Occurrence of Musty Odor in Clean Upper River due to Benthic Cyanobacteria - Occurrence and Behavior in River -

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Introduction

The Tama River (Sunniwa Bridge)

- Musty odorants causative agent are the substances which actinomycete and cyanobacteria such as *anabaena*, *oscillatoria* and *phormidium* produce, and generally this cyanobacteria grows due to water deterioration in eutrophication water systems such as dam reservoirs.
- In Japan, the culture of drinking tap water directly from a tap is established, and musty odor accounts for the majority of off-flavor and taste damages in tap water. Its typical causing substance is 2-MIB. The Ministry of Health, Labour and Welfare positioned it as the tap water quality standard from a viewpoint of good taste and the standard value of 10ng/L was set.
- The Tama River, which is one of the water resources for Tokyo and whose source is in Mt. Kasatori which is full of nature, has the total length of 138km and is popular among many people. As its upper river basin is not urbanized and the water quality is very clean.
- As highly-concentrated 2-MIB has been detected since FY 2011 and Ozaku Purification Plant where water is taken in from the Tama River has been forced to add more powdered activated carbon, the Tokyo Metropolitan Waterworks conducted various surveys in the upper basin of the Tama River following such problems.

Method

1 Survey on occurrence of 2-MIB

- ✓ Because 2-MIB has been intermittently detected in the Tama River since FY 2011, the river survey to measure its concentration distribution was conducted.
- ✓ Multiple survey points were selected in the range from Hamura Intake Weir to Okutama Ohashi Bridge that is 20 km upstream. (Figure 1)

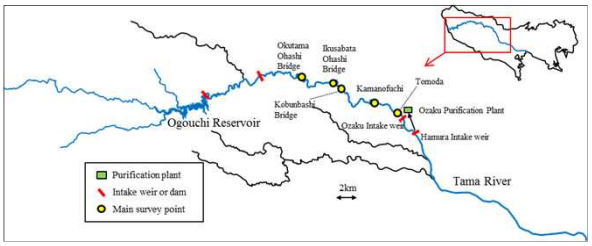

Figure 1: The Tama River Water System and Survey Points

2 Survey on cause of 2-MIB

- ✓ As highly-concentrated 2-MIB was detected when algae clinging to stones in the river bed were examined, we assumed these clinging algae were the cause and conducted the survey for identification of species.

3 Distribution survey for benthic cyanobacteria

- ✓ In the distribution survey for cyanobacteria attaching to stones in the river bed, we conducted periodic surveys in the range from Hamura Intake Weir to Okutama Ohashi Bridge that is 20 km upstream.
- ✓ Stripping off deposits of 5cm x 5cm by a brush from each stone after randomly collecting three stones from the river bed at each survey point, and counting in units of 100μm under a microscope, we calculated as nuit per square cm.

4 Situation survey at the time of flood due to rainfall

- ✓ Because flow velocity is considered to be a factor which affects the existing quantity of benthic cyanobacteria, we conducted a situation survey.

Results

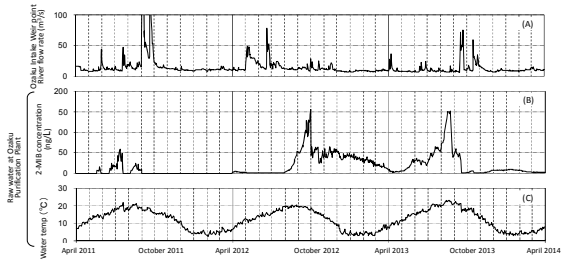

Figure 2: 2-MIB concentration and water temperature in raw water, and river flow rate at Ozaku Intake Weir point

- ✓ Each year, 2-MIB concentration increased during the period from May to September when water temperature increases (Figure 2-B and C). Also, due to drastic increase of river water volume by storm-water flooding, 2-MIB concentration showed a tendency to decrease widely (Figure 2-A and B).

Figure 3: Pictures of cyanobacteria producing musty odor (A: River bed, B: Collected stones, C: Enlarged picture of cyanobacteria cake)

- ✓ When we conducted isolation and culture of cyanobacteria strains and identified species based on the gene information, it was found to be *phormidium autumnale*.
- ✓ About 260,000 units/cm^2 was collected at Kamanofuchi point in a winter season (February 2013). (Figure 4-D)

Discussion

1 Relation between quantity of cyanobacteria and 2-MIB

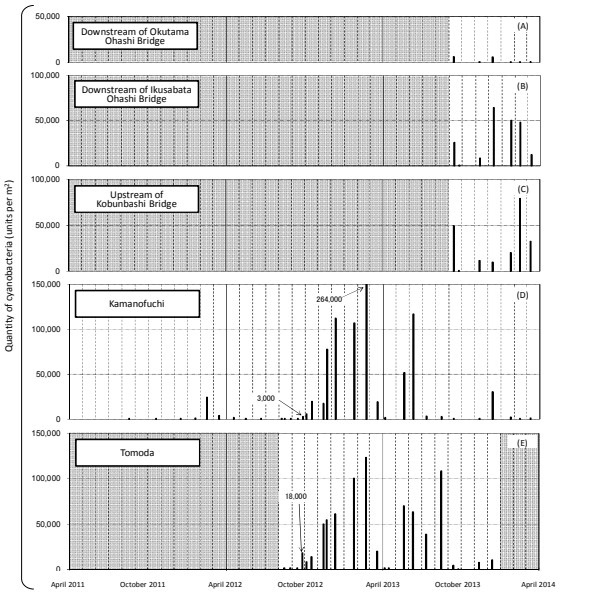

Figure 4: Changes in quantity of cyanobacteria at survey points (No measurement during the shaded period)

- ✓ In September 2012 when the highest 2-MIB concentration (Figure 2-B) was recorded, the quantity of cyanobacteria was small (Figure 4-D and E) at Kamanofuchi point and Tomoda point, and the existing quantity was 3,000 and 18,000 units/cm^2 respectively.
- ✓ Although the quantity of cyanobacteria increased about 90 times at Kamanofuchi point and about 7 times at Tomoda point in February 2013 compared with the quantity in September 2012 (Figure 4-D and E), 2-MIB concentration didn't increase. (Figure 2-B)
- ✓ Cyanobacteria's capability to produce 2-MIB showed a tendency to be high during a summer season when water temperature is high.

2 Increase of river flow rate and peeling of cyanobacteria

- ✓ We designated the product of river flow rate and 2-MIB concentration as 2-MIB load and assessed
- ✓ When river flow rate exceeded 30m^3/s, 2-MIB load drastically increased. And when river flow rate reached around 40m^3/s and went below 30m^3/s, the decrease of 2-MIB load stopped.
- ✓ It was assumed that cyanobacteria started peeling when river flow rate exceeded 30m^3/s.

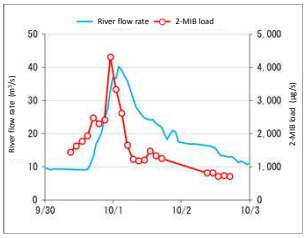

Figure 5: Changes of River Flow Rate and 2-MIB load

Conclusion

- ✓ 2-MIB concentration increased during the period from May to September when water temperature increases due to the influences of cyanobacteria producing musty odor.
- ✓ When we conducted isolation and culture of cyanobacteria strains and identified species based on the gene information, it was found to be *phormidium autumnale*.
- ✓ As the cause for which increase of 2-MIB concentration in winter season was not seen in February 2013, it was suggested that cyanobacteria's capability to produce 2-MIB is influenced by water temperature.
- ✓ Because from when river flow rate exceeded around 30m^3/s, it was assumed that peeling of cyanobacteria started.

[1] Oikawa T, Tsunoda T, Nakahigashi H, Shimoriku M, Kanami T and Kimura S., Musty odor producing benthic cyanobacteria in Tama River (Japan) and identification of species by genetic analysis, Journal of Water Supply: Research and Technology – Aqua, Volume64, Number7, pp 839-846, 2015
[2] Tsunoda, T., Nakahigashi, H., Kanami, T. and Oikawa, S., "Gene Analysis Results of Cyanobacteria Producing Musty Odor Occurred in Upper Basin of Tama River", *Water and Environment Technology Conference Journal*, Vol.37, No.1, pp 9-13, 2014