Ambivalence of Water: Beneficial and Detrimental Features

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Abstract. This chapter has examined two sides of water. As for its detrimental features, we have damage caused by heavy rains possibly due to urban warming; torrential downpours and urban floods. The frequency of typhoons will augment due to accelerating global warming. As benefits of water, some new technologies have been enumerated such as "*uchimizu"*, dry mist, photocatalyst of titanic oxide and a new pavement method using a slag. Water-control projects will be more and more important in the near future. We must use water and trees more wisely and keep off the water-related disasters and extreme incidents of weather.

1. Introduction

Water is a prerequisite for plants to grow properly. As for greening cities, a break-even point of water supply is significantly important for sustainable plant management. The price of water in Tokyo is more expensive than many other large cities in the world; thus, storing and sprinkling rainwater on the flowers and plants should be more actively explored. Waterworks and reservoirs must be suitably constructed to control or limit water supply for healthy plant growth especially in the dry summer season. Vegetation has numerous benefits for us and other creatures; such as having a healing effect, soundproofing and disaster prevention. Landscape gardeners play a very important role in cooling cities. Public utilities also cool cities by resuscitating ducts and by vegetation such as roof-top gardening and tree planting activities, etc.

Drawing water from wells to sprinkle on the rooftops can cool houses and watering the lawn and garden with a hose would cool the ground. It is easy to conclude that the more abundant the amounts of water and vegetation, the cooler the city, i.e., the more, the better. Note that these have a "public-good" property, since their cooling effects can prevail in all blocks of the city. For example, the existence of a vegetable garden with greenery and water could cool the city's residential area. Garden apartments have a better environmental amenity, where inhabitants can plant vegetables and enjoy flowers. They can live in comfort in pleasant surroundings. Greenery is the prerequisite for our domicile and environment. Trees and vegetation as important natural factors play a significant role in cooling the city.

The trees give us shade especially in summer, and the cool breezes prevail in woods and forests. We can enjoy the whisper of leaves in the breeze, whereas, treeless areas are hotter and do not provide shade for

us. Evergreens must be planted at the north side of buildings, and deciduous greens should be planted at the south side in order to introduce the light all the winter. Detached houses amid the trees are in general cooler than condominiums. Residents buy sunshades, or sprinkle water on their garden and the road in front of their house. Many people may want to live in beautiful and desirable natural surroundings, not in a desert area with no sign of vegetation anywhere. Green plants are treated as carbon sinks and water reservoirs and they contribute to cooling the city. Plants and insects nurse a sense of unity with nature.

This chapter presents both sides of water, i.e., its beneficial and detrimental features. Section 2 presents basic concepts of urban warming and urban heat island partly due to lack of water and vegetation in cities. Section 3 introduces some examples of various solutions and recent technological innovations.

2. Urban Floods as Water's Menaces

Heat Archipelago may now be a pertinent name for the Japan of late, since many of its cities have recently experienced a historically rapid increase in temperature during the summer months. Covering the ground of cities with asphalt and having buildings made of concrete is so artificial that the resulting temperature has unnaturally increased. Hotter areas in cities may now be called *urban heat islands* that are used to identify the hotter areas than that of the surroundings and the phenomena related to the urban heat. The center of Tokyo is a concrete jungle with its dense population and their residence, much of which is an uncomfortable area with very little vegetation. Many modern high-rise buildings and skyscrapers catch solar radiation. These structures block out the light from the west

Tokyo has such urban heat islands as Otemachi and Shinjuku which are central business districts, and they have numerous skyscrapers blocking the sky. Nevertheless, Hibiya Park, International Christian University, the Imperial Palace, the Meiji Shrine, and Shinjuku Gyoen National Garden as *cool islands* are cooler, and the temperature of these areas remains rather low compared to the hotter areas mentioned above.[1]

The ferocity of nature is characterized for example as a Tsunami which is the most recent Japanese experience of horrible phenomenon of the sea water. The mischief possibly due to urban warming is urban floods. In the 23 wards of Tokyo half of the rain sinks into the ground, yet 70-80% of the half of the rain pours into sewers or rivers. Recently, rivers frequently rise with heavy rains. On average the frequency of precipitation of more than 50 mm/h was 162 days per year (1976-1987) and 177 (1988-1997), whereas, it was 238 during 1998-2007 (The Tokyo Fire Department, personal communication, June 17, 2013). The rain came down in buckets and tragic accidents

[1] See Sato (2006) and (2008).

took a lot of lives. There has been an increasing tendency of bathing fatalities. Continuous downpours increase the bulk of water in streams which were swollen with rain.

An incident of heavy rain occurred in Nerima Ward in Tokyo on September 3, 2003. It was 33.9 °C in Nerima where there was no sea wind. While a sea breeze with a wind velocity of 3 meters per second blew to Otemachi in the midst of Tokyo, where it was 32 °C, and littoral Shinkiba with a breeze of 4m/s had 28.6 °C. The mercury touched 33.4 °C in Tokyo, but 19mm fell in 10 minutes of heavy rain from 18:30 to 18:40 decreasing the temperature from 31 °C to 24.2 °C, and it was accompanied by two thousand peals of thunders and flashes of lightning (Tokyo Meteorological Agency, personal communication, June 17, 2013). It is reported that Otemachi had more rain than the predetermined twenty-one suburban areas: it was 30% more than the other areas at the maximum. In the light of the potential for continued severe emergencies such as these, the Tokyo Metropolitan Government appointed priority areas where it endeavors to prepare improvement projects to raise the drainage capacity of the sewers. There is also an increasing possibility that underground shopping centers will be submerged by localized torrential floods due to urban warming.

Urban warming was not necessarily due to the consumption and production of goods in that area, but due to lack of greenery in those districts of Tokyo, as well as the climate conditions in that section of the city at that time. Consequently, it resulted in the worst case scenario that could happen locally in a block where some climatic conditions are met at some point in time, as in the above unforeseen incident.

On November 12, 2007, Aomori, the northernmost prefecture of the Honshu Mainland of Japan was mysteriously caught in an untimely big torrential downpour. Shichinohe Town and Towada City had more than 100 mm/h of precipitation. Three hundred households suffered from inundations above the floor level, partly because many overflows were filled with dead leaves. Disinfectants were handed out to the sufferers in order that no plague would spread in this devastated area. Even after the water is removed, flooded houses stank of dirt and remained humid. On the day, the temperature stood at 10 °C. Usually, the average temperature is 1-2 °C and it had already snowed in this prefecture. Between 1986 and 1995, daily precipitations had exceeded 400 mm on 3.4 days per year, and it was 11.1 days per year during 1996-2005 (Tokyo Meteorological Agency, personal communication, June 17, 2013). In 2008 “urban guerilla thunderstorms” increased due to a sudden occurrence of huge cumulonimbus clouds there, which are extraordinarily larger than the usual ones. Some of them had 6,000 m in height.

Submergence is anticipated in Tokyo’s subway stations and undergrounds. A sudden increase of water

can immerse subway stations. The bursts in the embankment of the Tonegawa and Arakawa Rivers have been simulated, because the banks would be breached in many places due to urban floods. Banks are made of several kinds of soils, the weakest compound of which was sand, where the flooded water could penetrate and burst banks. It has been reported that there were risky parts in Arakawa (57%) and in Tonegawa (62%), and an area of 370 km is in a critical condition (Ministry of Construction). However, the local governments did not have sufficient public funds to undertake to repair the risky banks, even knowing that there was an impending danger.

3. Technological Innovations as Blessings of Water

Making active use of water is very useful. As a technological innovation, let me first introduce the *photocatalyst of titanic oxide* (T_iO_2) which can be used to cool down structures. This method was invented by the former Professor Akira Fujishima at The University of Tokyo in 1972. He discovered that water can be decomposed only by photo energy and titanic oxide. In 2006 the university conducted an experiment on a rooftop (10 m^2) of a building, which was covered by a water film coated with titanic oxide. This test proved that this film of water could cool the building and showed that the temperature decreased by 30 °C. More precisely, that experiment verified that the mercury stood at 60 °C without the photocatalysis and water sprinkling, whereas, the temperature was 30 °C with both. The maximum temperature difference between the two cases amounted to 30 degrees. The indoor temperature at that time was 15 Celsius. The photocatalysis of titanic oxide on glass on the sides of the buildings can cool down their structures and save on the cost of air conditioning. The cooling effect and cost effectiveness could be augmented by utilizing rainwater and by coating windows with titanic oxide.[2] Currently, the size of the market for this technology amounts to 0.4 billion dollars, and it is anticipated to augment to 8.3 billion dollars in the future.

In 2006 the new variety of photocatalyst was discovered by Professor Kazunari Domen at The University of Tokyo.[3] By his method, applying the radiant energy atomically dissolves water to produce hydrogen which is well known as an ultimate form of clean energy. Its generation efficiency is several steps removed from the practical use. His findings are the following: a co-catalyst added to yellow powder as a composite of nitrogen gallium and zinc oxide becomes a catalyst which reacts to radiant energy. The resolution efficiency of water is about ten times more powerful higher than formerly and there is still room for enhancing further efficiency. Recently, Tohoku University developed the titania photocatalytic sheet

[2] See Tatsukawa (2005).

[3] http://www.nature.com/nature/journal/v440/n7082/full/440295a.html

which has resulted in ten times powerful dissolution of organisms.[4]

A new cooling system was developed in August 2007. It cools buildings by watering the windows which are coated by a photocatalytic sheet. This new material can make the system efficiently cool structures with very little water, since it reduces the surface tension of water. It was observed that a decrease of the temperature by 2-4 °C and the reduction of electricity demand by 20% resulted. As it is very costly, it can be installed only in public institutions and in commercial areas. This system smothers the radiant heat with water on the windows and cools both structures and communities.

Here is another recent technological innovation. When 10 million tons of steel is produced, about 3 million tons of slag is made, which is a dissolution of alumina-silica, etc. Slag is a by-product, a waste material that remains after metal has been removed from rock in the process of producing steel. A steel company has developed a technology to alleviate the urban warming by blending slag with asphalt in roads. As slag has a capacity to retain absorbed water for longer, using slag can make watering gardens more effective, and rainfall makes the road cooler by about 10 more than ordinary paving when slag is used in making the blacktop. Since slag traps rain in its imperceptible holes and vaporizes heat from roads, the temperature predictably falls by 16 degrees at most after rainfall or sprinkling and by 6-8 degrees on roads, a week later.[5]

"Dry mist" has been recently developed for cooling the city. It is a minute artificial mist of 60 μm-sized particles, which is one sixtieth of natural mist. Its vaporized heat can decrease the peripheral temperature. By detecting the temperature and the humidity, the device automatically sprinkles the dry mist to cool escalators of pedestrian decks in the Akihabara Area and at the shopping arcade of the Togoshi-Ginza in Setagaya Ward in Tokyo. Pedestrians and customers do not get wet by this dry mist and they can feel a cool atmosphere floating beside the nozzle which spouts out dry mist. Under the grilled sun, two or three degrees of temperature were observed to decrease by this new high-tech innovation. Dry mist is one of the measures against urban warming taken by the Tokyo Metropolitan Government. The issue to be solved is to develop a pump of high pressure by using a small amount of water. Osaka is also practicing a trial experiment of dry mist. The diameter is 20 μm and the water pressure is 2.0 MPa set at a wall, 120 μm and 0.3 MPa on the road, and 200 μm and 0.3 MPa on the roof. The jets of 20 μm dry mist lowers the sensory temperature of children in a park and polar bears in the Ueno Zoological Garden in Tokyo in the summer.

[4] www.tagen.tohoku.ac.jp/modules/www23/index.php?content_id=93

[5] See Tossavainen et al. (2007).

Lava as a new material has been used to cool areas in cities. Lava has countless tubular openings and collects water, when it is cooled and solidified. Differing from concrete, walls equipped with lava panels can cool cities: once they are wet with water, they can keep coolness for about two hours. Planting moss in tubular openings of lava panels on the walls can keep water. Lava panels are used at more than six hundred locations, 90% of which are public works projects. As a volcanic country, Japan has inexhaustible deposits of lava which was a dead natural asset previously.

Policies to reduce urban warming have been undertaken in the areas of Marunouchi, Kojimachi, Shiodome, and Nishi-Shinjuku in Tokyo. These were the first attempts to carry out policies for specific areas. Four policies planned have already been undertaken in Shiosite in Shiodome on 31 hectares: (i) water-retaining paving for more than 1,210 m of roads, (ii) automatic sprinklers by using the reworked sewage on the water-retaining pavement from July to September 2003 to investigate the temperature falling effect, (iii) promotion of tree planting, including rooftop gardening in private institutions in the area (about 1.9 hectares were planted with trees and flowers), and (iv) undertaking an inquiry into the somesthesia of the falling effective temperature, by sprinkling, etc.

A Japanese word, "*uchimizu* activity" i.e., spattering the ground with water has been now coming into use especially in Tokyo.[6] In 2003 Tokyo carried out a trial of watering road surfaces in some areas between 12:00-13:00, which resulted in a decrease of 0.5-1 °C. As a measure to cool the cities, a nationwide "operation" of watering roads was undertaken in the summers of 2004-2006. This environmental movement has been established to be one of numerous regularly held Japanese summer events. It is anticipated that watering the road with 1 ℓ/m^2 could lower the temperature by 2 °C. It is observed by infrared camera that the temperature of the road decreases in about 20 minutes and that its effect could persist two hours approximately. Watering employs vaporization which decreases the heat stored in the roads. Storekeepers of shopping malls have begun to water the road, which results in activating the vicinity and cultivating friendships among them as favorable by-products. As a matter of fact, reciprocity is a key concept to resolve most environmental problems. Reciprocal actions that are easy on the environment better the well-being of all concerned.

Next, let me introduce a high-tech building named *Sony City Osaki* in front of Osaki Station in Tokyo. Its principal characteristic is the facade of 140 m^2 called a "bioskin" at the east side of the construction. This facade consists of continuous porous ceramic tubes in which rainwater col-

[6] http://202,133,121,121/eng/index.html Site explaining this custom for foreigners (in English)

lected on the roof circulates. The *uchimizu* effect cools around the area when rainwater deprives the surrounding heat by evaporating. The soil is piled up at the foot of Sony City Osaki with green space of more than 6,300 m^2. Though it may be considered an apparition, this building has brought about the effect of planting many trees, as well as that of alleviating urban warming, by decreasing the burden of air conditioning and, moreover, offering a comfortable outdoor environment.[7]

It is also important to build facilities where people, especially children, can have a close relationship with water. The Tokyo Metropolitan Government appropriated about 900,000 dollars to resuscitate small-to-medium-sized urban rivers, e.g., the Kandagawa River and the Nihonbashigawa River. The impertinent construction of a superhighway over the Nihonbashigawa has conspicuously marred the beauty of that symbolic landscape in Tokyo, one of the inheritances from Edo. The speedway over the bridge lasted more than forty years, and its rebuilding in some other place has been decided upon for that reason. On September 15, 2006, a tentative agreement was reached to redevelop the Nihonbashi Area in Tokyo by removing the freeway over the Nihonbashi Bridge. This expressway is decrepit, and to take preventive measures against earthquakes, it was decided that this old and rotten freeway must be removed. It will be a subterranean expressway of about two kilometers between two junctions. The bridge is now planned to be rebuilt by 2016. An increase in the value of real property and the frequency of visitors to this area will require surrounding related companies to partially pay the redevelopment cost which will be about 44 billion dollars.

The Kohonegawa River is a tributary of the Shibuyagawa River. This is known as the model of the song called “Haru no Ogawa River (Spring Stream)” that was sung as a famous song for school music classes. The Shibuyagawa River as a prototype of urban rivers has sometimes caused floods, so embankment was carried out to address this problem, and it was diverted underground to avoid an offensive odor. Fortunately, we have projects such as the Shibuyagawa River Resuscitation Project.

But there is much that Japan can learn from neighboring countries, like the Republic of Korea, about how to use water to mitigate the urban warming. In October 2005 Seoul already resuscitated the Chongechun River at great cost by clearing the superhighway over the river. The Chung Gye Stream Restoration Project was undertaken by removing the 6 km Chongechon Overpass.[8] On the border of the river 333 species were observed as of July 2007. Roads of winds have been recovered along the river to decrease air pollutants by 30% and dust pollution by 10%.

[7] www.nikken.co.jp/ja/archives/ndvukb000000oqxk.html

[8] See Cho (2010).

Winds have blown off fine particles and purified the air of dirt. Now the periphery of the river has become a popular relaxation spot for the citizens of Seoul. Many people can have a stroll in the morning. Some people's asthma was recovered. The restoration of the river has brought to Seoul's citizens not only the improvement of climate but also a sanctuary that is restful to their minds. The nostalgic value of the river in many people's childhood and the memories of having happy days of playing along the river have been also recovered. In thermographical observations of the river, many red parts of the image were changed from orange to blue from June 2003 to July 2007, which means that the temperature decreased over the resuscitated river. Such river restoration projects are undertaken throughout Korea. Japan should follow Korea, since it suffers urban warming much more than the neighboring country.

4. Final Remarks

This chapter has examined two sides of water. As for its detrimental features, we will have damage caused by heavy rains possibly due to urban warming. The frequency of typhoons will augment due to accelerating global warming. As benefits of water, some new technologies have been enumerated. Water-control projects will become more and more important in the near future.

Almost all of us might be unconcerned with the tap water, although it is essential for our life. When an earthquake occurs, it is not gas, nor electricity, but water we require to survive. After the 3.11 Earthquake we had a problem getting water. That is when we learned how terrifying a tsunami can be. It has been announced that emergency water stocks are required for a week, when the South Trough Earthquake occurs in the future.[9]

We turn a faucet on to drink water and turn it off again many times every day, but many of us might not know that we drink about a half-gallon of water per day. If we drink city water throughout the year, instead of bottled "mineral water," approximately 80,000 yen can be saved, because 0.24 (yen/ ℓ) × 365 = 88 yen and 110 yen/500 ml × 2 × 365 = 80,000 yen. We must drink water in order to stay alive. But even so, we know nothing about it, and most people seem indifferent about learning about water. We are careless about the source of water supply. Most of us are oblivious to watershed forests. We just know that water boils at 100 °C and that when it boils, it changes into steam. Also we know that water turns into ice, when it freezes. How little we know about the water which sustains us!

Earth is a water planet; however, there is a growing global water shortage. Fortunately, Japan is blessed with plentiful safe water which is all

[9]It is anticipated to occur from Suruga Bay in Shizuoka Prefecture to Shikoku, according to IZE News: www.iza.ne.jp/news/newsarticle/event/disaster/657984

right to drink. Nevertheless, residents of Japan need to accumulate accurate knowledge of water through various sources in order to be able to "wade through" current water difficulties and access water opportunities.

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