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Mini Review

Thermo-Mineral Springs, Old and Unique Aquatic Ecosystems to Survey and Preserve

Aude Beauger[1,2]*, Lory-Anne Baker[2,3], Carlos E Wetzel[4], Luc Ector[4] and David Biron[2,3]

[1]GEOLAB, Clermont Auvergne University, France

[2]LTSER "Zone Atelier Uraniferous Territories", France

[3]Laboratory "Microorganisms: Genome and Environment" (LMGE), University Clermont-Auvergne, France

[4]Luxembourg Institute of Science and Technology (LIST), Environmental Research and Innovation, Luxembourg

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***Corresponding author:** Aude Beauger, GEOLAB, Clermont Auvergne University, CNRS, France

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Abstract

Thermo-mineral springs are particular ecosystems that are present all over the world. However, they are largely disregarded by monitoring programs. They present a wide variety of physical and chemical properties of waters leading to a wide spectrum of interesting habitats available for the development of diatoms, such as new species recently described, that could be considered as endemic for some of them. During a survey performed in the French Massif Central, diatoms were sampled in different springs. Some of these emergences are natural, while others are Man-made springs. Significant differences are observed between species richness of these two types of springs. The natural springs tend to present higher richness than Man-made ones. This highlight the importance of restoring thermo-mineral springs and to suppress constructions done around the emergence when use is not on-going anymore. This would allows the reestablishment of these aquatic habits, favouring the development of unique diatom species.

Keywords: Thermo-mineral springs; Diatoms; Species richness; Restoration; Protection

Introduction

Thermo-Mineral Springs (TMS) are particular ecosystems that are present all over the world. However, springs are largely disregarded by monitoring programs. For instance, they are not explicitly considered by the environmental policy and legislation of the European community (Water Framework Directive, 2000/60/CE) [1] promulgated to prevent further deterioration, and to protect and enhance the status of aquatic ecosystems [2,3]. In this European directive, freshwater environments such as rivers and lakes are mainly considered. Concerning Habitats-Fauna-Flora directive (92/43/CEE) [4] there is only a reference to mineral springs about the development of acid sphagnum peatlands and to Cratoneurion related to limestone marshes. Thus, TMS are not taken into account by European commission and the European environment agency to achieve ''good ecological status'' in these particular aquatic ecosystems, and then to protect and restore these ones. In fact, only the IUCN Red List of Ecosystems Categories and Criteria could be used to assess the ecological status of TMS [5].

TMS are studied by diatomists all over the world and particularly in Europe [6-12]. These studies highlighted a wide variety of physical and chemical properties of waters leading to a wide spectrum of habitats available for the development of diatoms. Moreover, during the different survey done on TMS, new taxa are regularly described [8-10,13-19]. The presence of these undescribed and listed species that could be considered as endemic for some of them, highlights the importance of protecting these extreme and particular habitats of the biosphere. Indeed, springs can be considered as isolated aquatic ecosystems whose conditions have changed very little over the past millenia, thus providing in some cases reference conditions and an exceptional window into the history of life on earth [20]. Moreover, as the observations done in Poland, the TMS offer a reservoir of threatened species [8]. Currently, linked to insufficient protection of diatoms by regional, national, European and global legislation, the destruction of their natural habitats is the main result. This is the case for many springs of the French Massif Central (FMC) located at the southern part of France.

The FMC is the largest massif of France (>85,000km^2). Due to its surface area, this region, the Auvergne, includes one-third of the French TMS. In 1864, Lecoq [21] recorded more than 450 mineral springs, such as the most radioactive of France [22]. In the FMC, few of the springs have kept their original form (i.e., natural spring) because they have been used by man for a long time. Indeed, some of TMS were used since the Gallo-Roman period for therapeutic purposes. Moreover, bottled water industry uses many springs: for example, the mineral water St. Yorre near Vichy but also some ones are collected for artisanal activities (creation of petrified objects).

An on-going investigation made on springs of the FMC (not used for any type of activities) reveals that these habitats shelter hot-spots for biodiversity [10,17,18,23]. Species such as Navicula sanctamargaritae Beauger [10] are widely abundant in high conductivity (ranging between 2,000 and 10,000µS.cm^{-1}) (Beauger, personal communication) while Sellaphora labernardierei Ector prefers the presence of nitrates (around 10mg L^{-1}) [17]. All these characteristics and observations could be useful tools for monitoring and evaluation of the ecological status of springs as diatoms are classically used for bio-assessment. This inventory also underlined that 10% of the springs have disappeared since 1864, either destroyed due to human activity or to their abandonment. Moreover, the layout of springs induces an artificialization and anthropization of the habitat, i.e., the conversion of natural environments by human action. All the human activities lead to the degradation of the biodiversity of TMS [24] or could induced a disappearance of species. Nevertheless, biodiversity is the keystone of the functioning of these ecosystems from which derive ecosystemic services useful for human societies.

The project DISCOVER started in 2019 focused on the study of diatoms communities inhabiting 22 mineral springs of the FMC: 1) 12 TMS emerged in a naturally context; 2) for 10 others, springs are characterised as Man-made springs or springs with medium-to-high anthropogenic activities (Figure 1, Annex 1). The mean of diatom species number in natural springs was 15±3 in autumn 2019 and 16±7 in spring 2020. Man-made springs showed generally lower richness with a mean of 7±5 for autumn 2019 and spring 2020. A Kruskal-Wallis tests reveals significant difference between species richness of natural and Man-made springs (p=0.003 in 2019 and p=0.001 in 2020) (Figure 2) and no difference when considering the Shannon index.

Figure 1: Man-made spring a. (named “Salins”) vs natural spring b. (named “Salut”).

Annex 1: Data on thermo-mineral springs configuration and the number of taxa observed in Autumn 2019 and Spring 2020: MM= Man-made springs; N= Natural springs.

		Number of Taxa Observed		Diversity (Shannon Index)	
Name of the spring	Spring configuration	Autumn 2019	Spring 2020	Autumn 2019	Spring 2020
Tennis	MM	2	3	0.18	0.85
Salins	MM	3	3	0.18	0.35
Giraudon	MM	3	4	0.69	0.91
Bard 1	MM	3	4	0.71	0.57
Ours	MM	3	2	0.71	0.54
Estreys	MM	6	8	1.57	1.44
Graviers	MM	8	5	1.30	0.98

Saulcée	MM	14	5	1.38	0.12
Montagne 1	MM	14	20	1.63	1.67
Croizat	MM	4	2	0.27	0.63
Daguillon	N	6	6	0.49	0.58
Rocs bleus	N	7	10	0.93	0.88
Trois sauts	N	9	13	1.27	1.17
Saladis	N	10	12	1.14	1.56
Poix	N	11	25	0.75	2.51
Chemin	N	13	16	1.25	1.77
Tête de lion	N	16	6	0.99	0.27
Bard 2	N	17	26	1.75	1.99
Sail	N	21	22	2.34	2.00
Salut	N	23	30	1.77	2.57
Combris	N	25	9	2.48	0.35
Ceix	N	19	17	0.99	0.71

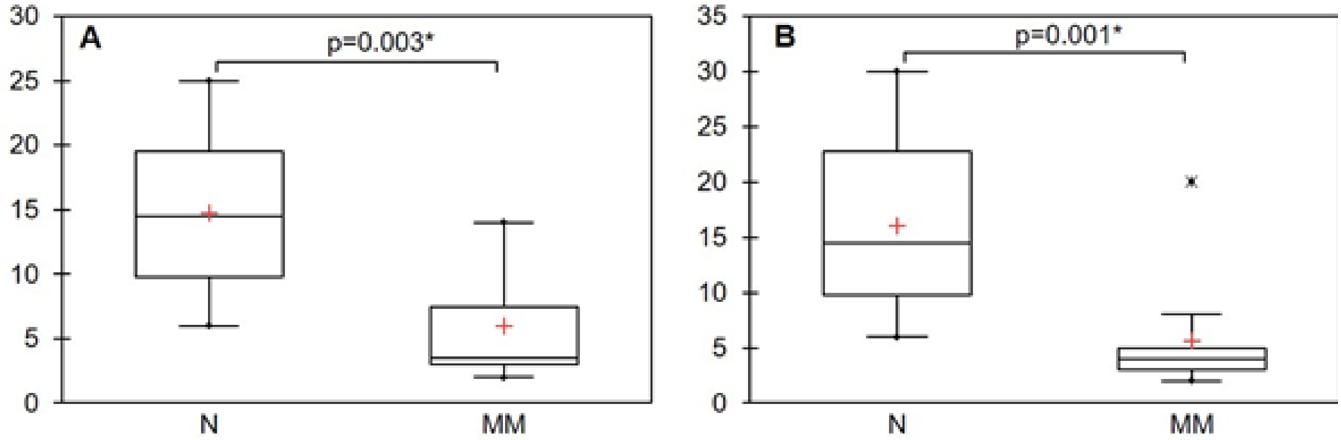

Figure 2: Kruskal-Wallis tests on richness of different mineral springs sampled in
A. Autumn 2019 and
B. Spring 2020. N: Natural springs (n=12); MM: Man-made springs or springs with medium-to-high anthropogenic activities (n=10). *: significant p-value with α level = 0.05.

This study underlines the importance of restoring the thermo-mineral springs and to suppress the construction made around the emergence when use is stopped. This would permit the prompt reestablishment of these aquatic habits and favour the establishment of unique diatom species. Not only is diatom biodiversity increasing, but the reappearance and development of plants typical of such habitats such as Triglochin maritima also happens. This improvement enhances consequently the ecological status of the thermo-mineral springs and the ecosystemic services offer by this aquatic habitat.

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