Impacts of Climate Change on Water Quality and Measures against Future Issues

Yukihisa HOSAKA, Ph.D.*
Director in charge of Water Quality, Purification Division,
Bureau of Waterworks, Tokyo Metropolitan Government

1. Introduction

We are facing a crisis that we have never experienced before. Climate change such as global warming is thought to have large impacts on waterworks.

This paper is to explain the influence of climate change on the water quality related in waterworks, and to consider some mitigation and adaptation measures against climate change.

2. Influence of climate change on water quality

2.1 Increase in frequency of turbid water inflow into reservoir due to an increase in the number of days of heavy rain

Recently, we have had many days of record heavy rain nationwide. Heavy rain days with rainfall of 100 mm or more are expected to increase over the next 100 years.

Typhoon No.9 in September 2007 brought the heaviest rain in the recorded history of Okutama (total amount of rainfall: 699 mm in Ogochi Reservoir Maintenance Office observation). This heavy rain caused a large amount of turbid water to flow into Ogochi Reservoir, one of the water resources of Tokyo, leaving the reservoir with high turbidity for three months or more. The turbidity of raw water in Ozaku Purification Plant, which takes water about 25 miles downstream of Ogochi Dam, rose to 1900 degrees just after the typhoon. The plant should modify water management and request other purification plants to supply the deficient amount of purified water.

It is estimated that flooding and landslide will frequently occur, resulting in frequent inflow of turbid water into reservoirs.

2.2 Stagnation of circulation in reservoir due to global warming

Due to global warming, the surface water temperature of a reservoir in winter does not lower as much as it had before, and as a result, it does not complete circulation in the reservoir bottom. Therefore, nutrition salts elute from sediments at the reservoir bottom, deteriorating the water quality and resulting in phenomena such as water-bloom. Such a phenomenon is observed in Lake Biwa already.

In Ogochi Reservoir, we are also worried that water will not be circulated in the entire reservoir, when atmospheric temperature will not be low enough.

* 2-8-1 Nishi-shinjuku, Shinjuku-ku, Tokyo 163-8001 Japan
e-mail: hosaka-yukihisa@waterworks.metro.tokyo.jp

2.3 Increased risk of toxic chemicals in raw water due to increase in the number of vermin

It is pointed out that atmospheric temperature rise may have an impact on terrestrial ecosystems, raising concern in terms of waterworks that it may also affect water resource forests. It is also pointed out that a temperature rise of 2 ℃ may cause a large deviation between actual forest distribution and optimum distribution. And wind or insect damage should be considered in a forest where distribution deviates from the optimum and its activities are low. The amount of agricultural chemicals is expected to rise due to an increase in the number of vermin, and therefore there is fear of an increase in the concentration of agricultural chemicals in the water resources.

2.4 Increase in production of trihalomethane due to water temperature rise

With respect to quality of tap water, trihalomethane is considered to be largely influenced by water temperature. The following two factors are related to this phenomenon.

(1) Trihalomethane is produced by reaction between chlorine and organic material. The reaction rate increases with water temperature, increasing production of trihalomethane.
(2) Rise in water temperature increases consumption of residual chlorine. Therefore, more chlorine has to be supplied in the water purification process.

2.5 Increased risk of pathogenic microorganisms in tap water due to water temperature rise

There is concern that if water temperature in distribution pipe lines and receiving tanks rises due to increase in atmospheric temperature, larger amounts of residual chlorine will be consumed, causing a shortage of residual chlorine at the water supply end. When water coming out of a water distribution net is reserved in a receiving tank, water temperature will rise due to external air. Especially, elevated water tanks influenced by the urban warming will increase the risk of pathogenic microorganisms in the tap water. Therefore, attention for disinfection should be paid to the tanks with a higher consumption of residual chlorine.

3. Measures in waterworks against climate change

The Bureau of Waterworks, Tokyo Metropolitan Government will continue promoting the following current activities, and prove their effect as mitigation or adaptation measures against climate change.

3.1 Mitigation measures in waterworks

(1) Promotion of renewable energy

The Bureau of Waterworks, Tokyo Metropolitan Government is intensively promoting the use of renewable energies such as solar power generation and small-scale hydraulic power generation. Solar power generation facilities are installed in the upper parts of distribution reservoirs, and also installed when lids for filtration ponds in water purification plants are introduced. Small-scale hydraulic power generation facilities are installed, which utilize residual pressure and the amount of water when

tap water is induced to distribution reservoirs in water supply facilities.

(2) Promotion of measures for water leakage prevention

The Bureau of Waterworks, Tokyo Metropolitan Government has been intensively promoting water leakage prevention as one of its major activities. We have successfully reduced leakage rate that was 20%, 50 years ago to 3.3% in 2007, enabling the use of water resources of 340 million m^3 annually. As a result, discharge of about 68 thousand tons of carbon dioxide could be reduced.

3.2 Adaptation measures in waterworks

(1) Measures to mitigate water-bloom in reservoir

In Ogochi Reservoir, there has been water-bloom in the summer season for the past 15 years. There has been growth of algae covered on all surface of the reservoir in 2003. Therefore, we equipped the fences to stop the flow of algae toward the direction of the dam and the pump systems to transport algae to the reservoir bottom. In the last few years, the effect of this equipment has been very successful.

The Bureau of Waterworks, Tokyo Metropolitan Government requests annually to make measures in the other upper reservoirs, where Ministry of Land, Infrastructure, Transport and Tourism manage.

(2) Introduction of advanced water purification treatment

The Bureau of Waterworks, Tokyo Metropolitan Government is trying to reduce musty odor materials and other organic materials by combining the normal, rapid filtration method with ozone or biological activated carbon treatment as an advanced water purification treatment. We plan to structure the advanced water treatment facilities at all of the 5 main purification plants receiving raw water from Tone/Ara River by 2013.

Introduction of the advanced water treatment causes lower consumption of residual chlorine due to lower concentration of organic materials in purified water.

(3) Proliferation/promotion of direct connection water supply

The Bureau of Waterworks, Tokyo Metropolitan Government is promoting proliferation/promotion of direct connection water supply. Changing to direct connection water supply causes not only reduction of carbon dioxide emission due to decreasing power consumption of pumps used for lifting water from receiving tanks, but also decreasing consumption of residual chlorine.

Currently, direct connection water supply systems have been introduced to 90% or more of new construction.

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Influence of Climate Change on Water Quality

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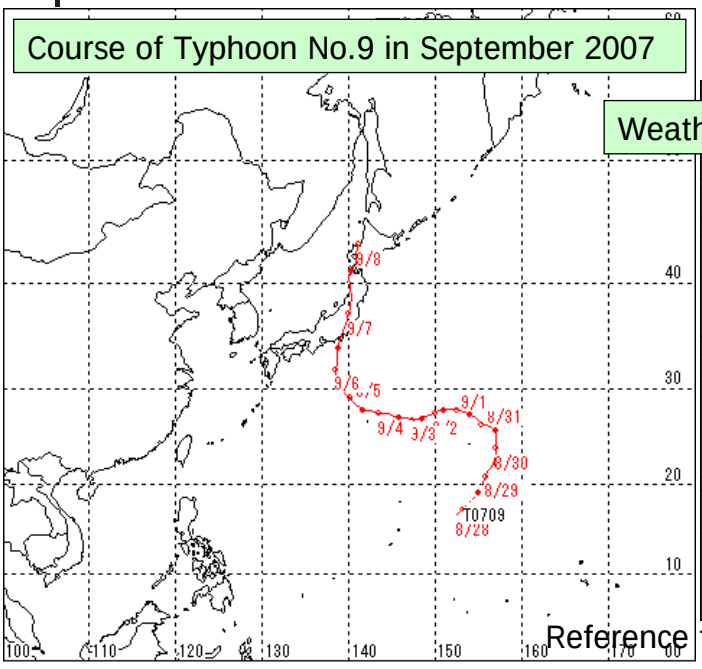
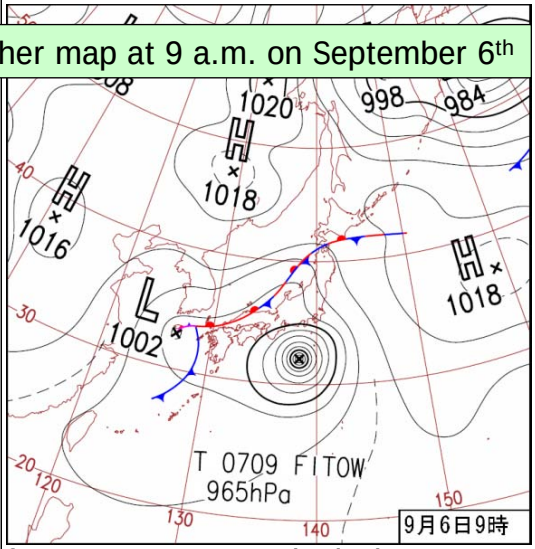
2. Stagnation of circulation in reservoir due to global warming
3. Increased risk of toxic chemicals in raw water due to increase in vermin
4. Increase in production of trihalomethane due to water temperature rise
5. Increased risk in pathogenic microorganisms in tap water due to water temperature rise

Heaviest Rain by Typhoon No.9 in September 2007

Course of Typhoon No.9 in September 2007

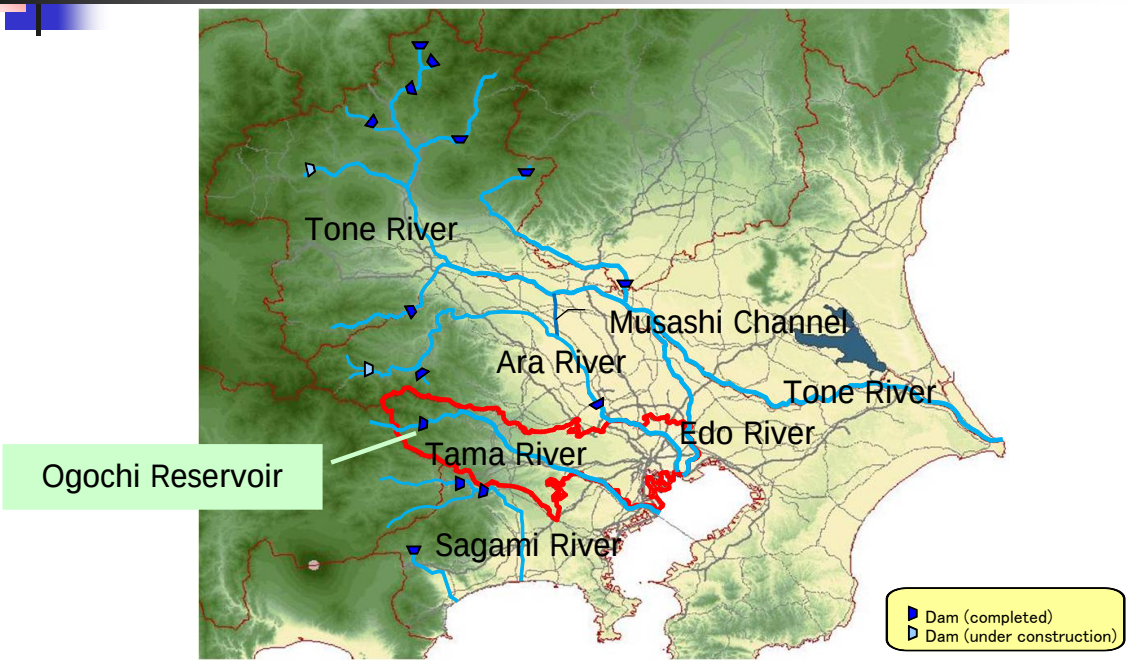


Weather map at 9 a.m. on September 6th

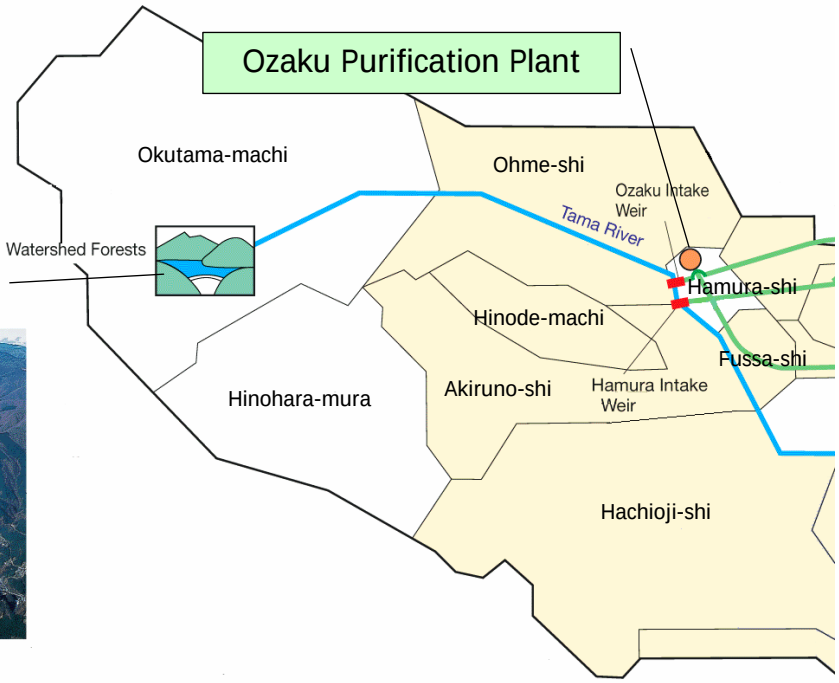


Reference from Japan Meteorological Agency

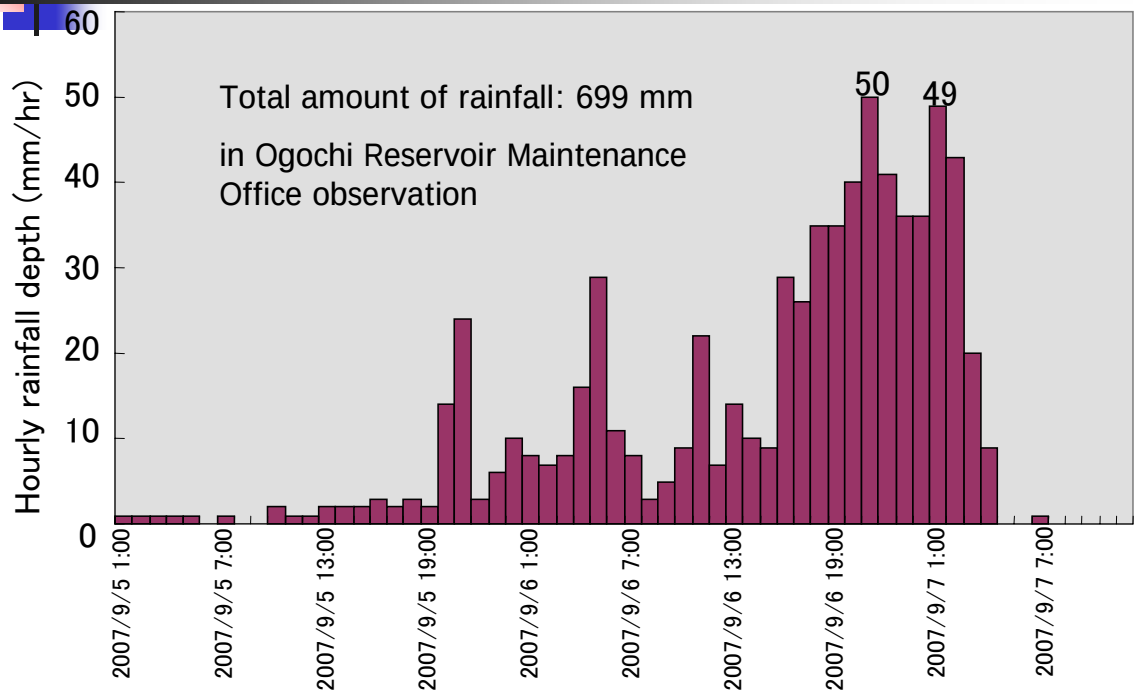
Water Resources for Water Supply in Tokyo



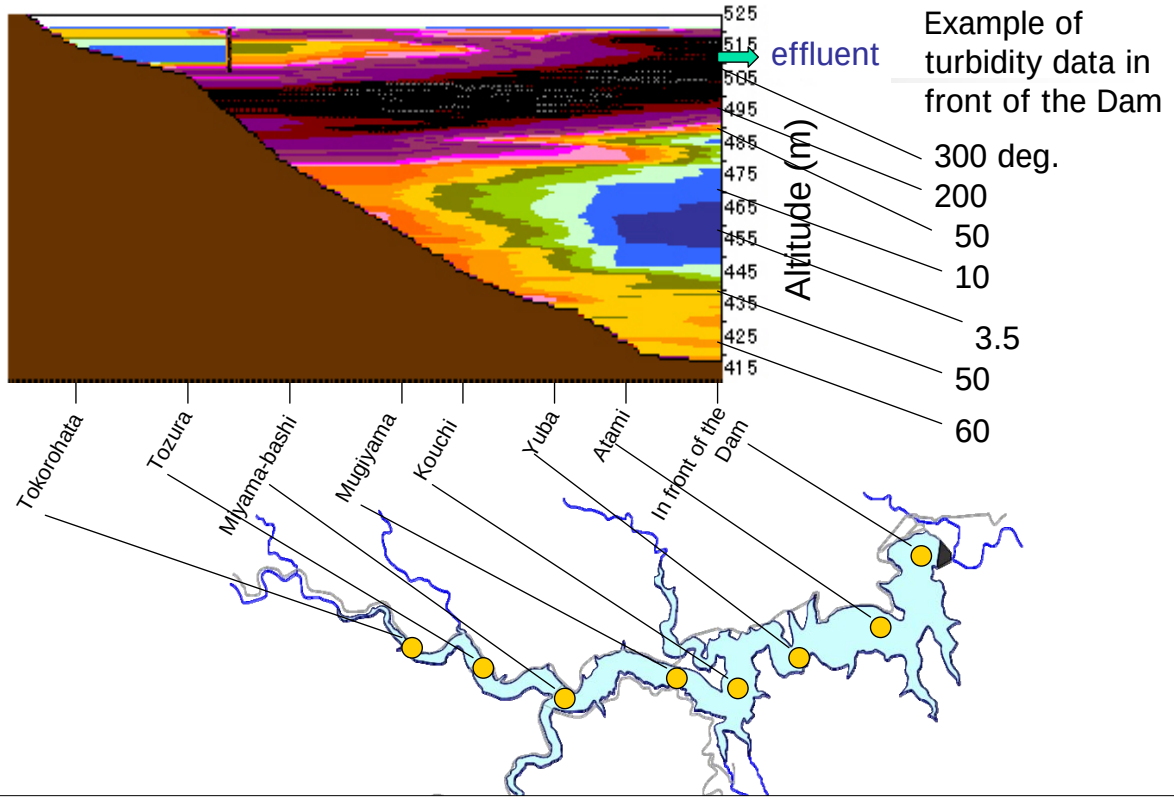
Ogochi Reservoir and Ozaku Purification Plant



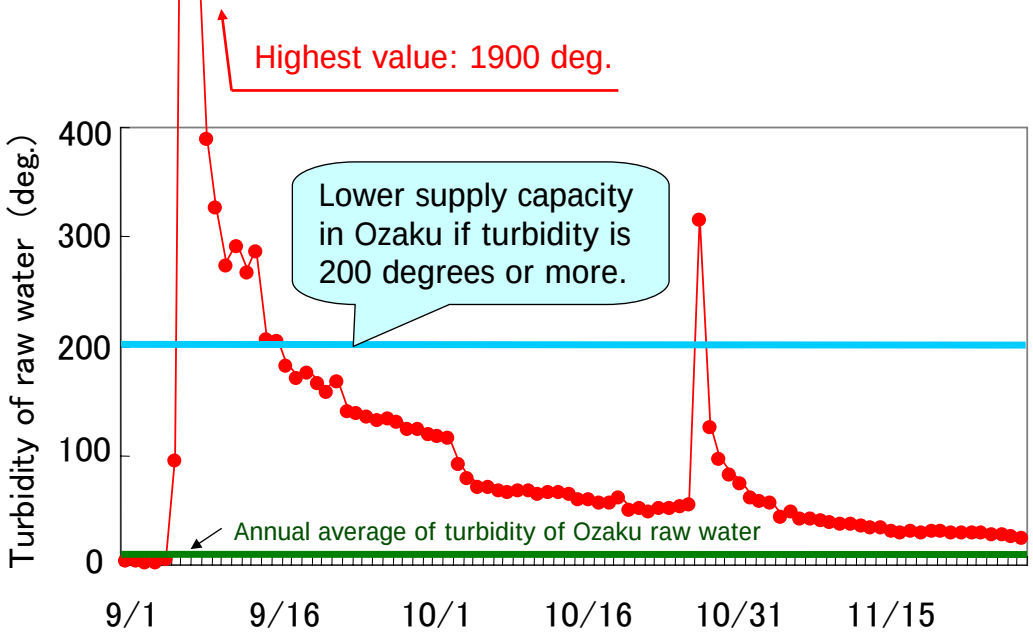
Rainfall Status of Typhoon No.9 in September 2007



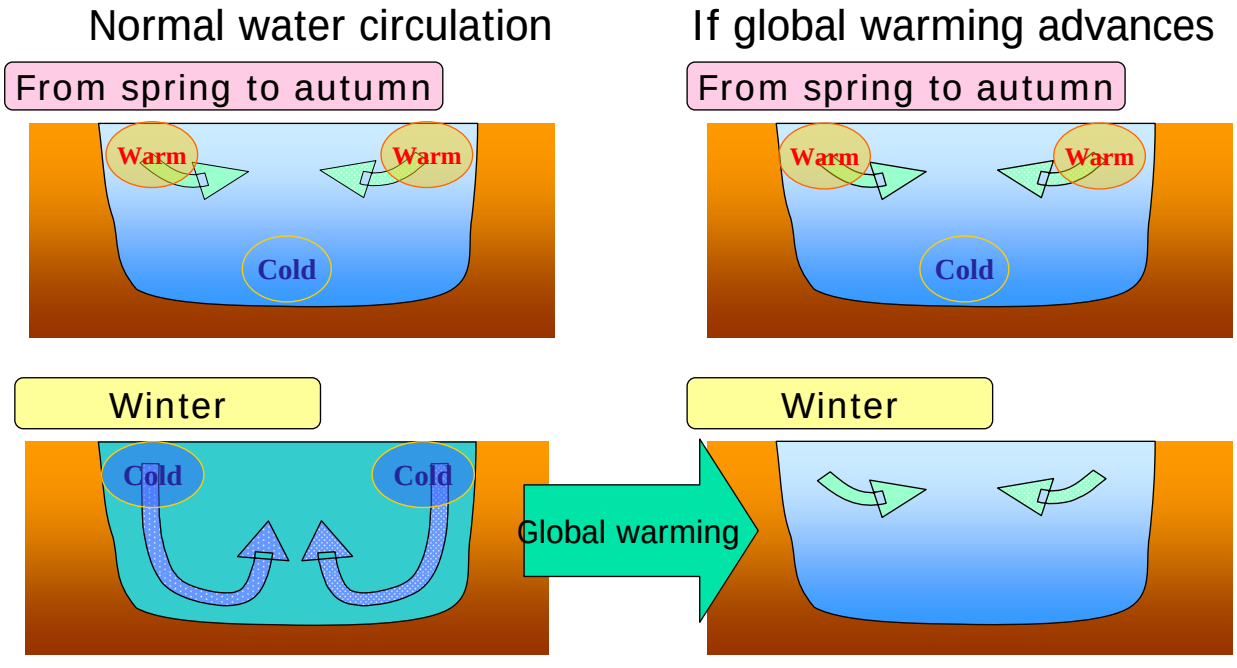
Contour Map of Turbidity in Ogochi Reservoir on September 18, 2007



Change in Turbidity of Raw Water in Ozaku Purification Plant after Typhoon No.9



Stagnation of Circulation in Reservoir due to Global Warming



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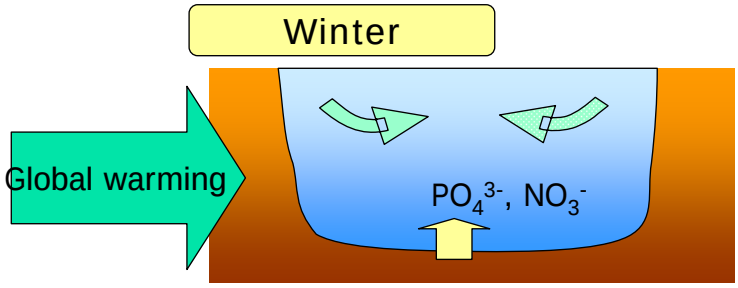


- Nutrition salts eluting from sediments at the reservoir bottom may cause phenomena such as water-bloom even in winter.

Increased Risk of Toxic Chemicals in Raw Water due to Increase in Vermin

- Atmospheric temperature rise may have an impact on terrestrial ecosystem.
- The amount of agricultural chemicals is expected to rise due to an increase in the number of vermin.

Increase in Production of Trihalomethane due to Water Temperature Rise

- The reaction rate of production of trihalomethane increases with water temperature.
- More consumption of residual chlorine due to water temperature rise requires more supply of chlorine in the water purification plant.

Organic material + Chlorine → Trihalomethane

Increased Risk of Pathogenic Microorganisms in Tap Water due to Water Temperature Rise

- Elevated water tanks affected by urban warming will increase the risk of pathogenic microorganisms in the tap water.

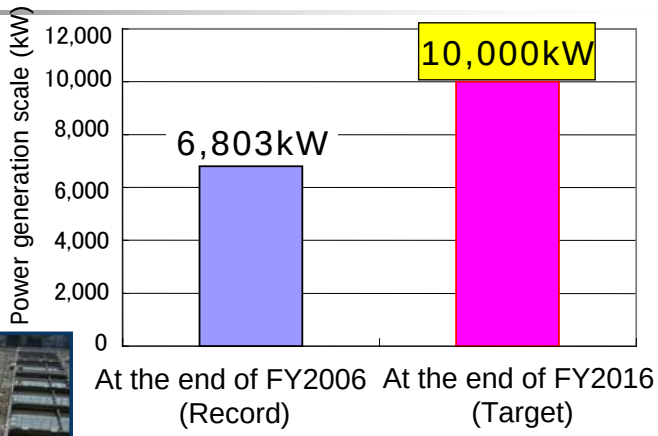
Measures in Waterworks against Climate Change

- Mitigation measures in waterworks
  1. Promotion of renewable energy
  2. Promotion of measures for water leakage prevention
- Adaptation measures in waterworks
  1. Measures to mitigate water-bloom in reservoir
  2. Introduction of advanced purification
  3. Proliferation/promotion of direct connection water supply

Promotion of Renewable Energy in Waterworks

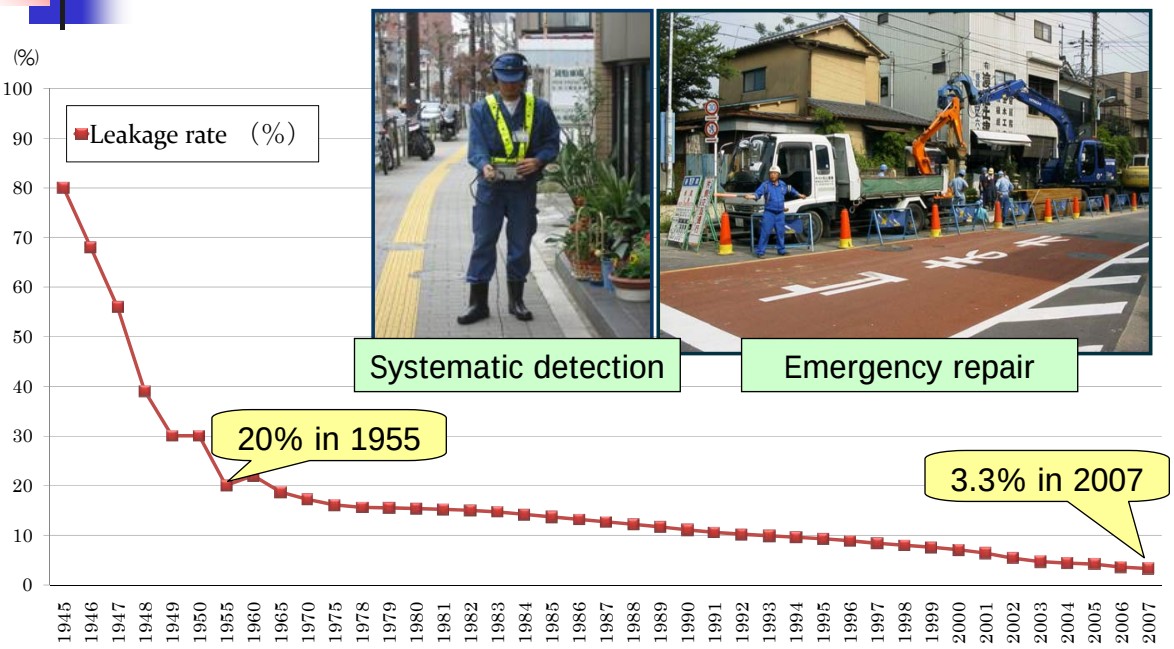
Solar power generation

(Asaka Purification Plant)



Target of power generation scale of renewable energy in Tokyo Waterworks

Promotion of Measures for Water Leakage Prevention



Effect of Water Leakage Prevention

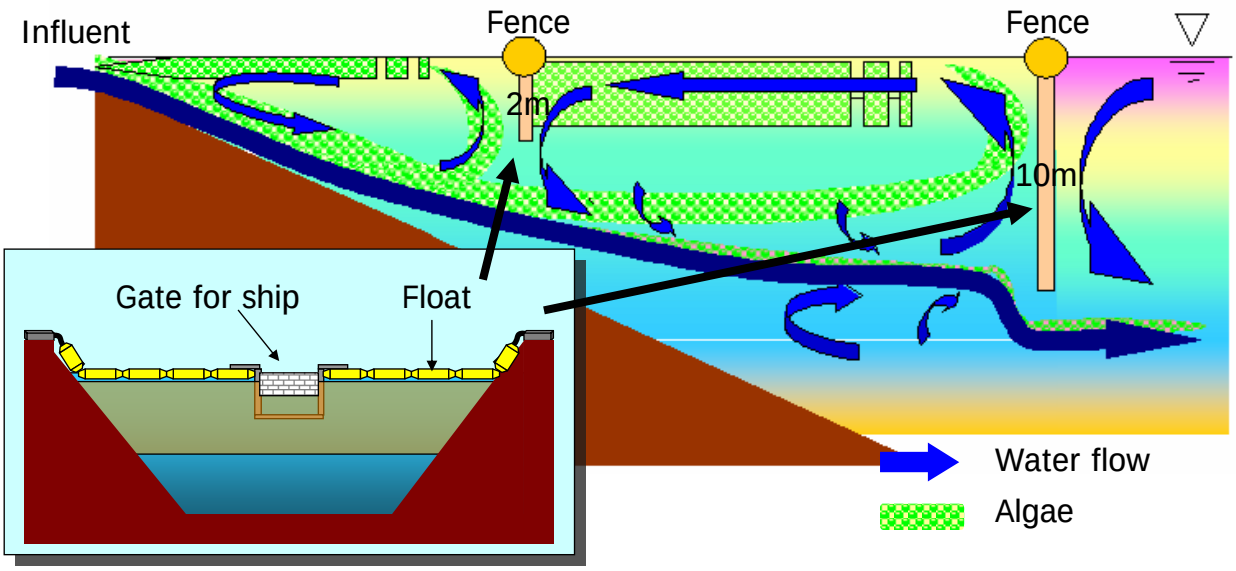
Leakage rate

20% in 1955 ⇒ 3.3% in 2007

- Saving of approx. 340 million m^3/year of water (equivalent to water distribution in a city with 2.5 million residents)
- Saving of approx. 70 billion yen/year of cost
- Approx. 68 thousand tons/year reduction of CO_2 emissions

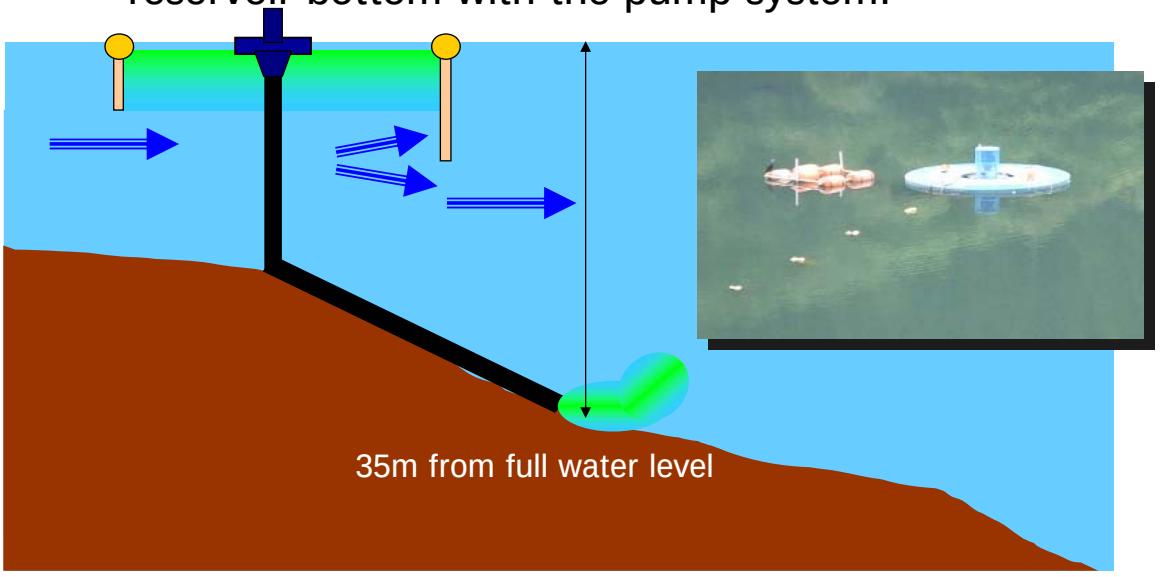
Measures to mitigate water-bloom in reservoir against global warming

- Fences stop the flow of algae toward the direction of the dam in Ogochi Reservoir.

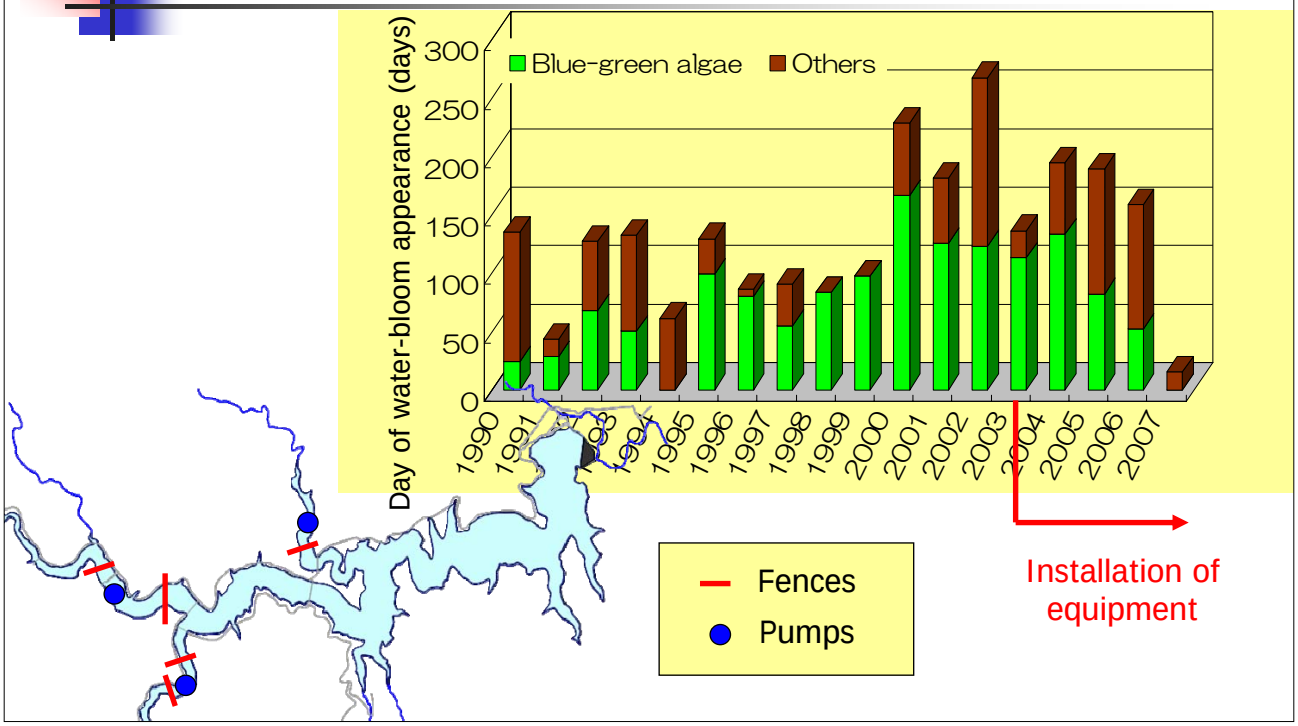


Measures to mitigate water-bloom in reservoir against global warming

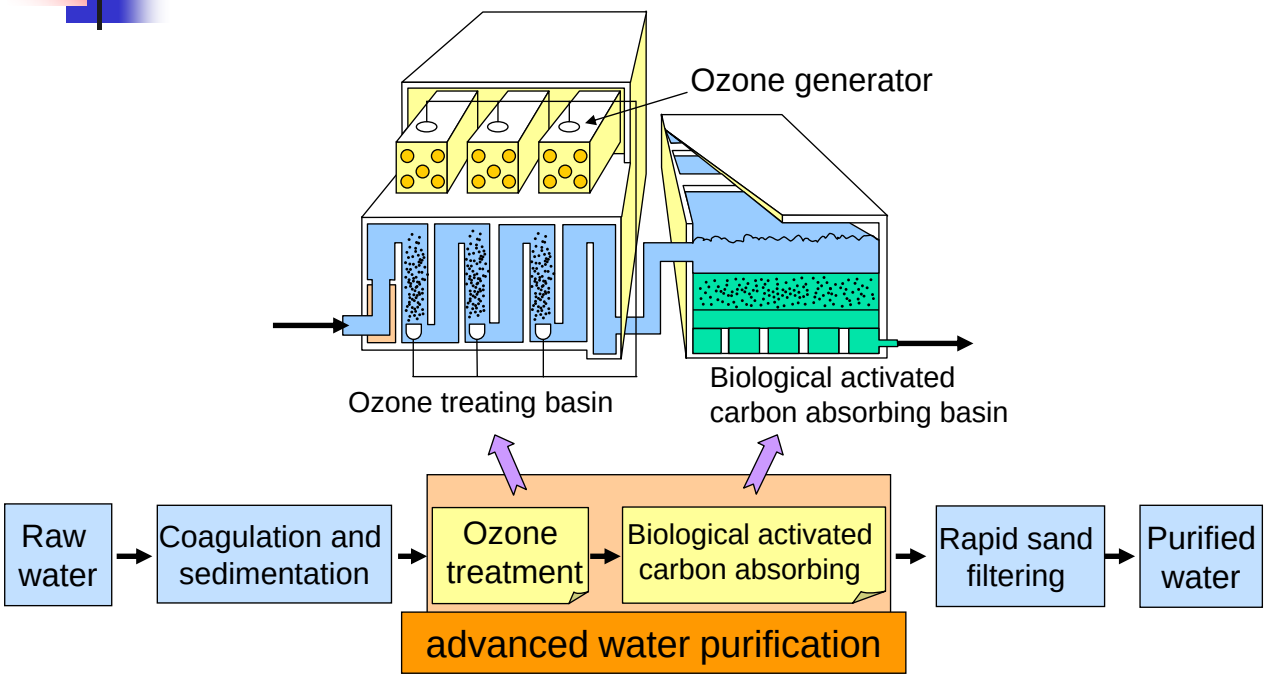
- Algae between the fences is transferred to the reservoir bottom with the pump system.



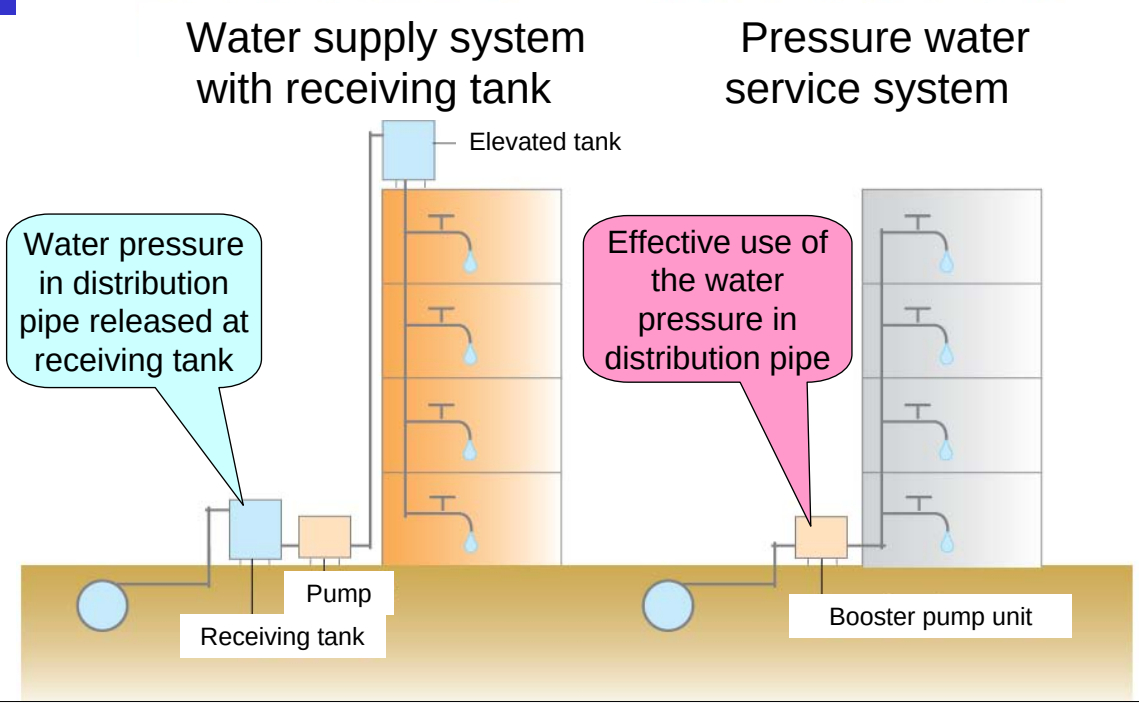
Effect of measures to mitigate water-bloom in Ogochi Reservoir



Introduction of Advanced Water Purification Treatment to Reduce Odors and Chlorine Supply



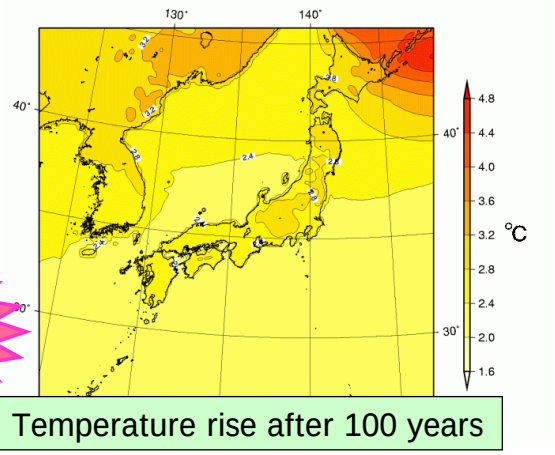
Proliferation/promotion of Direct Connection Water Supply



Waterworks in the Future: Preparing for Risks Caused by Climate Change

Waterworks: Operations based on past climate conditions (patterns of rainfall and snowfall)

Unprecedented changes in the environment due to climate change



Temperature rise after 100 years

Analysis/research of risks associated with climate change and provision of appropriate information

Studies of approaches that are not bound to conventional ideas or frameworks