Background
Microbiological Communities in MHS

Microbiological communities are an integral part of the MHS system. They contribute to growth and change within the system (abiotic processes) and respond to the system by altering their own growth and change (biotic processes). These communities also contain an enormous amount of diversity within them. These are described further with examples below.

Influences of Abiotic (Non-living) Processes
The microorganisms that live in MHS directly influence the rate of travertine (calcium carbonate in the form of aragonite and calcite crystals) precipitation (accumulation) and the shape of the minerals formed.

Example 1
In the places where microorganisms influence the precipitation of calcium carbonate the most (where terraces grow the fastest), these microorganisms, also called microbes, also influence the overall spring flow system at MHS. In other words, the rapid growth of travertine can alter the flow path of the water and result in wildly changing flow paths in the system in as short a time as a year. (See Figure 1)

Figure 1 – Canary Hot Spring – images taken 10 days apart showing a dramatic shift in flow.
Example 2

The specific microorganisms present can permanently influence the shape of the calcium carbonate mineral deposits in the spring. A good example of this can be found in both modern and ancient/fossilized travertine. Streamer bacterial populations (associated with the species Aquificales) are found in locations within the hot springs with temperatures between 60º and 70º C. These bacteria form filaments several centimeters long and are composed of thousands of individual cells. The filaments are visible to the naked eye and grow in the direction of water flow within the Apron Channel facies. (See Figure 2A)
In other springs, they can be seen as separate filaments, as seen in Figure 2B.

While walking around the upper terraces at MHS, it is easy to find old hot spring features that preserve the filamentous shape in calcium carbonate rocks. (See Figure 3) It is even possible to speculate which bacterial community was present when the rock formed even when there is no longer any water present.

Figure 3: Aquificales aiding in the formation of the distinctive Apron Channel Facies in new travertine at Narrow Gauge in May 2006 (left) and evident in old travertine (right) along the Upper Terrace Road (January, 2006). (Houseal Photos)
**Influences of Biotic (Living) Processes**

**Example 1**

The hot spring water at MHS provides food to the microbial populations in the communities adapted to the highest temperatures (>70°C). One source of food for microorganisms is hydrogen sulfide (H₂S) or "rotten egg" gas. Humans can detect this gas at very small concentrations and children tend to be more sensitive to the smell than adults. While this diet may seem unusual to us, it is a viable option for these microbes. The microbes that consume it convert it to yellow sulfur or to sulfate salt and in the process get energy to grow, just as animals do when they eat carbon-based foods.

**Example 2**

Recall that the water comes out of the vent supersaturated with carbon dioxide (CO₂) and at a temperature of around 70°C. As the spring water flows down the facies, the temperature of the water decreases due to exposure to cooler ambient air temperatures and much of the CO₂ leaves the water creating an increase in the pH. This creates new habitats, varying in size from the cm (10⁻³) to m (10⁰) scale. Different microorganisms reveal different colors within the hot spring system. This can be a very dynamic occurrence at MHS, changing rapidly. For example, one part of the spring might be green one day and orange or brown the next (See Figure 4). This may be because the temperature differs slightly or the pH has changed. These changes allow different types of microbial communities to flourish in the system.

Figure 4: Note the differences in colors in the microbial communities in these photos taken a day apart. The black arrows are pointing at the vent, which is much more active on the 30th than the 29th. (Photopoint photos)
Photosynthesis is also an important process in the spring system. It is believed that some of the color changes are due to the photosynthetic processes. Late in the day, turquoise pools change to a salmon color when the sun moves below the horizon and is no longer hitting the pools directly (See Figure 5).

Figure 5. Ponds at Narrow Gauge. These photos were taken of the same section of the spring a day apart – the one on the left was taken when the sun was overhead, and the one on the right after the sun had gone behind the hill west of the spring. (Houseal photos)

**Diversity**

Microbial systems within MHS contain greater diversity within their communities than the larger ecological communities in Yellowstone National Park (YNP) (e.g. riparian areas, lake ecosystems, etc.) and also than larger communities in the world (e.g. rainforests and prairies).

How is this possible?

**Example 1**

One way to consider the extent of microbial diversity in the MHS system is to try to imagine how many habitats are available. In these springs, habitats are small in size. It would be useful here to use the Powers of Ten tool to explain what size they are. As mentioned previously, the habitats range in size from the cm ($10^{-3}$) to m ($10^{0}$) scale.

First, consider that a microbial community in any single habitat consists of all the different types or species of bacteria or archaea present there. It is known from genetic studies of some of these habitats that there could be roughly from 5 to 10 species present within a single habitat (as defined in this case, primarily by differences in pH, temperature, available Oxygen (O2), and light). These populations depend on each other or adjacent habitats for essential resources such as food or vitamins. Some of the research done on Angel Terrace in MHS demonstrated that completely different communities of organisms lived adjacent to each other, separated by seemingly small differences in pH and temperature (Fouke et al., 2000).
Example 2

A conceptual mathematical expression can be used as another way to think about this diversity: Imagine if a habitat could be defined based on the temperature, pH, and food differences in the MHS system. If we suppose that temperature and pH could be divided into 10 different optimal ranges that supported different communities, then theoretically based on these two factors alone, 100 different habitats could be supported. Then, consider 20 different food sources, including light (for photosynthesis); the number of habitats could be extended to 2000 (20 x 100). If at least ten populations (species) live in every habitat, there could be up to 20,000 different microorganisms in the entire system. These factors provide a powerful argument for great diversity in the spring system.

If this same approach is used to look at a riparian area or lake ecosystem, it is easy to see that diversity in these areas in YNP would not be as great.

General Web Links:

1. Microbiology in Yellowstone National Park by Dave Ward
   http://lasp.colorado.edu/education/journalists/yellow_stone/Articles/life%20in%20extreme%20environments%20readings/Microbiology%20in%20Yellowstone%20National%20Park.pdf

2. American Society for Microbiology K-12 Resource Page

3. American Society for Microbiology K-12 Resource Page
   http://www.asm.org/images/Education/k-12%20website%20review%2010.pdf

Links to the Windows Into Wonderland websites: http://www.windowsintowonderland.org/

References:


Yellowstone Park Map figure courtesy of B.W. Fouke.