Effect of the River in the Urban Area on Local Climate in the Vicinity of the River

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1. Introduction

According to the literature (Horikoshi et al., 1990, Katayama et al., 1990, Mitsuya et al., 2001), it has been generally recognized that rivers running through the urban area may mediate urban climate, so-called heat island, because cool air produced in the river course by water evaporation or cool air is delivered from the ocean and through the river course. However, since rivers in the urban area run on deeper surface and the side walls of the river course are mostly made of concrete like an artificial narrow canyon, air temperature in the river course may not be lower but higher than air temperature in the vicinity of the river. To prove this hypothesis, meteorological observation was made on local climate of the river course and vicinity in Nagoya city, Japan.

2. The abstract

It has been generally recognized that rivers running through the urban area may mediate urban climate because cool air is generated in the river course by water evaporation or cool air is delivered from the ocean and through the river course. However, since rivers in the urban area run on deeper surface and the side walls of the river course are mostly made of concrete like an artificial narrow canyon, air temperature in the river course (T_{ar}) may not be lower but higher than the vicinity of the river. To prove this hypothesis, meteorological observation was made on local climate of the river course and its vicinity.

Five locations were selected on Ueda River which runs in the east of Nagoya city, and 2 locations were selected on Yada River which runs in the rural area east of Nagoya city. Meteorological factors such as air temperature, relative humidity, wind velocity, wind direction, solar irradiation and radiation reflected from the ground were continuously measured from 10:00 to 16:00 at the lowest surface in the river course, and consecutively at 3 locations which were situated at 20 m, 40m, and 60 m from the edge of the river moat.

Observation in the river course demonstrated that absolute humidity became highest in the noon and wind direction often differs from the direction of the river flow. Statistical analyses indicated that T_{ar} was significantly ($p<0.01$) correlated with a flow speed, the amount of water and river width. Observation in the vicinity of the river demonstrated that T_{ar} often became higher than air temperature in the vicinity of the river and was delivered only in the morning period.

3. METHODS

3.1 Meteorological observation in the river course

Two observation locations in the Yada River and five observation locations in the Ueda River were selected. Photos 1 to 8 showed overview of each observed site in the river course. Observation was made in fine days in summer 2013. Air temperature, relative humidity, irradiation, reflected irradiation, wind velocity, 3D wind direction were continuously measured from 9:30 to 16:00. In addition, a trait of the location in the River was identified. The river width, length between the river moats, water temperature, amount of flowing water, water flowing speed were measured, and an area ratio of green to the river course around the location was estimated. All the data collected was listed in Table 1.

Table 1 Physical factors related to formation of climate in the river course

River	Ueda					Yada	
Location	A	B	C	D	E	F	G
Length between moats (m)	47.3	39.4	32.6	27.5	28.9	219.8	70.2
River width (m)	14.4	18.57	9.71	8.28	3.57	17.6	8.44
Distance between bottom of the bridge and water surface (m)	8.18	8.77	6.53	6.18	7.18	9.90	4.90
Water depth (m)	0.52	0.9	0.57	0.26	0.29	0.47	0.25
Flow speed (m/s)	0.11	0.09	0.08	0.81	0.11	0.47	1.05
Amount of flowing water (m^3/s)	0.82	1.50	0.44	1.74	0.11	3.89	2.22
Water temperature (^oC)	29.6	29.5	31.2	29.5	29.5	30	30.9
Ratio of green to river course surface (%)	18.4	28.6	26.7	10.8	20.0	36.3	56.5
Ratio of water surface to river course surface (%)	30.4	47.1	29.8	30.1	12.4	8.0	12.0
Direction of water flow	SE	SE	SE	S	SE	NW	NW
Surface of side walls	Concrete						Soil

Photo. 1 Overview of Location A

Photo. 2 Overview of Location B

Photo. 3 Overview of Location C

Photo. 4 Overview of Location D

Photo. 5 Overview of Location E

Photo. 6 Overview of Location F

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Photo. 7 Overview of Location G

Photo. 8 Overview of Location H

3.2 Meteorological observation in the vicinity of the River course

In order to observe climate factors in the vicinity of the river course, the location nearby the moat (Location 1) was first selected based on observation locations in the river course. The next location (Location 2) was situated with a distance of 20-30 m from location 1, and then the last location (Location 3) was situated with distance of 30 to 40 m from the location 3. Using the mobile battery which can measure air temperature, relative humidity, wind velocity, 2D wind direction and irradiation, climate factors were consecutively measured for 30 min at each location. Observation took place from 9:30 to 11:00 in the morning period and from 14:00-15:30 in the afternoon period. In addition to climatic observation, surface temperature of the houses surrounding each location was measured with an infrared thermometer (Thermo-Shot F30, NEC Avio Techno-logy Co. Ltd), and a ratio of greens to the target area and density of housings were also estimated.

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4. RESULTS AND DISCUSSION

4.1 Results from meteorological observation in the river course

An example of change in air temperature in the river course (T_{ar}) and relative humidity (Rh) were shown in Fig. 1. The T_{ar} increased from 10:00 and became the highest at noon. However, Rh remained consistent. This means that absolute humidity increased from the morning to the noon due probably to increase in water evaporation from river water with increase in T_{ar}. Wind velocity (V) in the river course fluctuated during observation. However, the mean V was 1.08 m/s which was unexpectedly low. Wind direction differed from river direction in the most of observation period, so that T_{ar} was supposed to flow out to the vicinity of the river. Statistical analyses revealed that T_{ar} was significantly ($p<0.01$) correlated with a flow speed, the amount of water and the river width.

4.2 Results from meteorological observation in the vicinity of the River course

An example of change in relative humidity in the vicinity of the river course is shown in Fig.2. The Rh decreased as air temperature (T_a) in the vicinity of the river increased, so the absolute humidity was supposed to be constant. Wind velocities in the vicinity of the river were mostly lower than V in the river course. An example of wind distributions at two observation periods is described in Fig. 3. Blue and red polygons indicate wind distributions in the morning period and the afternoon period, respectively. The results showed that air in the river course flew out over the moat to the vicinity area regardless of time periods. Differences between T_a and T_{ar} ($=T_a-T_{ar}$) in Locations A to E were indicated in Fig. 4. Although T_{ar} was generally lower than T_a, it was found that T_{ar} became higher than T_a in the morning period. Since T_{ar} is expected to become higher in the afternoon due to heat stored by irradiation, the results did not agree with the hypothesis, and then demonstrated that cooling effect by the air flowing out from the river may be expected only in the morning period for some reason.

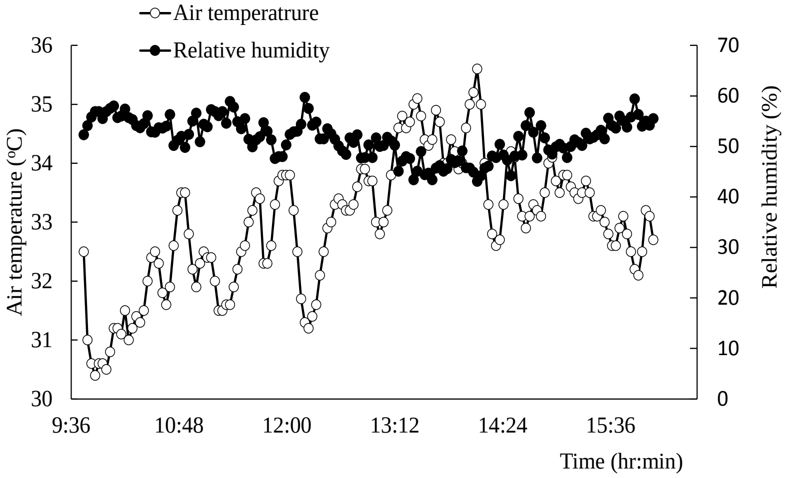

Fig.1. An example of change in air temperature and relative humidity in the river course (Location E)

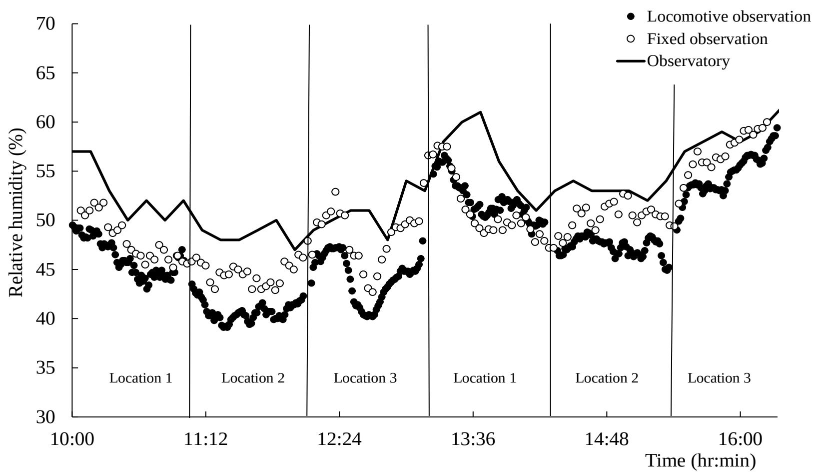

Fig.2. An example of change in relative humidity in the vicinity of the river course (Location C)

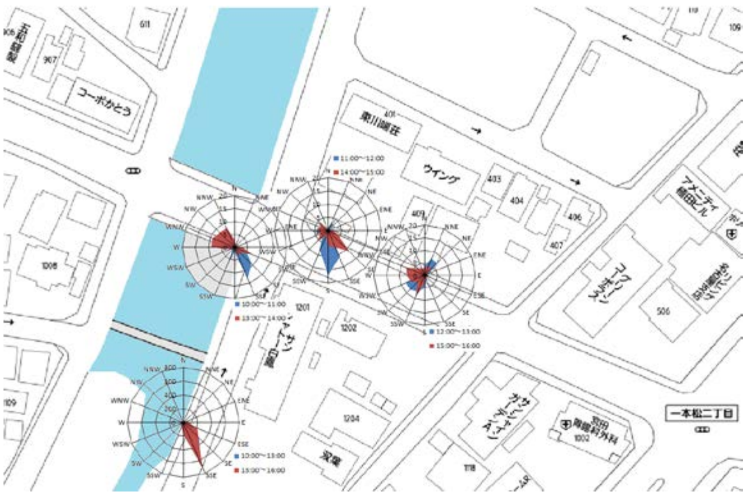

Fig.3. An example of wind direction distributions in the river course and in the vicinity of the river (Location C)

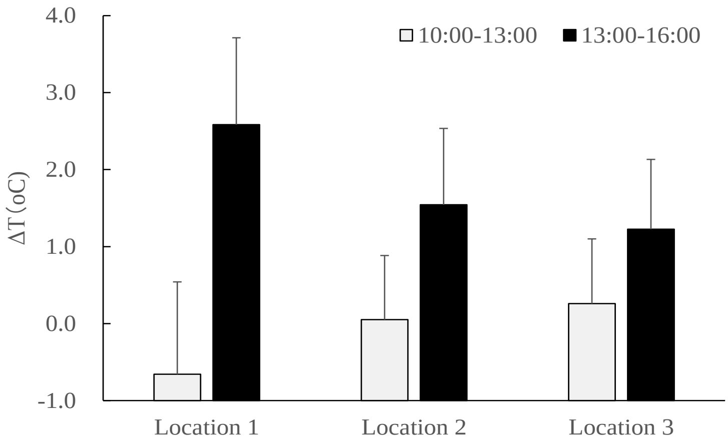

Fig.4. Differences between air temperature in the vicinity of the river and air temperature in the river course at Locations A to E

5. CONCLUSION

The present study demonstrated that air temperature in the river course may become higher than air temperatures in the vicinity of the river in the morning period, particularly in the narrow river running though the urban area. The results did not agree with the hypothesis predicting that air in the river course is heated due to accumulation of irradiation to the concrete walls surrounding the river during daytime. In order to resolve the problem, more extensive observation is necessary.

References

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