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Urban heat island study between different size of towns and cities

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1. Introduction

According to one research in 1999, urban heat island intensity of four biggest cities in Taiwan was 4.5 to 2.7 degree C in summer midnight. Therefore, the heat island effect could increase energy consumption by air-condition system in Taiwan. This paper demonstrates the relationship existing between the population of village, town or city, and the magnitude of the urban heat island it produces. Series of air temperature of 14 neighboring cities in Tainan, whose populations range from 23,000 to 740,000 inhabitants, were measured by automobile traverse in a cloudless and windless midnight in every month during 2002~2003. The regression correlation line between urban heat island intensities and populations is compared with previously published data in other climates, such as in Europe by Oke (1973), North America by Landsberg (1981), Korea by Lee (1993), Japan by Fukuoka (1983), and Taiwan by this study. It proved that the urban heat island intensities in hot and humid climate areas are very small compared to the other researches in temperate climates, because of the higher humidity and lower anthropogenic.

2. Methodology

Mobile transects were conducted 10 times in order to measure the temperature between cities and towns (Table 1) at night. The data of this study consisted of 10 mobile transects in 2002-03 and over a prescribed route (Fig 1). The instrument setup on the top of car and were utilized to obtain spatial temperature data. The mobile transect instruments which were used in this study were the TR-72U Thermo Recorder which can measure and record temperature (in a range of -60 to 155 degree C with 0.1 degree C resolution and ±0.3 degree C accuracy). As these sensors were not aspirated, it was also important that measurements occurred when the air was not completely stagnant during the study to minimize lags in sensor response. Each TR-72U sensor was synchronized and programmed to sample temperatures and geographical coordinates at 2-s intervals. The TR-72U sensors were subject to pre- and post-fieldwork calibration to ensure that the measurements were within the manufacturer's specifications.

All temperature data have accurate temporal adjustment of temperature change rates over the study area based off the weather station data. All transects had been completed within three hours in similar traffic condition and by the same route. Climatic conditions during the field measurement days are presented in Table 2.

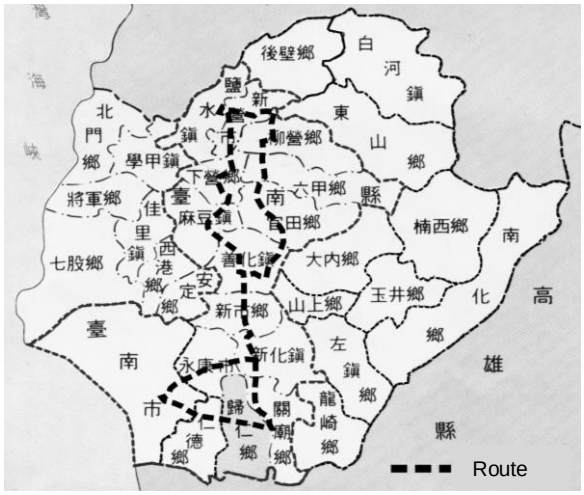

Fig. 1 The route of survey area.

Table. 1 Population of Places.

Name of Place	Population	Density (person/km^2)
Gueiren Township	64,107	1,214
Guanmiao Township	38,255	752
Guantian Township	23,283	364
Lioujia Township	25,203	391
Liouying Township	23,916	399
Sinying City	78,105	2,136
Yanshuei town	28,765	587
Xiaying Township	27,596	828
Madou Town	47,098	1006
Shanhua Town	41,850	820
Sinshih Township	35,190	711
Sinhua town	45,322	760
Yongkang City	201,090	5,139
Tainan City	740,846	4,222

Table. 2 Climatic conditions during the field measurement days.

date	ΔT (℃)	temperature (℃)	humidity (%)	Wind speed (M/S)	Sunshine (hr)	Cloudiness (0~10)	Insolation (mJ/㎡)
2002/02/28	3.47	22.61	63.25	2.48	10.4	0.3	16.03
2002/04/02	1.88	25.68	74.38	2.31	4.9	5.9	11.25
2002/06/18	1.67	29.58	68.38	2.67	9.9	5.5	18.94
2002/08/14	1.69	29.78	77.46	2.11	10.7	4.3	17.70
2002/09/19	1.48	29.93	73.67	2.49	8.7	2.4	16.26
2002/10/17	2.62	27.21	76.38	2.17	7.7	2.1	17.78
2002/11/05	3.13	22.03	64.17	1.89	9.6	0.6	16.07
2002/12/18	2.34	23.72	74.42	1.97	7.1	2.6	12.71
2003/02/20	1.89	19.69	71.38	2.85	9.2	3.0	18.36
2003/04/24	2.64	27.39	82.25	2.47	6.5	6.5	20.48
1897~1990	---	23.50	80.40	2.90	7.0	5.7	---

Table. 3 Heat island effect in four season.

Name of Place	Urban Heat Island Effect				
	Spring	Summer	Fall	Winter	Average
Gueiren Township	2.76	1.86	3.11	3.07	2.70
Guanmiao Township	1.22	1.03	2.00	1.97	1.56
Guantian Township	1.09	0.70	1.62	1.66	1.27
Lioujia Township	1.08	0.84	1.19	1.42	1.13
Liouying Township	1.26	1.27	1.37	1.14	1.26
Sinying City	1.82	1.69	2.31	2.19	2.00
Yanshuei town	1.54	1.59	1.60	1.28	1.50
Xiaying Township	1.64	1.23	1.77	1.65	1.57
Madou Town	1.93	1.20	1.96	1.68	1.69
Shanhua Town	2.20	1.39	2.08	2.20	1.97
Sinshih Township	2.21	1.36	2.37	2.38	2.08
Sinhua town	2.43	1.45	2.64	2.54	2.26
Yongkang City	3.26	2.18	3.20	3.02	2.91
Tainan City	3.66	2.85	3.79	3.60	3.47
Average	**2.01**	**1.47**	**2.22**	**2.13**	**1.96**

3. Result

3.1 Heat island effect in four season

According to the result from the investigation of this study (Table 3), heat island effect is the most significant studies of the subject. Especially in fall and winter, heat island effect was much serious compare with summer. Nevertheless, Tainan metropolitan area has high temperature in September and October; therefore, heat island effect in fall would cause a great energy consumption of air condition system.

3.2 Population and heat island effect

There is significant relation between population and heat island effect which was been found in this study (Fig 2). Additionally the more population present the more anthropogenic heat was released from the cars, buildings and air-condition systems. Nevertheless, there are some towns which have small population but have much higher heat island effect. Because there is very difficult to control the population of town; therefore, finding the way to improve the natural ventilation and to increase green space in town could be the possible solutions for mitigating heat island problem.

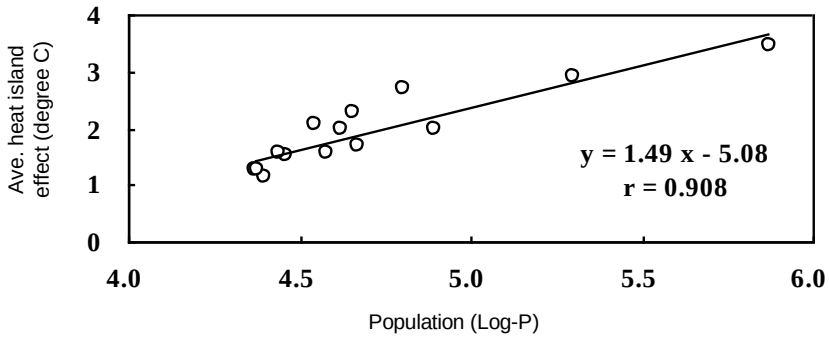

Fig. 2 Relation between population and heat island effect.

3.3 Heat island effect between different climate zoon

In this study, series of air temperature of 14 neighboring cities in Tainan, whose populations range from 23,000 to 740,000 inhabitants, were measured by automobile traverse in a cloudless and windless midnight in every month during 2002~2003. The regression correlation between urban heat island intensities and populations is compared with previously published data in other climates, such as in Europe by Oke (1973), North America by Landsberg (1981), Korea by Lee (1993), Japan by Fukuoka (1983), and Taiwan by this study. It proved that the urban heat island intensities in hot and humid climate areas are very small compared to the other researches in temperate climates, because of the higher humidity and lower anthropogenic.

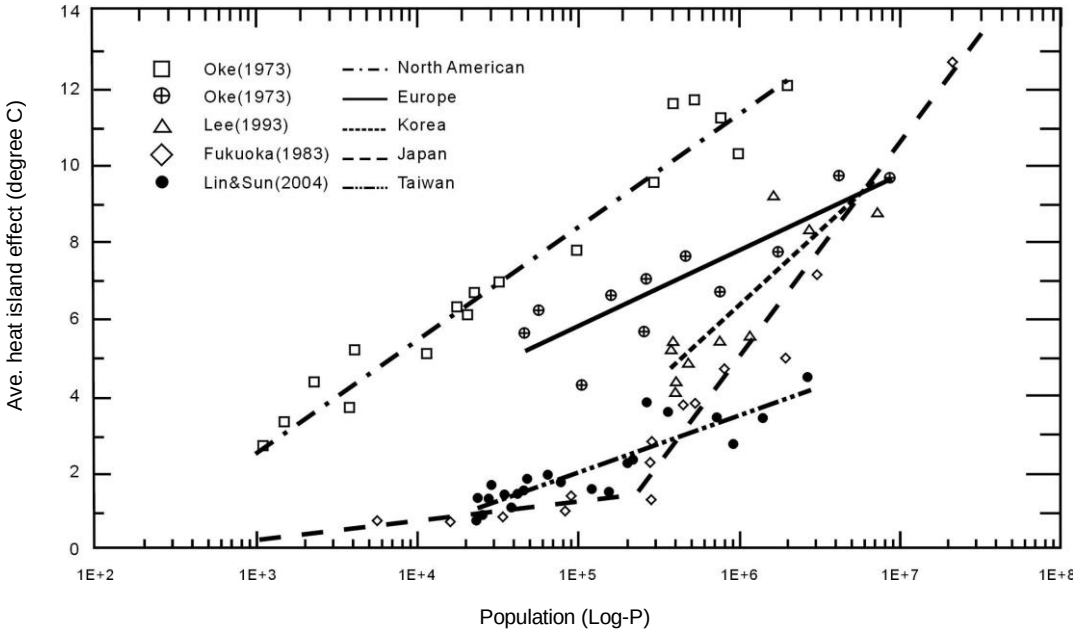

Fig. 3 Heat island effect between different climate zoon.

4. Conclusion

In this paper, mobile transect data and GIS data were used to analyze the heat island effect in the Tainan metropolitan area. The results of this paper show a clear relationship between heat island effect and population. Furthermore, this study also gets some conclusions which could explicate heat island effect between difference studies:

1) Urban structural differences: Due to the different urban development model, it may make a difference on urban patterns (such as: street scale, architectural patterns, materials, green ratio, open space, evaporation ... etc.), resulting in thermal storage and city different cooling effect.
2) Different climate Zoning: Latitude, altitude, temperature, humidity, wind direction, wind speed and weather patterns could make significant impact of the urban heat island.
3) Urban activity behavior: Urban functions are derived from the energy consumption, the anthropogenic heat, and urban activity status. It will directly affect the thermal environment, and eventually cause the high temperatures condition.

Acknowledgment

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