명여고와 양재천 두 지점의 기온차가 7.7℃로 가장 크게 관측되었으며 이때 기상상태는 바람이 없고 맑고 개인 날씨이었다. 또한 일 중 기온 저감효과는 낮보다는 밤에 뚜렷하였으며 관측 기간 중 숙명여고 (SM)에서 열대야 현상이 13일로 가장 많이 나타났는데 비해 양재천 (YW와 YT)은 4일로서 열대야의 특성인 도심지 최저기온 상승을 하천이 억제함으로써 하천의 기온저감효과가 확인되었다.

주요어 : 도시복원하천, 기온, 저감효과

I. Introduction

Rapid urban expansion in Seoul since 1960s induced urban environmental problems including urban heat island (UHI) and urban stream pollution. To improve these problems the natural-style urban stream restoration project has been implemented for the first time at Yangjae Stream, Gahngnam-ku, Seoul in Korea. Many researchers have been taken to investigate riparian ecosystem rehabilitation after Yangjae Stream Restoration, however, there are few researches have been carried out for determining air temperature decreasing effects by restored urban stream. UHI characteristics have been studied during the past several decades (Oke, 1987; Arnfield, 2003). UHI shows the difference between heated urban area and rural (stream) area and it is known that UHI intensity is obvious in nighttime, winter, windless and cloudfree conditions (Klysik, 1999; Steyn, 1991; Kim, 2002). Therefore, the objective of this study is to determine the air temperature decreasing effects by restored urban stream.

II. Methods

1. Study Site

The study site is Yangjae Stream at Gahngnam-ku, Seoul in Korea. It is located between $37^{\circ}25'19''\text{N}$ to $37^{\circ}30'04''\text{N}$ and $126^{\circ}59'47''$ to $127^{\circ}04'24''\text{E}$. The Yangjae Stream is 15.6km long and is 23~140m wide and slope gradient is 1:500. Topographically it originates from the Gwanahk Mountain, flows through the Gahngnam-ku and Seocho-ku and joins the Tahn Stream which joins the Han River (Figure 1).

After the restoration the Yangjae Stream has a potential as an ecological corridor which connects

Han River and several mountains adjacent to the stream. From the 1980s, the population of study site has grown rapidly mainly due to the urbanization and the site development for housing construction. The climate of the site belongs to the Temperate Zone featuring four seasons. Temperatures show large seasonal variation, reaching as high as 36.2°C in the summer and dropping as low as -18.6°C in the winter (December to February) (www.kma.go.kr (1999~2007)). Seoul has hot and humid summer (June to August) with average high temperature of 28.5°C . In the winter, dry and cold wind flows from Siberia. Therefore, the site shows a typical continental climate.

2. Data Observation

In order to determine air temperature decreasing effects by restored urban stream, temperature and humidity data was measured using Hioki

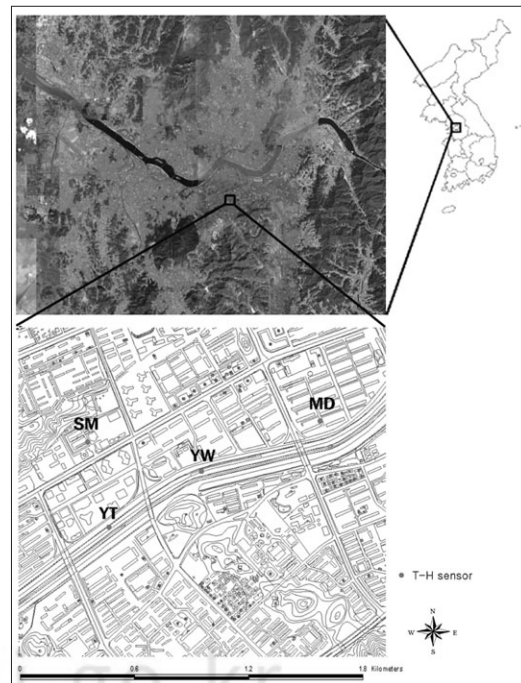


Figure 1. Study site

temperature-humidity (T-H) sensors at four observing positions from June 1, 2007 to May 31, 2008. These four fixed observing positions are shown in Figure 1. Two T-H sensors have been installed at Yangjae Stream sites - Yangjae Tower Palace (YT) and Yangjae Woosung (YW) - and two sensors at nearby urban sites - Sookmyoung Girls' High School (SM), and Meedo Apartment (MD) - based on the distance from the stream (Figure 1). SM site is adjacent to high rise residential-commercial complex buildings and high rise apartments. At the high rise residential-commercial complex building block, the highest building is 267m high. MD site is medium-density apartment site with fourteen story. The every ten minute average values were recorded during the study period. Calibration of T-H sensors was carried out before installation at observing positions.

In order to determine the seasonal air temperature differences between SM and two stream sites, weather data whose cloud cover value is 3 or more, rainy day and the wind speed is over 3.4m/sec was excluded because significant thermal differences cannot develop in these weather conditions. Then air temperature difference between SM and two stream sites and the numbers of tropical nights at the study site were derived.

III. Results and Discussion

The observed data was analyzed in terms of UHI intensity, the difference between the hottest urban spot (SM) and Yangjae Stream (YW and YT). Figure 2 shows the diurnal variation of air temperature at observing positions for one year (06/01/2007-05/31/2008). As we can see in Figure 2, the lowest mean air temperature during the day were observed at 6:00h (9.0°C) and the highest mean air temperature at 14:40h (17.0°C). Both of them were observed at YW site.

The maximum air temperature throughout the study period was 34.5°C observed at SM at 15:10 on August 25, 2007 and the minimum one - 11.8°C at YW at 6:50h on January 17, 2007. The urban land use (SM and MD) show the higher air temperature during the nighttime and lower air temperature during daytime. In terms of average air temperature, SM shows the highest one (13.31°C) and is followed by MD (13.30°C), YT

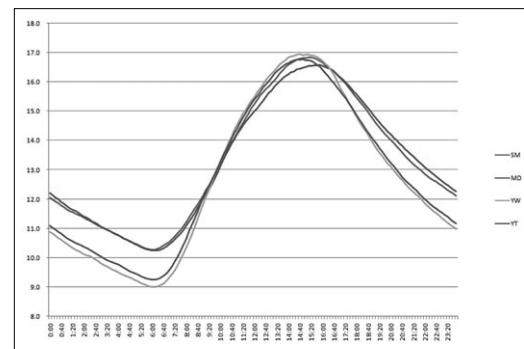


Figure 2. Diurnal variation of air temperature at observing positions for one year

Table 1. Observing position description

Site abbreviation	Name	Land use
SM	Sookmyoung Girls' High School	Educational adjacent to very high density residential (267m)
MD	Meedo Apartment	Medium density residential (14 story)
YT	Yangjae Stream at TowerPalace	Stream
YW	Yangjae Stream at Woosung Apartment	Stream

(12.74°C), and YW (12.67°C).

In order to determine the air temperature decreasing effects by stream, the UHI intensity results are examined in terms of diurnal and seasonal variation. First, the data excludes the weather data whose condition is rainy day, 3 or more cloud cover value, over 3.4 m/sec's wind speed. The number of the above weather condition days is shown in Table 2.

Then diurnal variation in UHI intensity is derived to illustrate UHI change during the whole day (Figure 3). Usually the urban land air temperature is higher than streams, however, it

Table 2. The number of days used which fit the free convection weather condition

Month	Number of days
January	12
February	17
March	11
April	9
May	10
June	8
July	0
August	3
September	2
October	9
November	14
December	14
Total	109

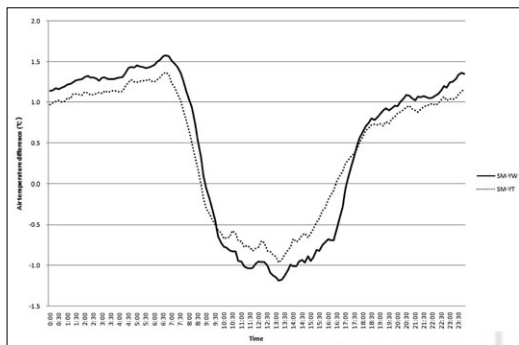


Figure 3. Diurnal variation of UHI intensity between SM and stream sites (YW and YT)

shows the negative UHI intensity value during the daytime because the urban land surface materials - asphalt or concrete - stores the incident solar energy while the vegetation and soil in the waterfront reflects more incoming solar radiation than urban surface materials. As a result, air temperature of daytime at stream area, YW and YT is higher than that of urban area, SM. The maximum UHI intensity between SM and two stream sites (YW and YT) was observed at 1:30h on June 17, 2007 by 7.6°C. According to meteorological data by Korean Meteorological Administration (KMA) Gahngnam Automatic Weather Station, wind speed is 1.6 m/sec by near weather station observation.

Mean UHI intensity was highest at SM with a maximum value of 1.3°C from 6:30 to 6:50. The lowest value was recorded from 13:00 to 13:20 by -1.2°C. Both records were observed at YW site. It is known that maximum UHI intensity occurred at night generally, however, maximum UHI intensity occurred at 6:30 at our study site. It shows similar results to Nagano City in Japan, which is located at valley area (Hamada *et al.* 1999). The mean UHI at YT follows a similar diurnal variation, but the UHI intensity during night-time are consistently lower and while UHI intensity during daytime are consistently higher compared to YW sites.

In terms of seasonal variation UHI intensity between the hottest urban spot (SM) and Yangjae Stream (YW and YT) are used. Seasonal variation of average UHI maximum values for all days within a month for selected free convection weather conditions is plotted in Figure 4.

As we can see in Figure 4, the highest UHI intensity occurred in summer followed by spring, fall and winter sequentially. It means UHI inten-

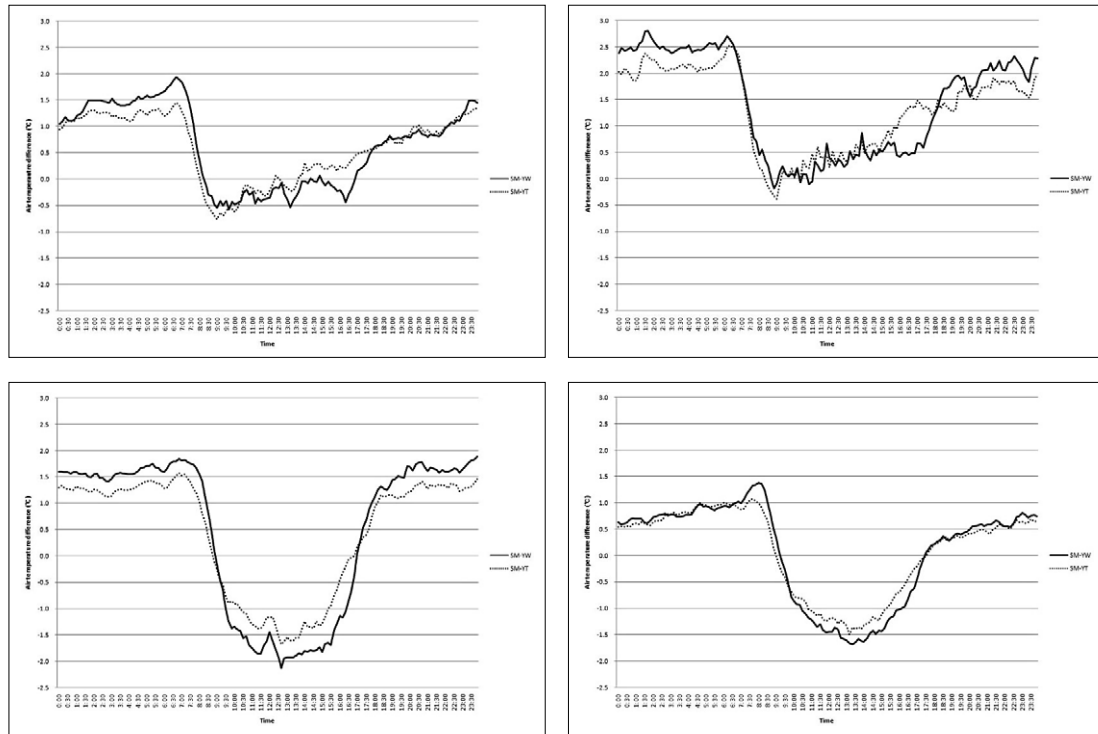


Figure 4. Seasonal variation of UHI intensity between SM and stream sites

sity is prominent at seasonal change. There is distinct seasonal variability in the data for all observing positions. In spring, the air temperature during daytime increases rapidly, however, the land is still cool due to the freezing effect of winter. So, after sunset the air temperature decreases rapidly. Highest UHI intensity was observed during summer night, however, it should be noted that the number of free convection weather in 2007 summer is only 11. Especially there is no free convection weather in July whose weather shows cloudy throughout the month. It means that number of observation days in summer is not enough to represent the seasonal variation. Thus, in terms of seasonal variation, especially summer it needs to be compared with data observed in other year.

Figure 5 shows the number of tropical nights for all observing positions. SM shows the highest

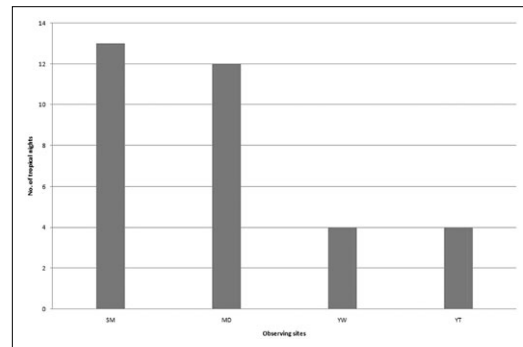


Figure 5. Number of tropical nights at observing positions

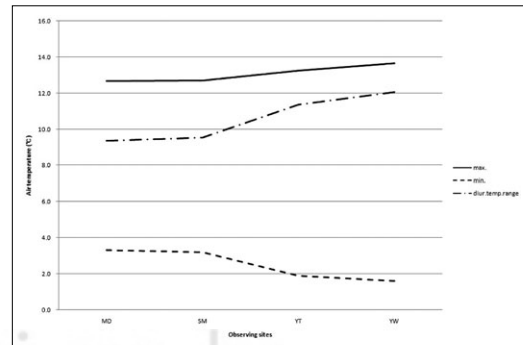


Figure 6. Annual mean max. min. air temperature and diurnal temperature range at observing positions

number of tropical nights by 13, followed by Meedo (12), and YT and YW both 4. It shows the daily minimum air temperature of SM in summer is higher than that of stream sites. At large urban areas UHI is still notable at the time of sunrise (Landsberg, 1981). It induces the increasing number of tropical nights at SM. In urban area UHI at night raises the daily minimum temperature and reduces the diurnal temperature range as we can see in Figure 6. In terms of daily maximum temperature there is no significant air temperature difference between SM and stream sites, however, daily minimum temperature of YT and YW is definitely lower than that of SM. It means the urban stream mitigates the UHI intensity.

IV. Conclusion

This study was implemented to determine the air temperature decreasing effects of restored urban stream by investigating UHI intensity between restored urban stream and nearby urban land use. The following conclusions were derived.

1. The maximum UHI intensity 7.6°C was observed at 1:30 on June 17, 2007 between SM and two stream sites.
2. The maximum mean UHI intensity in diurnal variation was observed from 6:30 to 6:50 (1.3°C) while the lowest one from 13:00 to 13:20 (-1.2°C).
3. The air temperature decreasing effects by urban stream is dominant during nighttime which lowers the daily minimum temperature while there is no significant difference in daily maximum temperature.
4. The number of tropical nights at observing

positions was 13 at SM, followed by 12 at MD, 4 at YW and YT, respectively.

In this study, only air temperature data was used to determine the air temperature decreasing effects by the restored urban stream. Furthermore, the energy budget and radiation balance needs to be investigated by observing radiation. It would help the energy transfer mechanism by the urban stream to influence the air temperature differences

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