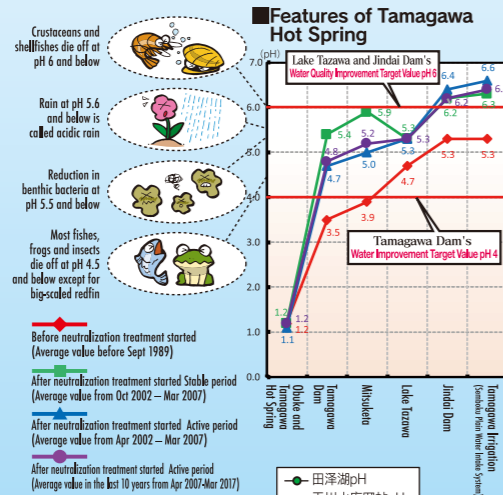


Effect of Neutralization Treatment

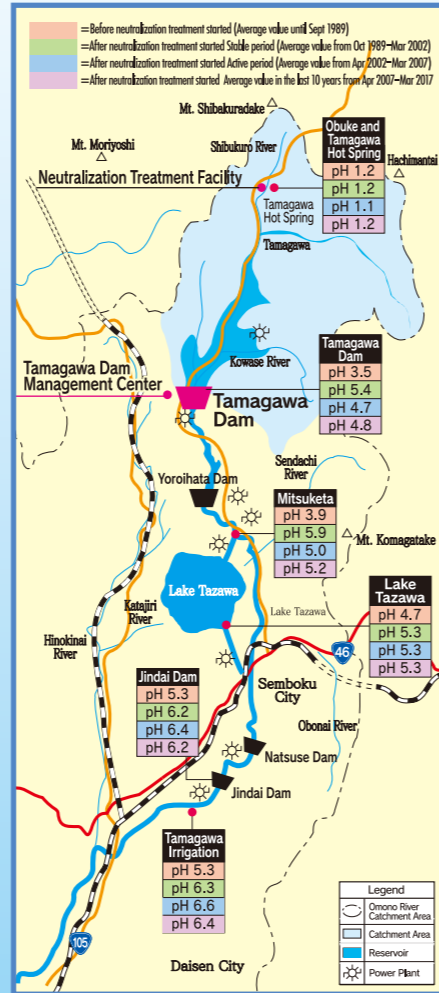
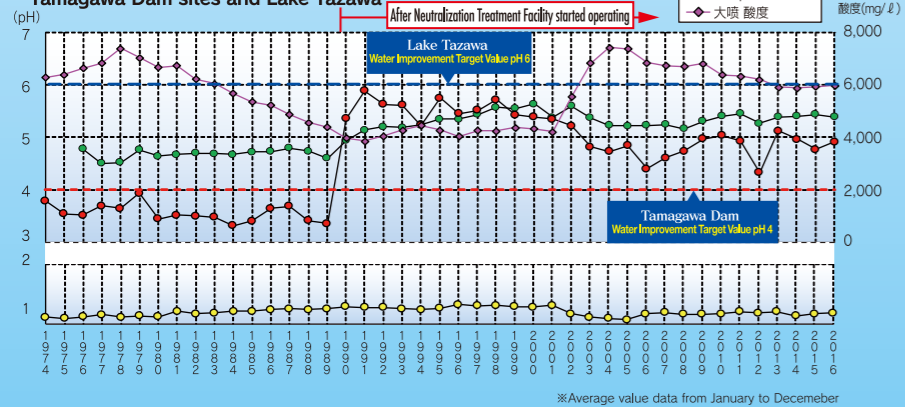
The water quality of Tamagawa was greatly improved after the Neutralization Treatment Facility started operating from October 1989. This event brought about the increase in the number of aquatic organisms living in the neutral river of Tamagawa Dam lake (Hosen Lake). These organisms became food for fishes and the number and types of fishes increased. As a result, even fishes such as Japanese fluvial sculpin can be found inhabiting at the clear downstream. Furthermore, acidity of soil decreased and rice production increased due to the improvement in water quality, elevating the quality of life of residents at the surrounding area.

Active Period of Tamagawa Hot Spring

Since 2002, Tamagawa Hot Spring became more active and efforts such as increasing the amount of limestone at the Neutralization Treatment Facility was made but the pH value dropped suddenly. However, it can be considered that Tamagawa maintained a high pH value when compared to the state before Neutralization Treatment Facility started operating. This value meets the standard of water quality improvement target value of Tamagawa Dam and Jindai Dam and also the agricultural water standard of Tamagawa's irrigation which is also the agricultural water intake site.



Transition of pH at Obuke, Tamagawa Dam sites and Lake Tazawa



The neutralization treatment had a big influence on the downstream area's ecosystem.

- Water quality for agricultural use was satisfactory and more rice was able to be harvested.
- The acidic level of soil at the downstream was reduced.
- Damages on structures near the river such as the dam and power plant reduced.
- Tamagawa and Lake Tazawa became suitable for fishes and plants to inhabit.

Tamagawa Acidic Water Countermeasure Tamagawa Neutralization Treatment



Tamagawa (river) gathers wetland water from places such as Yakeyama, Komagatake and Mount Nyuto of Ou Mountains, flows from southern Tazawako, passes through Obonai, joins Hinokinai River and finally joins with Omono River at northern Omagari. Shibukuro River's source which is located at the upstream flows acidic water downstream. Due to the presence of hydrochloric acid from Tamagawa Hot Spring, it caused farmers distress for a long time. It is said that the acidic water of Tamagawa caused a reduction of rice harvest by 20-30% and damaged 2,500ha of paddy fields located 80km downstream. The river water was unsuitable for farming, drinking and power generation. The improvement in water quality of Tamagawa became a long-standing wish for the residents along the river. In order to solve this problem, the Ministry of Land, Infrastructure, Transport and Tourism built the Acidic Water Neutralization Treatment Facility at Tamagawa Dam.



One of the Few Highly Acidic Hot Spring in Japan, "Tamagawa Hot Spring"

Features of Tamagawa Hot Spring

There are geysers of different sizes at Tamagawa Hot Spring and one of them is called "Obuke" which is a hot spring of 97°C in temperature and 5,000~15,000 litre of water is ejected every minute. Among the volcanic acidic springs, there are those with hydrochloric acid and those with sulfuric acid. It is believed that the difference between these 2 is the contact point between volcanic gas and groundwater. In other words, hydrochloric acid which is highly soluble in groundwater at deep underground will dissolve before reaching the surface while hydrochloric acid which comes in contact with groundwater near the surface will flow into the hot spring. Tamagawa Hot Spring belongs to the latter and is a rare hot spring that contains a lot of hydrochloric acid. This hot spring also has a large amount of aluminium and iron while freshwater normally only has about 0.3mg/l and 0.5mg/l of aluminium and iron respectively. It is said that Tamagawa Hot Spring has therapeutic benefits and many visitors from all over the country visit this hot spring to enjoy these benefits.



Tamagawa Hot Spring "Obuke"

Change in Water Quality of Tamagawa Hot Spring

Water quality of the volcanic acidic hot spring, Tamagawa Hot Spring changes according to volcanic activities. The factors are unknown but it can be observed that the acidity increased a few years after the eruption at the nearby mountain called Yakeyama. Volcanic activities calmed down between 1989 and 2001 but it became active after that and in 2004, the highest acidity value was recorded. In recent years, it is becoming more stable.

Tamagawa Hot Spring Water Quality (pH:mg/ℓ)

	pH	Acidity (8:AX)	Calcium ion (Ca ²⁺)	Chloride ion (Cl ⁻)	Sulfate ion (SO ₄ ²⁻)	Iron (T-Fe)	Aluminium (Al ³⁺)
Before Neutralization Treatment Facility started operating	Average value from 1974-1997	1.2	6,010	102	2,958	1,972	121
After Neutralization Treatment Facility started operating	Hot Spring Activity Average value of stable period from Oct 1989 to Mar 2002	1.2	4,331	98	2,576	983	67
	Hot Spring Activity Average value of active period from Apr 2002 to Mar 2007	1.1	6,811	175	4,025	1,558	180
	Hot Spring Activity Average value in the last 10 years from Apr 2007-Mar 2017	1.2	6,289	132	3,505	1,570	133

Acidic

- Sour
- Change blue litmus paper to red

Alkaline

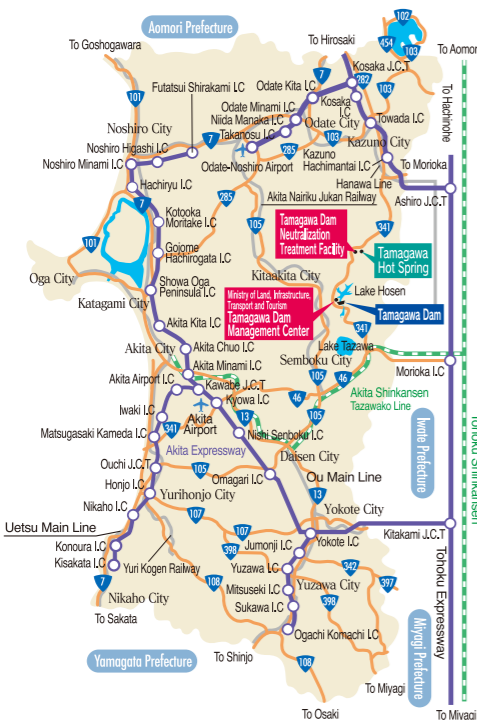
- Feel soapy and bitter
- Change red litmus paper to blue

What is acidity?

Acidity can be expressed as the concentration of calcium carbonate (CaCO₃) which reacts with strong acids such as hydrochloric acid and sulfuric acid in solvents where higher concentration means stronger acidity. The regular acidity of river is about 10mg/L. The acidity of Tamagawa Hot Spring in 2004 was 7,500mg/L which is the highest in Japan.

What is pH?

"pH is an index that indicates the acidic or alkaline property of solution whereby pH of pure water is 7 (neutral). As the value gets smaller, acidity increases while alkaline increases as the value gets larger. Tamagawa Hot Spring has a pH value of 1.2 which is highly acidic and is similar to the acidity of battery liquid and human gastric juice."



Tamagawa Dam Mascots

Ron Run

Tohoku Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism

Tamagawa Dam Management Center

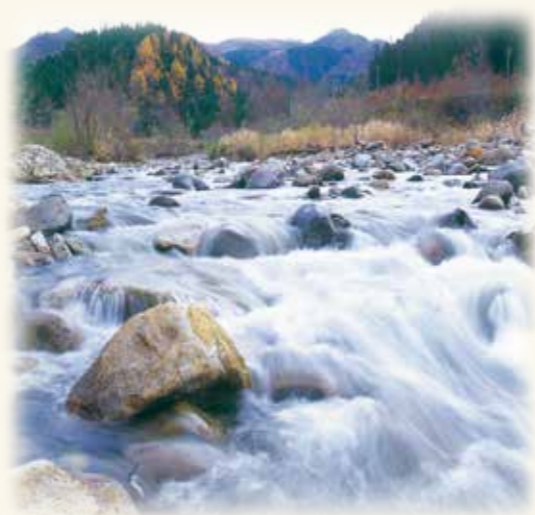
Shitamizunashi-92 Tazawako Tamagawa, Semboku-shi, Akita 014-1205
TEL:0187-49-2170 (Representative) FAX:0187-49-2166
URL: <http://www.thr.mlit.go.jp/tamagawa/>
E-mail: thr-tamagawa01@mlit.go.jp

History of Tamagawa Acidic Water Countermeasure

Many countermeasures have been tested to neutralize the acidic water at Tamagawa up to this day.

It started in Tenpo 12 (1841) when Taguchi Kouemon of Kakunodate built a wetland water inflow prevention system to tackle this problem. In 1939, the underground penetration method and another method of diluting water of Tamagawa and directing it to Lake Tazawa were implemented (Tamagawa's river water was directed to Lake Tazawa in 1940). These methods brought forth positive effects in the beginning but Kunimasu inhabiting the lake soon disappeared due to the high acidity.

Due to this, piled limestones were sprayed with acidic water at Akita Prefecture since 1972 and the simplified limestone neutralization method was implemented. However, it wasn't enough to solve this problem. The Ministry of Land, Infrastructure, Transport and Tourism then assisted by building a water treatment facility at Tamagawa Dam. The Tamagawa Acidic Water Neutralization Treatment Facility started operating in October 1989 and it greatly improved the local water quality which contributed to the area's development.

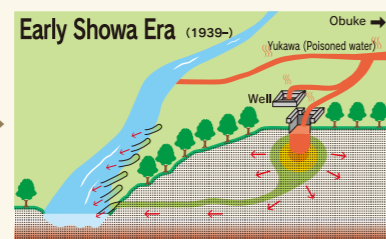


History of Neutralization Methods



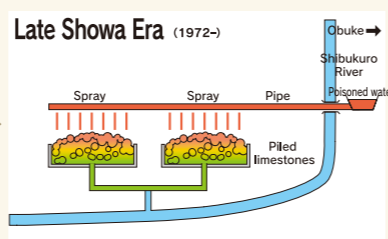
① Poison Removal

In the past, it was thought that rainwater seeped into the ground and was later released as acidic water (poisoned water) through geysers. Aqueducts were made to prevent rainwater from seeping into the ground.



② Underground Penetration Method

A method of digging well and infiltrating acidic water into the well so that it will chemically neutralize with clay and rocks in the underground. The detoxified water then became groundwater and released to Shibukuro River (which flows to Tamagawa River). It was later implemented at Lake Tazawa.



③ Simplified Limestone Neutralization Method

After conducting many surveys and experiments, it was found that limestone has the effect to dilute acidity when it comes in contact with acidic water. Therefore, the method of spraying acidic water on piled limestones at outdoor through pipes was implemented and the neutralized water was then released to Shibukuro River.

The Mystical Lake Tazawa

Lapis Lazuli Color

The acidic hot spring water contains a large amount of iron and aluminium that melt from rocks. As these substances flow along the river, acidity weakens and it becomes harder for them to melt. Between the two substances, iron precipitates faster and turns into reddish brown sediments at the riverbed of Tamagawa Dam's upstream. On the other hand, aluminium solidifies at a slower pace but due to its tiny size, it can hardly precipitate. The reason why the beautiful shiny lapis lazuli colored (purplish dark blue) lake surface came to be is because the particles only reflect blue light with short wavelength.



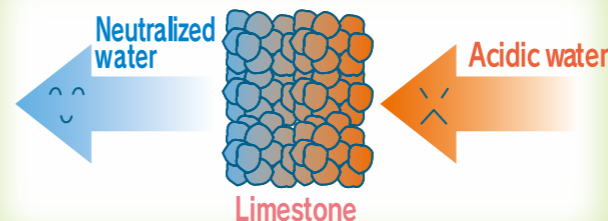
Granular Limestone Neutralization Method

The neutralization method carried out at the neutralization treatment facility is called "Granular Limestone Neutralization Method" and it works by adding acidic water of Tamagawa Hot Spring into a neutralization reactor filled with a large amount of granular limestones.

By utilizing this method, about 95% of Tamagawa Hot Spring's water that directly flowed to Shibukuro River (which connects to Tamagawa River) was neutralized and the goal is to increase the water pH value at Obuke from 1.1 to 3.5 and above before releasing the water to the river. The treated water mixes with wetland water while flowing downstream and it records a pH value of about 6.5 which is higher than the agricultural water standard pH value of 6.0 since 1991 at Tamagawa's agricultural water irrigation after the operation at Neutralization Treatment Facility went full-scale. At present, the daily amount of limestone used at this facility is about 40 tonnes.

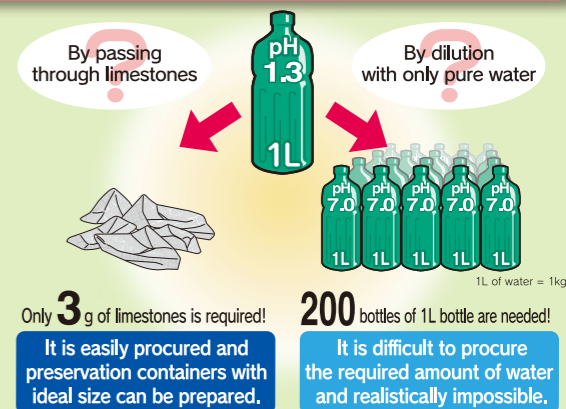
How Limestone Weakens Acidity

Limestone has the property to reduce acidity when it comes in contact with acidic water. Thus, it is used to perform catalytic reaction in the tank.



Method used to increase the pH of 1L of water from 1.3 to 3.5

(Acidity neutralized at the Neutralization Treatment Facility)



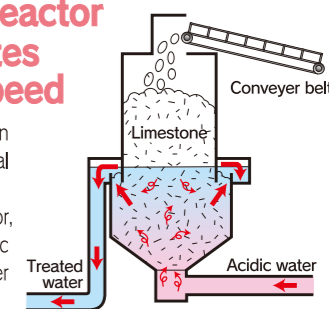
Neutralization Treatment Facility Specifications

Target	Water from Obuke
Rate of neutralization	95% (excluding about 5% consumption by hot spring inns)
Shape of reactor	Cone-shaped reactor
Limestone particle size	5~20 (mm)
Targeted maximum amount of lime consumption	55 (tonnes/day)
Concentration of diluted spring water (ideal concentration)	8.4A × 4,000 (mg/L)
Retention time	Approx. 5 minutes
Maximum diluted spring water (Hot spring water + wetland water)	0.31 (m ³ /s)
Maximum water intake (Hot spring water intake)	0.19 (m ³ /s)
Maximum diluted water (Wetland water intake)	0.12 (m ³ /s)
Number of reactors	6 (5 can be operated simultaneously at most, 1 for reserve)
Amount of treated water per reactor	3.72m ³ /min./reactor

Source: Tamagawa Acidic Water Neutralization Treatment Facility Construction Magazine, Tamagawa Dam Construction Office, Construction Ministry of Tohoku Regional Construction Bureau March 1991

Cone-shaped Reactor that Escalates Treatment Speed

In the cone-shaped neutralization reactor, the top part is cylindrical and the bottom part is conical. By using this type of reactor, stirring effect and catalytic reaction increase due to faster flow rate.



Flow of Neutralization Treatment

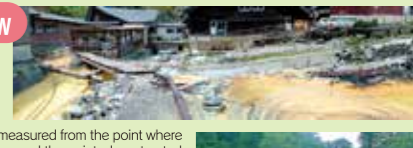
① Limestone Silo

Limestones can be supplied from the limestone silo at any time by using conveyor belt because limestones melt when they react with acidic water.



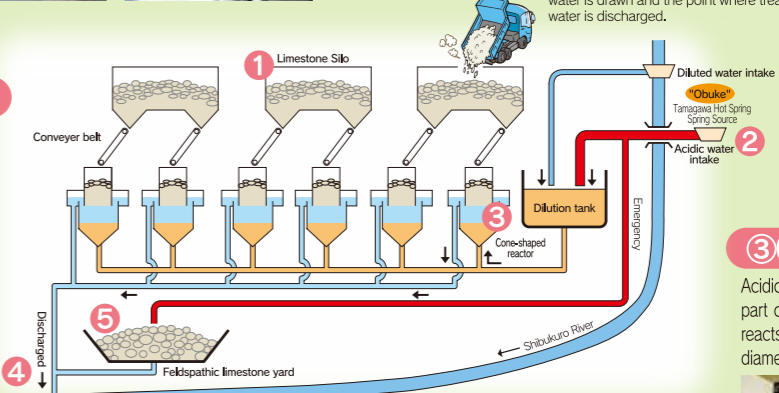
② Directing Water Flow

Water flow is directed from the surface of Obuke to Neutralization Treatment Facility.



⑤ Feldspathic Limestone Yard

Acidic water is directly flowed into feldspathic limestone yard during emergency and treated water is released into the river.



③ Cone-shaped Reactor

Acidic water is added from the lower part of the neutralization reactor and it reacts with limestones (of 5-20mm in diameter) in the cone-shaped reactor.



④ Water Discharged to Shibukuro River

Treated water with pH 3.5 and above is discharged to Shibukuro River (which joins Tamagawa River).



Timeline of Neutralization Treatment Facility

- 1968 Yuzawa Construction Office was established and investigations on acidic water were initiated
- 1969 Tamagawa Water Detoxification Committee was established
- 1972 Simplified limestone neutralization method developed by Akita Prefecture was implemented
- April 1973 Tamagawa Dam Survey Office was created
- Tamagawa Water Pollution Control Measures Agencies Liaison Conference (5-Agency Conference) was launched
- April 1975 Name changed to Tamagawa Dam Construction Office
- Investigations were conducted by Tamagawa Dam Construction Office
- October 1975 Tamagawa Water Detoxification Technology Examination Committee was established
- January 1978 Investigation report was issued by Tamagawa Water Detoxification Technology Examination Committee
- 1987 Tamagawa acidic water neutralization treatment on-site experiment was conducted
- March 1988 Construction of Tamagawa Acidic Water Neutralization Treatment Facility commenced
- October 1989 Test operation at Tamagawa Acidic Water Neutralization Treatment Facility commenced
- April 1991 Full-scale operation commenced