

Association between physical and geochemical characteristics of thermal springs and algal diversity in Limpopo Province, South Africa

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Abstract

Algal species commonly occur in thermophilic environments and appear to have very wide geographical distributions. Presence of algal species is strongly influenced by temperature, pH and mineral content of thermal waters. No research has previously been documented on the algal diversity in South African thermal springs. This paper describes the algal distribution in 6 thermal springs in Limpopo Province, South Africa, and attempts to link this to the physical and geochemical properties of the springs. Water samples were collected from Mphephu, Siloam, Tshipise, Sagole, Eiland and Soutini thermal springs and algae identified. Temperature, pH and TDS were measured on site and water samples analysed for macro- and trace-elements. Cyanophyta was the algal group most often present, followed by Bacillariophyta, Chlorophyta, Euglenophyta and Dinophyta. Some of the algae were present in waters with pH ranging from 7.1–9.7 and temperatures ranging from 40–67°C. Others (the cyanobacteria and green algae: Nodularia, Schizothrix, Anacystis, Coelastrum, Chlorella and Spirogyra) only occurred in high temperature (60+°C) and pH>9 waters, while a number of diatoms (Synedra, Aulacoseira, Nitzschia, Cyclotella, Gyrosigma, Craticula) occurred exclusively at temperatures <45°C and pH values <8. Algae were also present in waters with fluoride values exceeding that which is considered safe for human consumption as well as in waters relatively rich in uranium, rubidium, vanadium and manganese. It was clear that the occurrence of algae coincided with specific geological formations. These algae could act as indicator species of geology and heavy metals.

Keywords: thermal springs, Limpopo Province, algae, diversity, geochemical

Introduction

Algae are common in water and soil habitats, at different geographic latitudes, and on all continents. They occur in waters with different degrees of salinity, trophicity, organic matter, and hydrogen ions, and at various temperatures. Thermal spring algae communities have long attracted the attention of microbial ecologists because of their unique adaptations to harsh environments (Sompong et al., 2005). Although algae seem to be widespread in thermal waters, some thermophilic organisms have distinctive geographic distribution patterns, with their distribution being limited by their ecological adaptation, resistance and tolerance to extreme environments.

Thermophilic algae include members of the Cyanophyta (blue-green bacteria; cyanobacteria), Chlorophyta (green algae), Bacillariophyta (diatoms), Euglenophyta and Dinophyta. The occurrence of cyanobacteria is especially widespread in thermal environments; with members of the phylum inhabiting thermal springs all over the world (Winterbourn, 1969; Pelczar et al., 1988; Seckbach, 2007). Many species of cyanobacteria have been isolated from thermal springs in the Yellowstone National Park, from the sulphur hot springs in the Himalayas and from springs in Jordan. The most abundant cyanobacteria genera identified in these thermal springs were Phormidium, Schizothrix, Calothrix, Tolypothrix, Microcystis, Chroococcus, Oscillatoria, Scytonema, Synechococcus,

Fischerella and Lyngbya (Prasad and Srivastava, 1965; Mann and Schlichting, 1967; Stockner, 1967; Oren et al., 2009). These cyanobacteria appear to be favoured by high temperatures, low light, low nutrient (particularly nitrogen) availability and high predation pressure. Research on diatoms has revealed that Rhopalodia, Denticula, Mastogloia, Navicula, Nitzschia, Pinnularia, Caloneis and Achnanthes are some of the genera found in thermal waters (Stockner, 1967).

The diversity of algae in thermal springs is influenced by the mineral composition and water temperature of the spring (Castenholz, 1969; Sember, 2002; Sompong et al., 2005). Generally, diversity of algal species increases from 0°C to 25°C and decreases at temperatures >30°C, while biomass increases with temperature from approximately 0 to 30°C and decreases from 30 to 40°C (Dallas, 2008). According to Atlas and Bartha (1987), algae are restricted to growth below 55°C, while Winterbourn (1969) reported an upper temperature limit for algal growth of 68°C. Because of the shallowness and clarity of most thermal waters and the exposure of many hot springs to high light intensities, various types of 'sun adaptations' may have occurred in many thermophilic organisms (Castenholz, 1969).

Many algae appear to have adapted to high salinity and/or high concentrations of specific ions. Most alkaline hot springs contain between 1 000 and 2 000 mg of total dissolved solids (TDS) per litre; some have salinities higher than that of seawater (Castenholz, 1969). Generally, cyanobacteria prefer alkaline environments and exhibit a wide range of tolerance to salinity (Castenholz, 1969; Sember, 2002; Van Ginkel, 2004). Several cyanobacteria species have been isolated from thermal springs in Greece with sodium chloride concentrations of more than

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