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Research on Effect of Urban Thermal Mitigation by Heat Circulation through Tokyo Bay

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The Japanese Ministry of the Environment recently has clarified that only 1 deg. C drop in the temperature during daytime in central Tokyo might be achieved by the following implementations conducted in all 23 wards in Tokyo: 1) the anthropogenic heat from office buildings (50 %) and traffic (20 %) can be reduced; 2) replacement of 50 % of asphalt-paved surfaces with permeable paving surfaces can reduce the heat; and 3) greenery planted on 50 % of rooftops of buildings can reduce the heat (MoE, 2001). To mitigate urban thermal conditions, we have formulated a new strategy that effectively uses the sea breezes flowing into the Tokyo Metropolitan Area from Tokyo Bay with efficiency, when the temperature goes above 30 deg. C on a typical summer day. Tokyo Bay can develop high sea surface temperatures in response to daily high levels of anthropogenic heat discharge. If cool breezes would flow into the Tokyo Metropolitan Area from Tokyo Bay on a typical summer day, then it would be possible to mitigate the urban heat islands more beneficially. Therefore, to decrease the bay surface temperatures and thus to enhance the cooling effect of the sea breezes, we need to bring deep-ocean water from about 300 m to the surface.

The authors performed interviews with several national experts in relevant disciplines. Most of the experts pointed out the fact that water quality control before releasing deep-ocean water into bay is necessary, especially in summer season, when the water is nutrients-poor. On the other hand, water in Tokyo Bay actually shows higher concentration of nutrients than deep-ocean water. In case of Tokyo Bay, releasing deep-ocean water into bay might not cause a large negative impact to the water quality.

Rough estimation of the heat island mitigation project costs for all 23 wards in Tokyo is as follows:

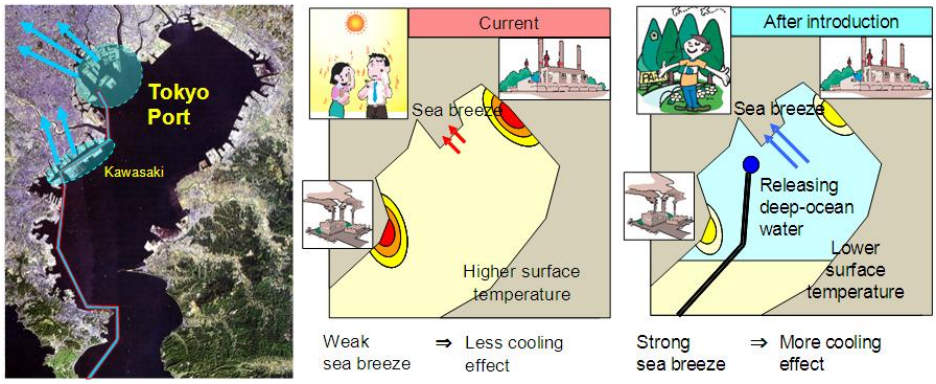
Water retentive pavement: 70 million (m2) x 18,000 (JPY/m2) = 1.30 trillion (JPY)
Rooftop vegetation: 140 million (m2) x 20,000 (JPY/m2) = 2.80 trillion (JPY)

Nowadays water quality problems in Tokyo Bay are not solved completely. The authors' idea is regarded to be available as a part of water pollution control in Tokyo Bay. Rough estimation of the initial costs on the water pollution control actions in Tokyo Bay is estimated to be 1.3 trillion (JPY) for the sewage treatment and 1.2 trillion (JPY) for the river management. On the other hand, cost for installing floating pipelines etc. to bring deep-ocean water to the surface is calculated as follows:

50 (km) x 2.5 billion (JPY/km) = 125 billion (JPY)

Based on monitoring data, Suzuki et al. (2004) showed that 9x1,000,000,000 (m3) of water, which is a half volume of Tokyo Bay, can be exchanged with outer-ocean water during 5 days in summer in an ordinary situation. This results support the authors' idea that transporting outer-ocean water to Tokyo Bay is reasonable. Southerly wind is a driving force of this in-flow at the surface layer of Tokyo Bay. A numerical simulation with CSU-MM (e.g. Ichinose, 2003) showed that 2 deg. C decrease in bay's sea surface temperature on fine days of late July would lead to 1 deg. C drop in air temperature in central part of Tokyo and to 1 m/s enhancement of the bay breeze.

To mitigate urban thermal conditions in the Tokyo Metropolitan Area, we have formulated a new strategy that propose an effective use of the sea breezes flowing into the area from Tokyo Bay on a typical summer day. We also demonstrated (1) the mechanism of heat exchange between the water surface of the bay and the atmosphere; (2) the mechanism for keeping the water surface area of the bay cool after bringing the deep-ocean water up; and (3) the advantage of already well known counteractions, such as the rooftop vegetation and water retentive pavement, over the strategy described in the cost analysis.



Keywords: heat island, Tokyo Bay, deep-ocean water, sea breeze, environmental improvement