Hydrogen-sulfide-oxidizing microbes and the concentration of hydrogen sulfide in hot water flowing outdoors in Nakabusa hot springs

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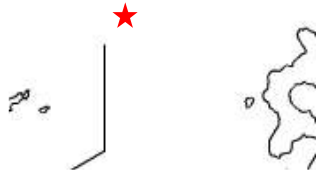
Background and purpose

- In the outdoor running hot water of Nakabusa (sulfur spring, hydrogen sulfide type, pH 8.6), microorganisms that oxidize hydrogen sulfide grow in aggregates.

- No studies have done how the hydrogen sulfide concentration in water changes due to the action of such microbes.

- The hydrogen sulfide concentration is measured before and after removing the microbes in the water to clarify the role of them in the change in the hydrogen sulfide concentration.

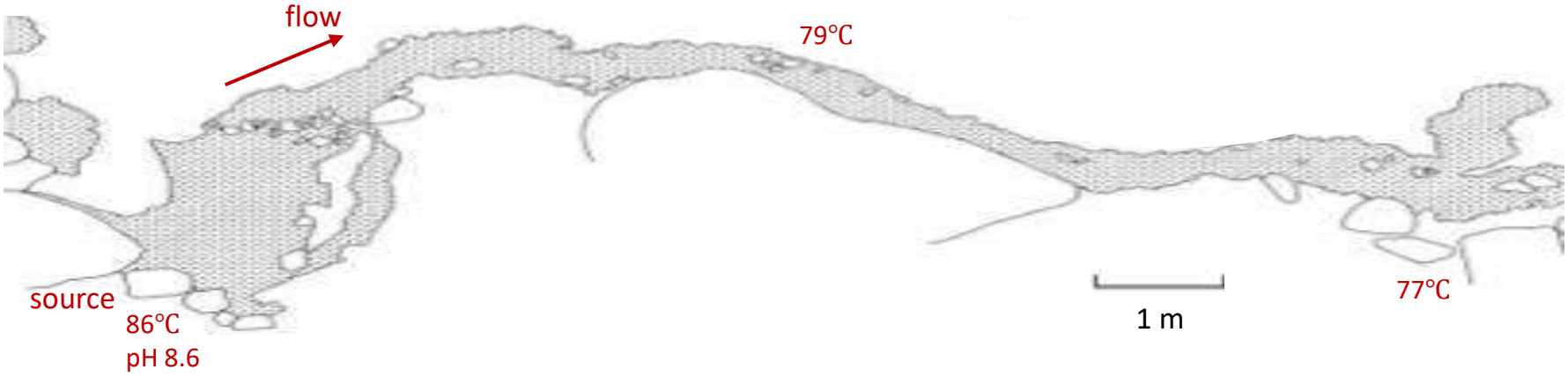
Nakabusa Hot Springs in Nagano: Sulfur spring: hydrogen sulfide type, alkaline



More than 30 springs
Temperature　60℃～95℃
Outflow 1500 L/min

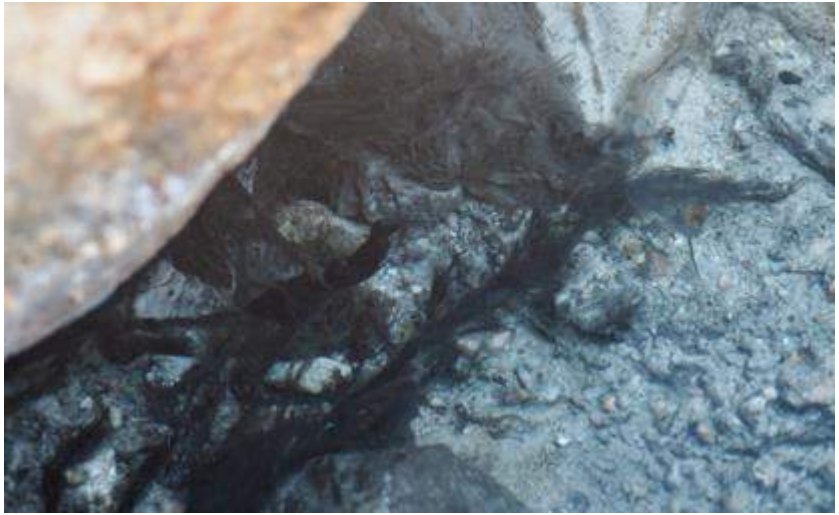
pH 8.0～9.5
Sulfide　200～400 μmol/L
Sulfate　150～300 μmol/L
Carbonate　1.5～2.5 mmol/L

Reserach site: Kassen spring: 86°C, flow on the sand base



Streamers of microbes grown in hot spring running water

Streamer: An elongated mass of microbes, one end of which is attached to a stone and sways in a stream



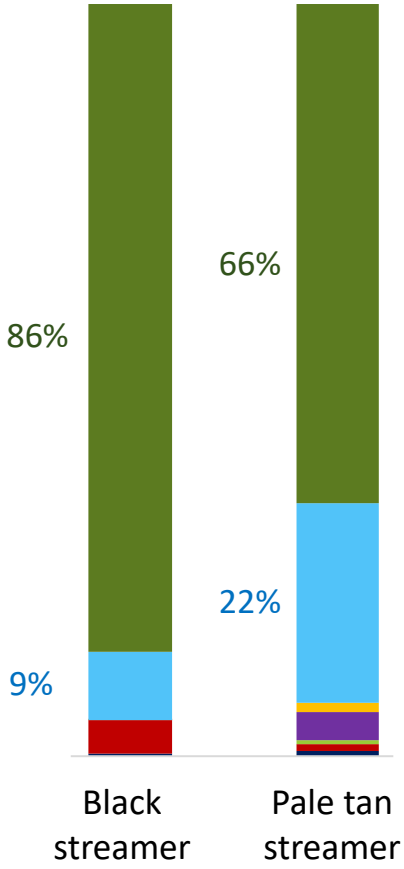
4 cm

Black streamer: 86 ℃: Near the spring source

8 cm

Pale tan streamer: 79 ℃: 5 m from the source

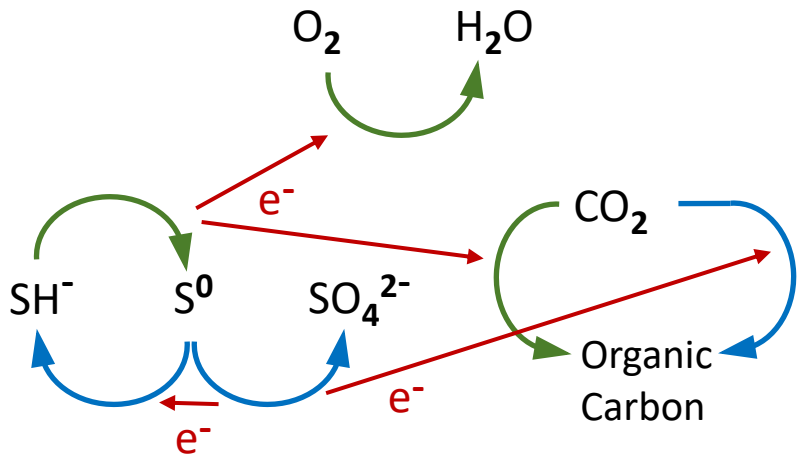
Two chemosynthetic bacteria metabolizing sulfur in the streamers



Thermocrinis

Hydrogen sulfide oxidizing bacteria

Oxidizes hydrogen sulfide into elemental sulfur and reduces oxygen and carbon dioxide *



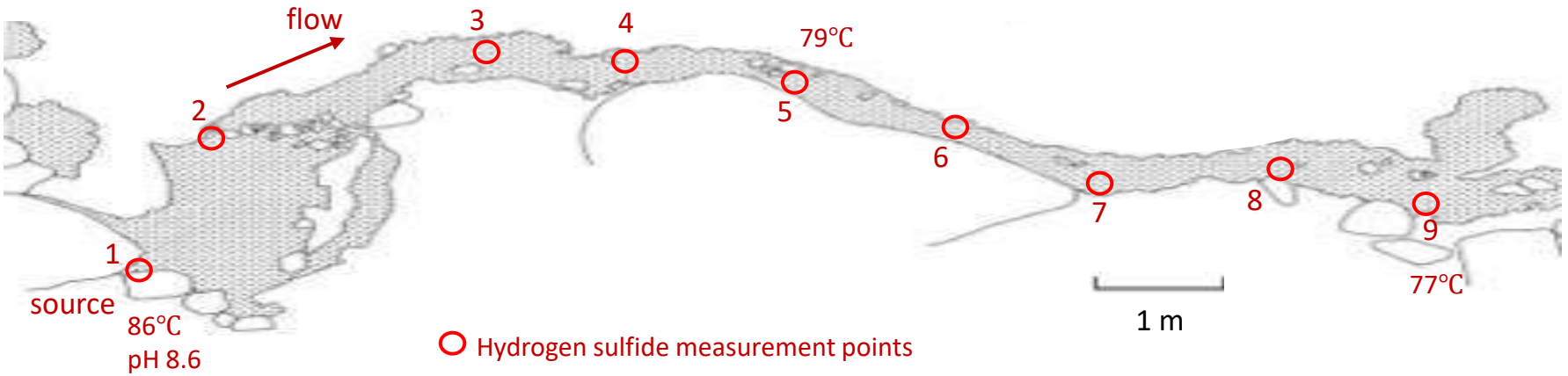
Caldimicrobium

Elemental sulfur disproportionating bacteria

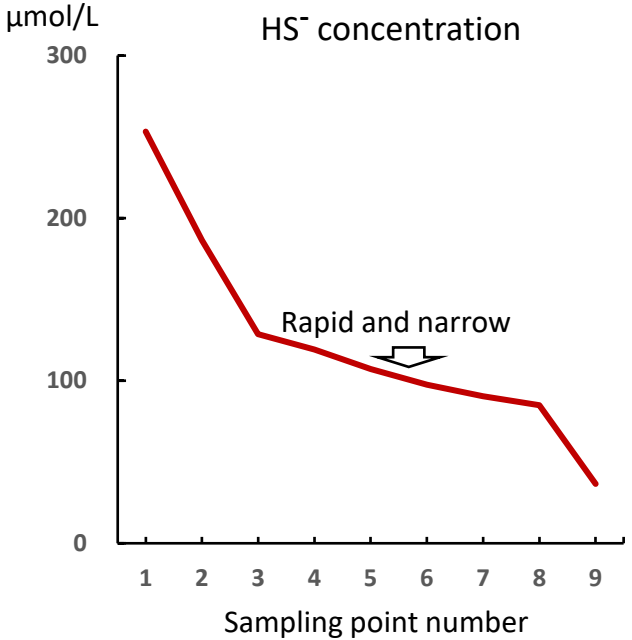
Disproportionates elemental sulfur to sulfate and hydrogen sulfide and reduces carbon dioxide *

* Both are supported by circumstantial evidence

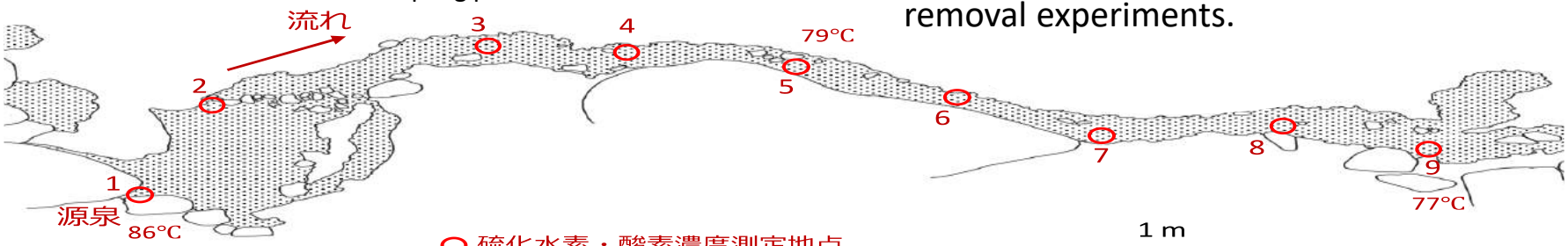
Measurement points: Kassen spring: 86°C, flow on sand base



Changes in hydrogen sulfide concentration along the flow of hot spring water



- The hydrogen sulfide concentration decreased significantly from 250 μmol/L to 40 μmol/L in a flow of 9 m.
- The average decrease rate in concentration per length was approximately 20 μmol/L/m.
- Where the flow was narrow and fast, the decease rate in concentration was slow.
- The influence of growing microbes was postulated, and we conducted a microbe removal experiments.



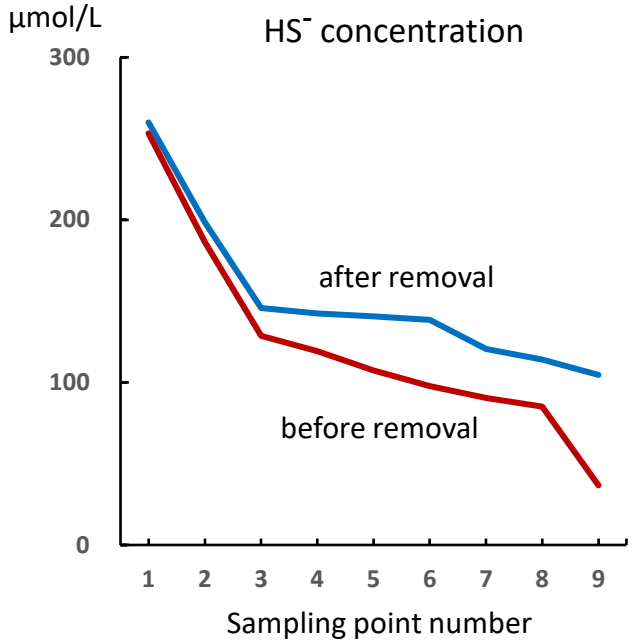
Appearance of microbial streamers before and after removal

Before removal

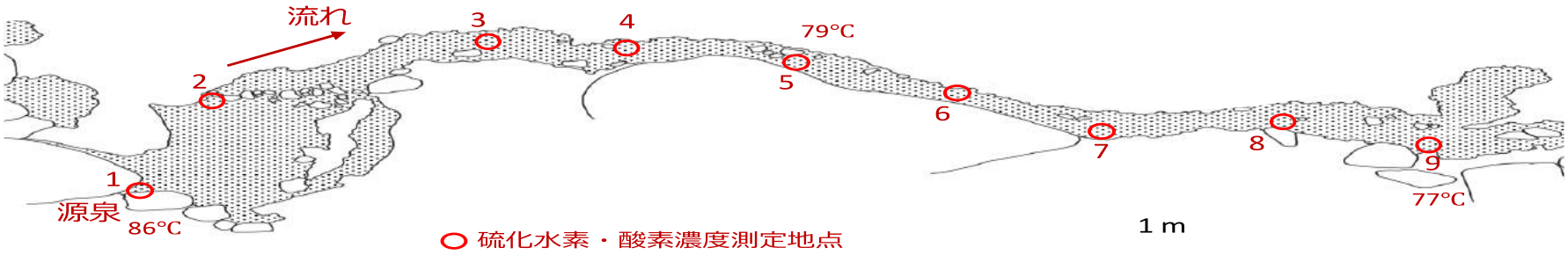
After removal

- The microbial streamer is weakly attached to stones at one end and sways in a fast flow, and it can be easily detached off with tweezers and flows away.
- Visually, about 98% or more of the microbial streamers was removed.

Effect of removing microbial streamers on the decrease of hydrogen sulfide concentration



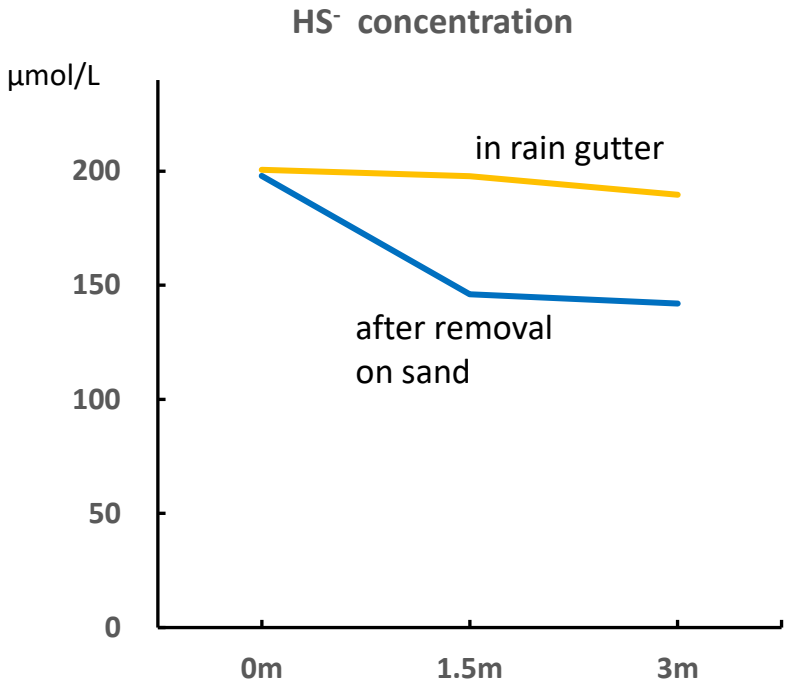
- Removal of most microbial streamers reduced the rate of decrease in hydrogen sulfide concentration by 30% from 20 μmol/L/m to 14 μmol/L/m.
- Even after the removal of streamers, a large decrease in hydrogen sulfide concentration was observed, suggesting the possible influence of microbes on the surface of sands and stones at the bottom.
- The concentration was measured next without the influence of microbes on the surface of the sands or stones, by using a 3.6 m rain gutter.



A rain gutter of 3.6 m was laid to run hot spring water

- The depth of the intake and the overall inclination of the gutter were adjusted so that the flow velocity to be 500 mm/s and the water depth to be 10 mm.
- The flow velocity was similar to the average velocity of the natural flow, and the water depth was similar to the depth of the water flowing over the streamer when it developed well.

Changes in hydrogen sulfide concentration flowing in a rain gutter

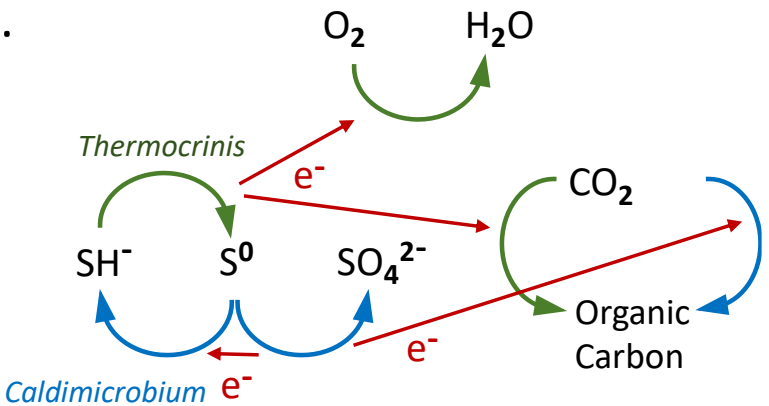


- The change in hydrogen sulfide concentration in the rain gutter was small, and 1/6 in the flow on the sand from which the microbial streamer was removed.
- The large decrease in hydrogen sulfide concentration on the sand when the microbial streamers were removed was considered due to the microbes on the surface of the sands and stones.

Summary

1. The concentration of hydrogen sulfide in the outdoor running water of 77℃ or higher at Nakabusa hot springs (sulfur spring, hydrogen sulfide type, PH 8.6) decreased significantly from 250 µmol/L to 40 µmol/L in a stream of 9 m due to the microbes that oxidize the hydrogen sulfide.

2. The microbes that decrease the concentration of hydrogen sulfide are considered to be both microbes that exist as aggregates (microbial streamers) in running water and that exist on the surface of sands and stones at the bottom.



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