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Effects of a Mt. Zao Eruption on Sendai City Waterworks Bureau Projects and Their Countermeasures

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Abstract: Sendai City Waterworks Bureau investigated the potential effects on water quality and countermeasures against these effects, assuming there was an eruption at Mt. Zao. We also prepared a crisis management manual for a potential eruption. After that, we trained together with other city waterworks preparing for a potential eruption of Mt. Zao, and made further improvements to the actual manual and its effectiveness.

Keywords: Volcanic eruption, water quality abnormality, crisis management manual

1. Introduction

There are about 1,500 active volcanoes in the world, most of which are located in the Pacific Rim. Especially in the case of Japan, where there are about 10% of the world's active volcanoes; it can be said that Japan is one of the world's leading volcanic countries. In 2014, a phreatic explosion occurred at Mt. Ontake near the center of the Japanese archipelago, and a lot of damage was incurred, including effects on the water supply.

Mt. Zao, one of Japan's active volcanoes, is located about 20km southwest from Sendai City's nearest water source. Recently, the eruption warning level of Mt. Zao has been raised, and there are concerns about the effects an eruption would have on the water supply.

In this study, we conducted a survey on the effects on tap water using volcanic ash samples, and prepared the responses as a manual. Based on the manual, we also conducted volcanic response training together with other city waterworks. Then we identified problems and edited the manual using these findings, in addition to preparing necessary equipment in advance, and established a series of systems, which we will report hereafter.

2. Preliminary Survey and Predicted Damage to Water Facilities Due to the Eruption of Mt. Zao

2-1. Predicted Crisis Events (Fig. 1)

Mt. Zao is an active volcano located about 30km southwest of Moniwa Water Purification Plant (MWPP) in Sendai City. In the upstream area of Kamafusa Dam, the water source of MWPP, it is estimated that the ash fall will be 1 to 10 cm if a phreatic explosion occurs and about 10 cm if there is a volcanic eruption.

2-2. Water Purification Treatment Survey and the Impact on Source Water Quality

- Observation of Shape and Composition with an Electron Microscope

We observed the shape of volcanic ash at Sakurajima and Mt. Zao using a scanning electron microscope. In addition, we observed components that might be dissolved or suspended from volcanic ash to water using the EDX spectrum. Volcanic ash released by phreatic explosion contained a lot of particles with relatively small particle size. Sulfur was detected in volcanic ash from the Mt. Zao phreatic explosion (Fig. 2). Therefore, there is a concern about a decrease in the pH value of water due to sulfuric acid and similar substances, or an effect on the smell due to hydrogen sulfide.

- Dissolution Test

Iron and aluminum from the Mt. Zao magma eruption, and aluminum from Mt. Zao phreatic explosion were detected relatively highly (Fig. 3).

• Coagulation Sedimentation Treatment Test with Sakurajima Volcanic Ash

We were concerned about a potential increase in turbidity in source water at MWPP when ash falls. Thus, we added Sakurajima volcanic ash to Moniwa source water, and performed a jar test to investigate for the coagulating sedimentation of PAC. Formation and sedimentation of floc was good with PAC samples of 50 mg / L or more. We could only confirm small treatment effects for fluorine.

• Odor Removal Test on Hot Spring Water Containing Hydrogen Sulfide Using Powdered Activated Carbon

A sample was prepared by adding spring water containing hydrogen sulfide to source water. Then we conducted an odor removal test with powder activated carbon. As a result, odor removal effects were confirmed with powdered activated carbon of 5 mg / L or more (Tab. 1). Next, we investigated the effects of removing odor, metals, etc. with a series of operations using 2% hot spring water, including powdered activated carbon treatment, pH adjustment, coagulation sedimentation treatment (Tab. 2). From these results, it was found that almost all iron and aluminum can be removed. On the other hand, the removal rate of manganese and fluorine was about 15%.

3. Establishment of the Crisis Management Manual for a Potential Mt. Zao Eruption

It covers the following six subjects: (1)Covering the openings of waterworks facilities (2)Enhancement of water quality management system (3)Enhancement of water purification (4)Water management (5)Emergency water supply (6)Public relations

4. Using the Crisis Management Manual

4-1. Joint Training with Other Cities for a Potential Mt. Zao Eruption

We implemented a crisis response training assuming a Mt. Zao eruption together with Sapporo and Niigata City Waterworks. In particular, as a measure to reduce ash at the water purification plant, we made temporary covering for the sedimentation reservoir.

4-2. Extraction of problem by joint training and revision of manual

Through this joint training, we were able to verify the effectiveness and practicality of the manual. However, as some problems were discovered, we discussed the manual with stakeholders and revised the manual.

5. Summary and the Future

It was found that volcanic ash influences water quality items of turbidity, pH value, odor, and metals in some of the surveys conducted. Assuming that these items were affected, we confirmed the coagulation settling effects of PAC, the deodorizing effects of powdered activated carbon on hydrogen sulfide, and there was no problem in the purification treatment. On the basis of these results, we formulated the Mt. Zao Eruption Response Manual, in which we compiled the response policy for the Sendai City Waterworks Bureau. We established a wide-area support system with joint eruption response training with Sapporo City and Niigata City, improved the manual and made it more effective. In the future, we would like to consider the continuation of water supply when fluorine exceeds water quality standards.

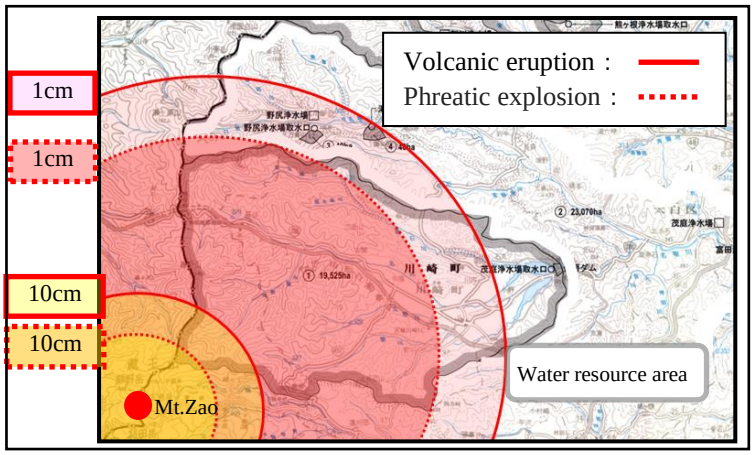

Fig.1 Influence range map of volcanic ash by Mt. Zao eruption

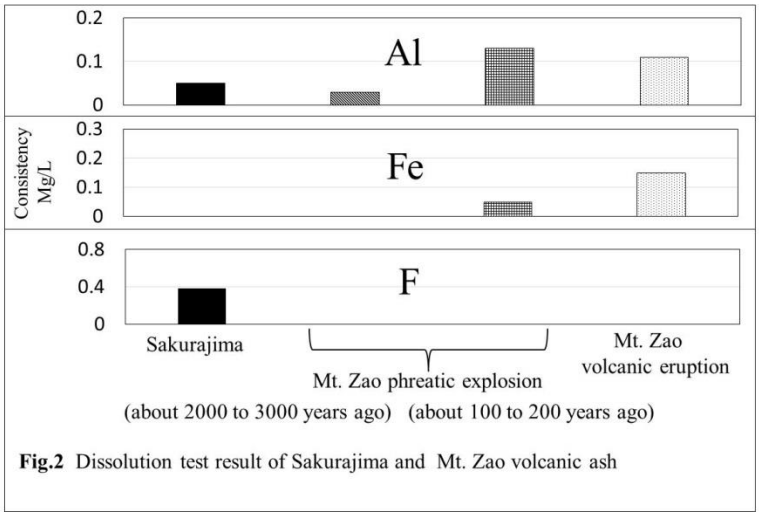

Fig.2 Dissolution test result of Sakurajima and Mt. Zao volcanic ash

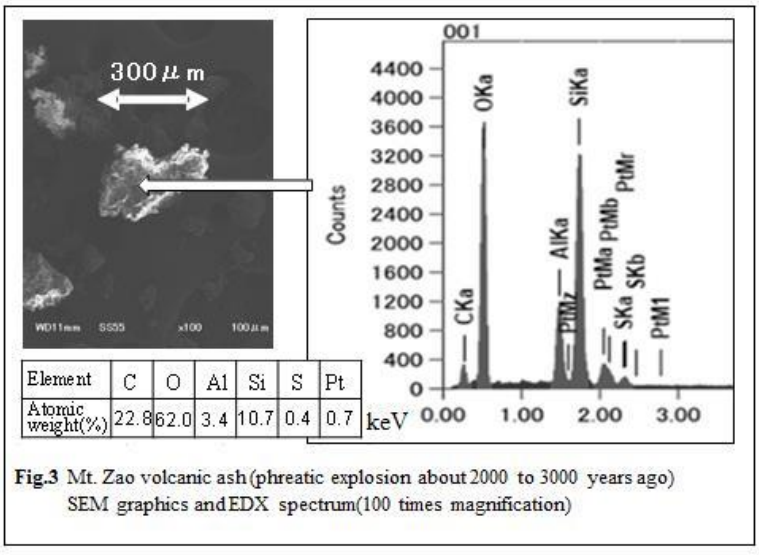

Fig.3 Mt. Zao volcanic ash (phreatic explosion about 2000 to 3000 years ago) SEM graphics and EDX spectrum (100 times magnification)

Table.1 Result of activated carbon odor removal test using 2% hot spring water(diluted with purified water)

Powdered activated carbon(mg/L)	0	5	10
Odor : TON	hydrogen sulfide odor : 15	hydrogen sulfide odor : 2	hydrogen sulfide odor : < 2
Odor : TON after filtration		odor - free	odor - free
Mixing condition : 60rpm,150minutes Filtration conditions : suction filtration by 0.45μm membrane filter			

Table.2 Result of removal test result of odor etc. using 2% hot spring water (diluted with purified water)

Examination items Other than odor (mg/L)	Moniwa raw water	2% hot spring water (diluted purified water)			2% hot spring water (before test)
Addition amount of activated carbon	5	0	5	10	0
Odor : TON	Odor - free	Algae odor : 5	odor - free	odor - free	hydrogen sulfide and algae odor : 15
Aluminum	0.03	0.03	0.02	0.02	0.059
Iron	<0.02	<0.02	<0.02	<0.02	0.018
Manganese	<0.001	0.074	0.074	0.073	0.087
Fluorine	<0.05	0.17	0.17	0.17	0.20
Powdered activated carbon treatment : addition of dry active carbon 5, 10 mg / L, 60rpm , 150 minutes pH adjustment : use of slaked lime, adjusted from pH4.7 to 7.5 (Moniwa raw water is not adjusted) Coagulation sedimentation treatment : PAC23mg/L, 120rpm, 3minutes→60rpm, 7minutes→keep for 10minutes Filtration treatment : 5A filter paper					