LONG-TERM CHANGE OF STREAM TEMPERATURE: IMPLICATION FOR IMPACT OF ANTHROPOGENIC HEAT INPUT DUE TO URBANIZATION

TSUYOSHI KINOUCHI [1], HIROSHI YAGI [2] and MAMORU MIYAMOTO [3]

[1] Associate Professor, Department of Environment System Management, Fukushima University, 1 Kanayagawa, Fukushima-Shi, Fukushima, 960-1296, Japan (Tel: +81-24-548-8296, Fax: +81-24-548-5208, e-mail: kinouchi@sss.fukushima-u.ac.jp)
[2] Associate Professor, Department of Civil Engineering, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-Ku, Tokyo, 152-8552, Japan (Tel: +81-3-5734-2591, Fax: +81-3-5734-2650, e-mail: hyagi@sea.mei.titech.ac.jp)
[3] JST/CREST Research Fellow, Department of Environment System Management, Fukushima University, 1 Kanayagawa, Fukushima-Shi, Fukushima, 960-1296, Japan (Tel: +81-24-548-8296, Fax: +81-24-548-5208, e-mail: miyamoto@sss.fukushima-u.ac.jp)

In aquatic ecosystems, water temperature is considered to be a most fundamental and significant water quality variable: most chemical and biological activities are a function of temperature and fish habitat changes along with thermal regime. The impacts of potential environmental changes induced by human activities on stream temperature have been investigated for global climate change, regional land use alteration and warm effluents from power generation plants. However, no study can be found dealing with the long-term impact of increasing anthropogenic heat input from urban areas. As urban growth in many parts of the globe is expected to result in a huge amount of water and energy consumption and its eventual release into the aquatic system, it is important to show how significant urban effluent is in determining thermal regime of rivers running through urbanized areas.

For this sake, long-term stream temperature variation was analyzed using temperature data in the past two decades to provide information on thermal regime change in streams and human influences due to urban effluent and other factors. The Ara River system, a major river system running through the central Tokyo area that is one of the most highly urbanized areas in the world, was selected for this study as the long-term temperature data is available and massive urbanization has proceeded in several decades.

Firstly, the long-term change in the anthropogenic heat input from urbanizing area, i.e., the wastewater effluent from treatment plants, was revealed. It is clarified that the temperature of effluent from treatment plants has been significantly increasing in the past three decades, especially in winter and early spring. As the volume of wastewater is also increasing, it is found that the total anthropogenic heat input to streams by urban wastewater has been increasing, resulting in more human influence on the stream temperature regime.

Then, the change of stream temperature regime was investigated using a relationship between stream temperature and air temperature for five segments in the Ara River system. Segment A locates in upstream rural area, whereas segments B through E are within highly urbanized areas. Segments C and E are connected to the Tokyo Bay. In segments B and D that are located in rapidly urbanizing areas, a distinct relationship between stream temperature and air temperature was found for two different periods when the weekly air temperature is below about 20°C (Fig. 1). Thus, it is considered that the

thermal regime of downstream reaches has been shifted to warmer ones possibly due to increased anthropogenic heat input from treatment plants.

Finally, the long-term trend of stream temperature at each monitoring point was calculated for the period of 1978 to 1999 by applying the linear regression analysis and the T-test. It is found that the stream temperatures have been increasing in downstream reaches (segments B, C and D) at the rate of 0.1°C/year and more in winter and early spring. Segments B and D exhibit higher increase rates for winter months (0.16°C and 0.21°C on average), which is equivalent to 3.2°C and 4.2°C increase in the past 20 years, respectively. It is found that increasing anthropogenic heat input by urban wastewater is a dominant factor of thermal degradation of tidal rivers than other plausible factors such as air temperature increase and warmer seawater intrusion by tidal movement (Fig. 2).

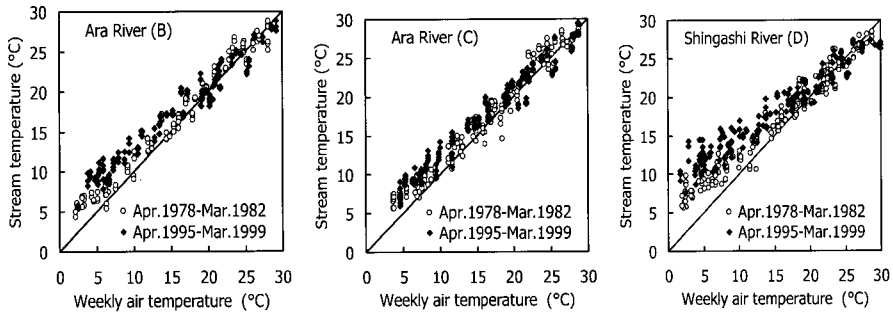

Fig. 1 Air temperature/stream temperature relationship for segments B, C and D.

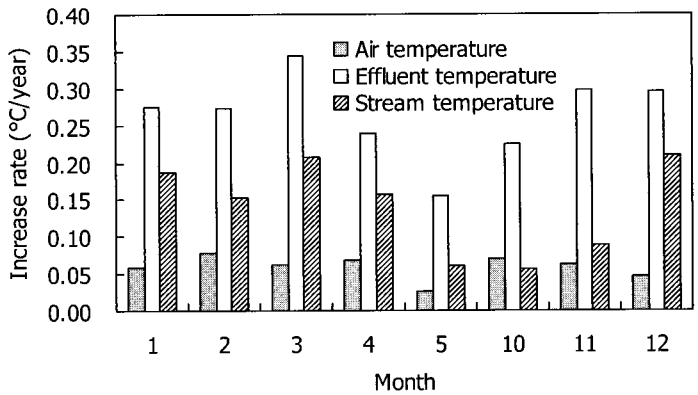

Fig. 2 Comparison of long-term increase rate of air temperature, effluent temperature and stream temperature for segments B and D.