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**Emergency Response against Water Quality Accident  
to Secure Safe Water Supply for Capital Area**

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**ABSTRACT:**

*Japan is one of the countries where people drink tap water directly. Therefore, careful water resources management is required especially in supplying drinking water. On May 17, 2012, formaldehyde (HCHO in chemical formula), one of harmful substance, was detected as exceeding the limit for drinking water regulation near capital area of Japan, and, eventually, water supply for around 360 thousand houses was stopped in Chiba Prefecture, next to Tokyo metropolis.*

*Japan Water Agency (JWA) is in charge of operation of water resources management facilities in major river basins in Japan such as dams, weirs and canals, etc. Therefore, JWA worked together with river administrator against the water quality accident through emergency operation which aimed at reducing consistency of causative substance of formaldehyde and to prevent expansion of troubles. Emergency discharge from upstream dams, stopping water delivery through canals which connects 2 river basins, etc. were implemented as emergency operation. Finally, most of water supply service area didn't suffer from water quality accident. Through the experience of the water quality accident and emergency operation, JWA learned importance of 1) appropriate information sharing and 2) grasping the potential risk in the basin in advance. In addition, JWA reminded that enhancing the capacity of risk management is essential to achieve the mission of "to deliver safe water stably" since water quality accident are directly link to citizens' daily lives and one trouble can give negative impact into wide area through the network of rivers, canals and water supply facilities.*

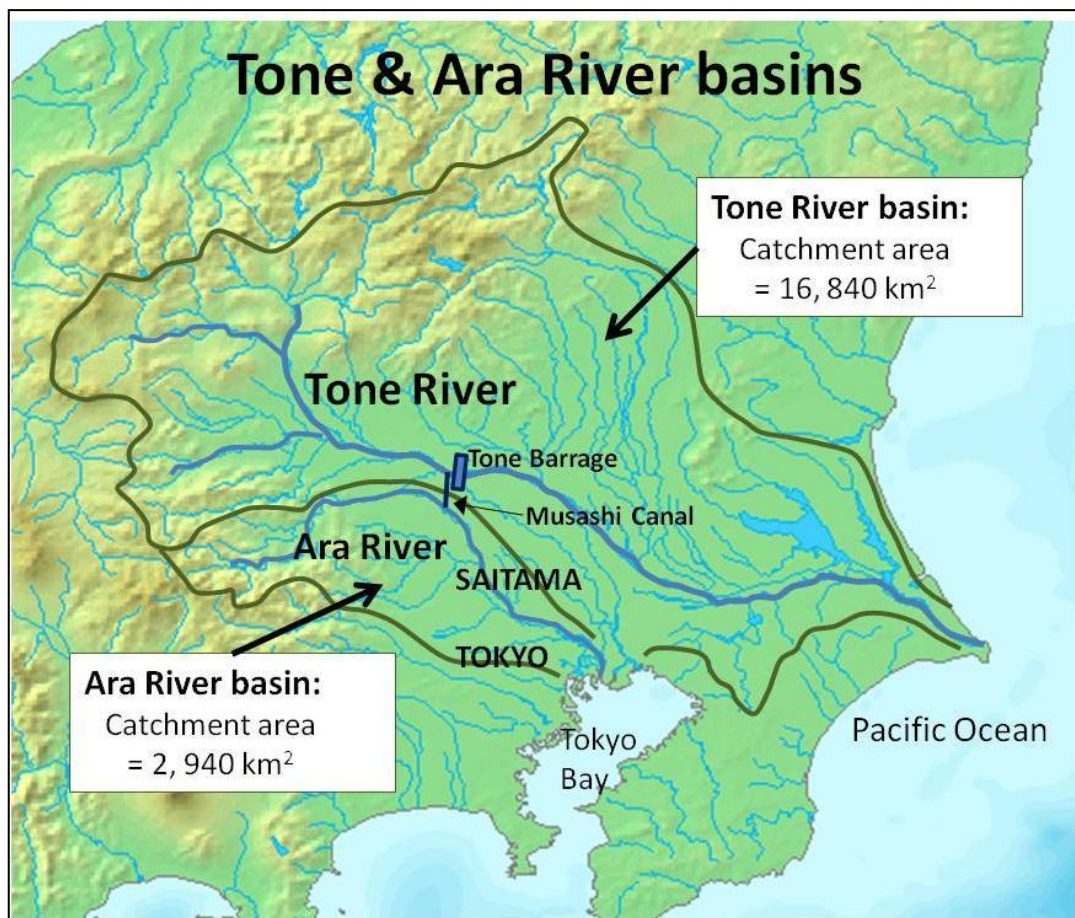
**Keywords:** *water quality accident, basin-wide response, emergency discharge, risk management,*

**1. ROLE OF JAPAN WATER AGENCY IN CAPITAL AREA ON WATER RESOURCES MANAGEMENT**

**1.1. Water Resources Development in Tone and Ara River Basins**

Tone River, one of Japan's major large rivers, originates in Mt. Ohminakami on the north boarder of Kanto Region. The river encompasses most of the Kanto Plain, collecting the waters of numerous tributaries and empties into the Pacific Ocean with part of the flow diverted at Sekiyado by the Edo River that enters Tokyo Bay (see Figure 1). The area of Tone River basin is 16,840km<sup>2</sup>, the largest in Japan, and covers most of the prefectures of Kanto Region, including some part of metropolis of Tokyo. The large river has long been providing abundant water resources and enriching the soils, but has also been causing floods and other great disasters. Between 1961 and 1964, serious drought generally

referred to as the “Tokyo Olympics drought” occurred, which had great influence on subsequent water resources development policies in Japan.



**Figure 1.** Tone and Ara River basins

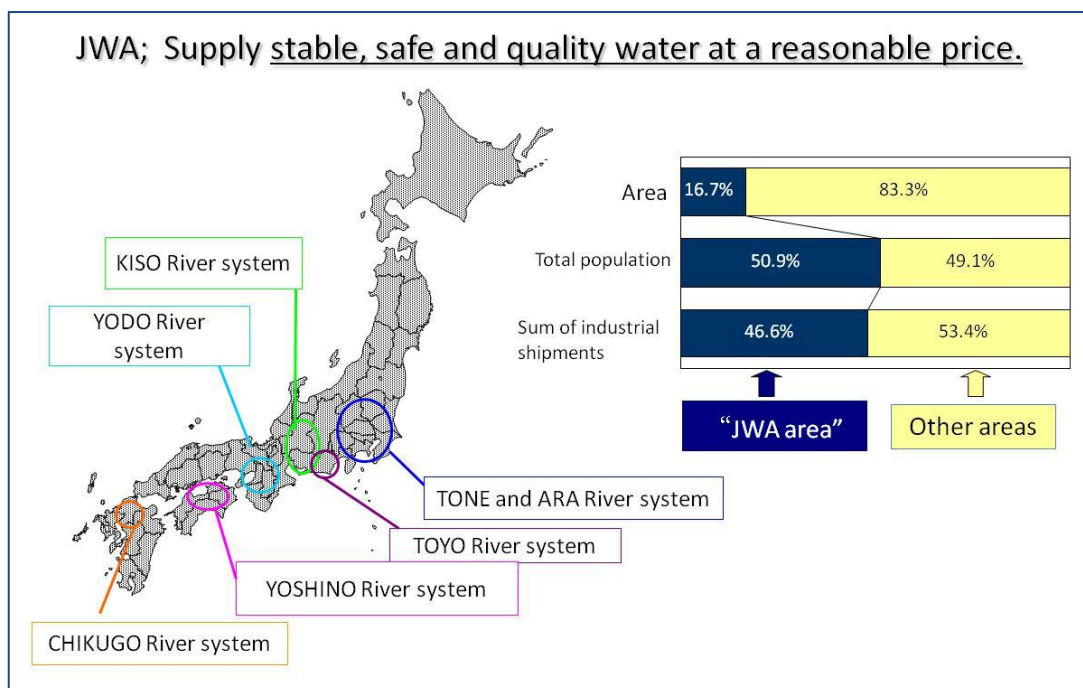
Ara River with headwaters in Mt. Kobushigatake locates western side of Kanto Plain runs through a group of major cities in Saitama and Tokyo in the south of the Kanto Plain, and reaches Tokyo Bay (see Figure 1). The basin occupies 2,940km<sup>2</sup>, next to Tone River basin.

Tone River basin and Ara River basin is connected by Musashi Canal, which is constructed near Tone Barrage, to deliver water which is developed in Tone River basin to Ara River basin (see Figure 1). The combined river basin of the Tone and Ara River Systems covers an area of 19,780km<sup>2</sup>, which represents 66% of five prefectures and a metropolis. The basin of both river systems is at the center of Japan’s political, economic and cultural activities. Water use and flood control in the basin is therefore of great significance.

## 1.2. Role of Japan Water Agency

Japan Water Agency (JWA), based on the Basic Plan for Water Resources Development Plan for Major seven river systems (Tone, Ara, Kiso, Yodo, Yoshino and Chikugo River Systems) designated for water resources development, is working on construction, operation, management and re-construction of water resources management facilities such as dams, estuary barrages, facilities for lake and marsh development, and canals (see Figure 2).

The seven river systems designated for water resources development where the plan above mentioned is applied cover major areas in Japan. Although the area of these river basins is only 16% of national land, the population and industrial shipments in value in the covered area account for 51% and 47% of national totals, respectively. Most of major cities in Japan are located in these cities. (e.g. Tokyo in Tone and Ara River basin, Kyoto and Osaka in Yodo River basin, Nagoya in Kiso River basin)



**Figure 2.** Cover area of Japan Water Agency

JWA has constructed 4 dams in upstream of Tone River System and 2 dams in Ara River System, and also a canal which connects Tone River and Ara River to deliver water collected in Tone River basin, larger river basin, to Ara River which goes through population concentrated area to meet water demand there. In addition, JWA worked on the development of lakes, construction of barrages and canals in Kanto Plain. JWA has completed and managing 18 projects in both river systems and, at present, implementing construction of 6 facilities.

JWA manages 72% of water resources developed in both river basins which is worth for drinking water for 14,000,000 people, provides agricultural water for 94,000ha, and contributing industrial production of approximately 36 billion USD per year.

## 2. DETECTION OF HARMFUL SUBSTANCE IN PURIFIED WATER

On May 17, 2012, “formaldehyde”, one of harmful substance, was detected as exceeding the limit for drinking water at a water purification plant in Saitama Prefecture, locating next to Tokyo.

“Formaldehyde” is an organic compound with the formula CH<sub>2</sub>O or HCHO. It is the simplest aldehyde, so that it exists everywhere in the world. However, it has toxicity and

volatility, exposure to formaldehyde is a significant consideration for human health. It is known as a cancer-causing material in highest category of International Agency for Research on Cancer under WHO. On the other hand, formaldehyde is commonly used as industrial materials, construction materials, etc. because of its low price.

In Japan, ordinance by Ministry of Health, Labour and Welfare on drinking water defines formaldehyde as one of the 50 regulated items and if consistency of the items in water exceeds their limits, water suppliers are not allowed to provide the water as drinking water.

Therefore, the fact that the consistency of formaldehyde in the treated water, which is to be supplied for drinking use, exceeded the regulated value means quite serious situation because water supplier cannot provide drinking water for its service area. Eventually, water supply service for around 360,000 houses stopped because of excessive formaldehyde.

### **3. EMERGENCY OPERATION**

#### **3.1. Outline of Emergency Operation**

The purification plant where formaldehyde was detected takes raw water from Tone River through the intake gate placed at Tone Barrage. Detection of formaldehyde made relevant organizations start emergency operation. The detection of formaldehyde at a plant which takes raw water from Tone River raised following concerns.

- a) The plant where formaldehyde was detected cannot provide drinking water, which brings problems in water supply service in cover area.
- b) Same problem can happen in other plants which take water from Tone River

In case formaldehyde is detected in other plants in capital area, it cause serious problem in water supply service in the area which bring large negative impact for the lives of the citizens there. Therefore, following actions should be implemented urgently.

- a) Identifying causative substance and preventing contamination
- b) Decision of “stop or not to stop” on water intake from Tone River at other purification plants
- c) Prevention of trouble expansion

For identification of causative substance and prevention of contamination were conducted by Ministry of Health, Labour and Welfare and local governments, and some days later, it was announced that the hexamethylenetetramine (HMT) which was contained in the effluent from waste disposer which is located in upper stream area was the causative chemical substance of formaldehyde.

As for the decision of water intake from Tone River, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), as river administrator, implemented urgent water quality tests along the Tone River and Edo River which diverted from Tone River repeatedly and provided the result to relevant organizations. As a result, many purification plants stopped, temporary, water intake from Tone River on May 19. One of them stopped water intake for 3 days

JWA contributed on prevention of trouble expansion. JWA implemented emergency operation of facilities under the coordination with MLIT, river administrator.

### 3.2. Outline of Emergency Operation by JWA

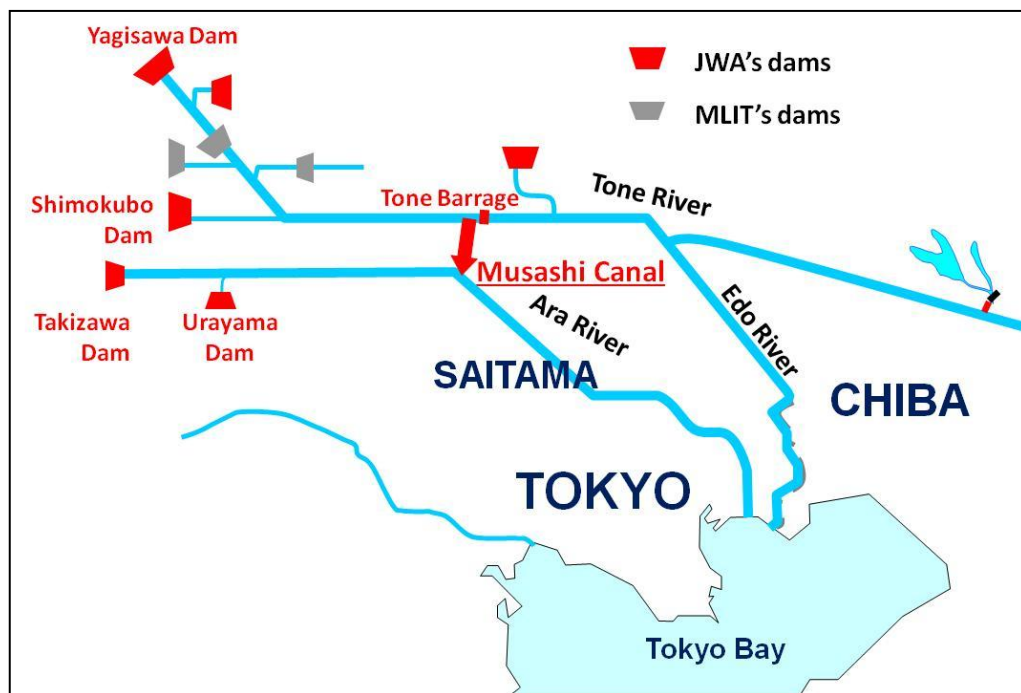
JWA and MLIT implemented emergency operation of water resources management facilities in Tone River System to prevent expansion of troubles, assuming the causative substance is coming through Tone River.

#### 3.2.1. Announcement of emergency response mode and stopping water delivery through Musashi Canal

Receiving first report of detection of formaldehyde from Saitama Prefecture at 17:30, May 18, JWA Headquarters (JWA-HQ) and related branch offices announced emergency response mode and implemented emergency operation under coordination with MLIT.

Assuming that the causative substance reached the purification plant through Tone River, one of the significant emergency operations was “stopping water delivery through Musashi Canal”.

Musashi Canal is the canal which connects Tone River and Ara River (see Figure 3). One of the objectives of the canal is to deliver water developed in Tone River Basin which has large area to Ara River which run through a group of major cities in Saitama and Tokyo for effective water supply. The canal was constructed in 1967, and has been delivering 40% of drinking water of Tokyo and 80% of Saitama through the canal of 14.5km.



**Figure 3.** Location of Musashi Canal and other major facilities in 2 river basins

If the causative substance reaches to Ara River from Tone River through the canal, water supply in Tokyo and Saitama may be affected by significant impact. Since Musashi Canal takes water from Tone Barrage, same place of troubled purification plant, stopping water delivery through the canal was essential operation to prevent capital area from expansion of serious troubles.

After the coordination with relevant organizations, JWA stopped Musashi Canal at 23:10 on May 18. The JWA-HQ's emergency operation mode is changed to higher level at the same time.

The operation was announced to public in the midnight, 24:00 with MLIT.

### 3.2.2. *Emergency water discharge from dams*

The other important emergency operations were “to reduce the consistency of causative substance in river flow” and “to wash causative substance into sea”.

Through the consultation, JWA and MLIT decided to release water in reservoirs in upstream area as emergency operation to achieve these missions.

At 1:30 on May 19, JWA started emergency water discharge at Shimokubo Dam, located in upstream of Tone River, with the amount of 200m<sup>3</sup>/s in maximum.



**Photo 1.** Shimokubo Dam

200m<sup>3</sup>/s of water never releases from the dam except the case of flood. Such large amount of water released from the dam as emergency operation. Normally, water users want to save water in reservoir to prepare against drought. However, to avoid the situation of closing intake gates of purification plants in downstream area, it is unavoidable option to improve the situation. Also dams of MLIT started emergency water discharge as well.

The emergency water discharge has not only problem of preparation against drought, but also technical problem. Rapid decrease of water level of reservoir may cause land slide around reservoir if geological condition doesn't fit.

Therefore, emergency water discharge was implemented under careful observation of the condition around the reservoirs as well as checking water quality test result of downstream

area to seek improvement of downstream condition and to avoid unnecessary trouble in reservoir management.

Emergency water discharged from dams of MLIT and JWA in upstream area of Tone River recorded  $543\text{m}^3/\text{s}$ , maximum in the emergency operation duration, at 5:00 on May 19.

On the other hand, many water purification plants along the Tone River and Edo River stopped water intake from the rivers to check water quality test result, and after confirming the safety of the water intake, they resumed taking water to their plants. Most of them started with the interval less than half day. But one of the plants stopped for 3 days. During the duration stopping water intake water from the river, the purification plants could deliver water for some time utilizing stored water, however, water supply service to around 360,000 houses, around 870,000 people in population, stopped for half – one day eventually. On May 23, the last plant which kept stopping water intake for 3 days restarted their operation.

### *3.2.3. Alternative operation against stopping water delivery through Musashi Canal*

The emergency operation, stopping water delivery through Musashi Canal, to prevent capital area from expansion of troubles raised another problem. Water volume in Ara River which normally receives water through the canal reduces when canal stopped water delivery. It may cause water shortage in Tokyo and Saitama Area.



**Photo 2.** Musashi Canal

Therefore, JWA carefully observed water discharge volume of the control points along Ara River whether it fits water demand of the area, considering the condition of stored water volume of 2 dams in upstream of Ara River and the possibility of additional discharge as alternative option of stopping water delivery of Musashi Canal to avoid unexpected water shortage in capital area.

### *3.2.4. Finishing emergency operation*

Considering water quality monitoring data, discharge volume of emergency operation from dams was reduced gradually. Since no additional troubles in the purification plants occurred, and consistency of formaldehyde was kept low than regulation value even after the reduction of emergency water discharge volume, MLIT as river administrator decided to stop emergency discharge of all the dams, and to restart water supply through Musashi Canal. Emergency operation for 7 days finished at 15:00 on May 24. Series of major emergency operation by JWA are shown in the table below.

**Table 1.** Emergency operation by JWA

<b>Date</b>	<b>Time</b>	<b>Operation by JWA</b>	<b>Remarks</b>
May 18	17:30	Received first report of detection of formaldehyde from Saitama Prefecture	
	18:00	Announced emergency response mode by JWA-HQ	
	23:10	Closed Musashi Canal which normally delivers water from Tone River to Ara River for water use of major cities in Tokyo and Saitama area	
	24:00	Press release on emergency operation of Musashi Canal	
May 19	01:30	Started emergency water discharge from Shimokubo Dam which is located in upstream of Tone River	Emergency discharge was continuously conducted from reservoirs in upstream area under coordination with MLIT.
	05:00		Emergency discharge from reservoirs recorded 543m <sup>3</sup> /s in total. <maximum volume during the emergency operation>
	08:30	Stopped emergency water discharge from Shimokubo Dam based on the coordination with MLIT	JWA kept standing by additional emergency discharge from dams in upstream area.
	22:30	Started emergency water discharge from Yagisawa Dam which is located in upstream of Tone River	
May 20	05:30	Stopped emergency water discharge from Yagisawa Dam	
May 21-24		Conducted several times of emergency water discharge from Yagisawa Dam	
May 24	15:00	Restarted water delivery through Musashi Canal	JWA continued careful monitoring of water quality of rivers and purification plants until finishing emergency response mode on June 8.
June 8	09:00	Finished emergency response mode	



After stopping emergency operation, JWA-HQ continued emergency response mode until June 8 and conducted checking water quality of the rivers and plants to secure safety water supply for water user organizations.

Causative substance was also identified by central and local government and announced to public about the cause and process of the water quality accident.

#### *3.2.5. Information Release*

Since the water quality accident is directly linked to peoples' daily life, prompt information release is required to related organizations. Therefore, during the emergency operation, JWA released information to public through website 6 times, and held press conference together with MLIT 4 times, in addition to frequent information sharing with relevant organizations on water resources management.

## **4. CONCLUSION**

In general, troubles in water supply service are directly link to citizens' daily lives and one trouble may give impact into wide area in river basin because of installed water supply network and rivers/canals.

In the case of emergency operation in May 2012, flexible facility operation of dams, canals, etc. contributed a lot to avoid expansion of water quality trouble in capital area. However, implementation of flexible facility operation was not so easy because it required proper decision making which meets sudden changes in circumstances and which is to be accepted by stakeholders.

Through the experience of water quality accident and emergency operation, JWA learned importance of 1) appropriate information sharing and 2) grasping the potential risk in the basin.

“Appropriate information sharing” means information sharing which is timely, including necessary information for receivers, and contributing well to share the recognition of each other, etc. and it is applied for information sharing between JWA and water user organizations, as well as between JWA and MLIT, and among JWA-HQ and branch offices in the Basin.

The characteristic of the trouble in this case was 1) trouble which directly link to citizens' lives, and 2) emergency operation was needed in large area of wide 2 river basins. Therefore, information sharing and coordination among various stakeholders such as river administrator, facility management authorities, water users, related ministries, etc. were essential and significant. The important information for proper decision making for emergency response in each organization should be delivered appropriately and sufficiently beyond the “wall” of organizations in any case. It is a key for success in risk management and information scheme and measures should be always reviewed and improved.

In addition, JWA leaned importance of “grasping potential risk in the river basin”, such as information of the companies who treat dangerous material, for the preparation of

emergency response simulation against quality accident in advance. It helps a lot prevent identifying source of accident and expansion of troubles.

Lastly, through the water quality accident, JWA reminded the importance of upgrading the capacity of risk management as one of the organizations which is working in the field of water supply service and water resources management under the mission of “deliver safe water to water users stably”.

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