ARTICLE IN PRESS

MICROC-01675; No of Pages 5

Microchemical Journal xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Microchemical Journal

journal homepage: www.elsevier.com/locate/microc

Hydrogen sulfide in thermal spring waters and its action on bacteria of human origin

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ARTICLE INFO

Article history:
Received 19 October 2012
Accepted 29 October 2012
Available online xxxx

Keywords:
Hydrogen sulfide
Thermal spring water
Pools
Bacteria
Disinfection
Hygiene

ABSTRACT

Hydrogen sulfide (H_2S) is a molecule dissolved in many thermal spring waters at variable concentration. The H_2S effects of thermal waters treatments have long been studied, for dermatological and clinical treatments, but its role in recreational waters was never investigated. The use of sulfur spring waters in pools raises concerns related to disinfection by oxidants. The aim of this work is to evaluate the survival rate of microbial species in waters with different titers of H_2S. Four selected thermal waters collected from Italian springs, belonging to different chemical categories, have been tested in comparison to Tyrrhenian sea water and natural mineral bottled water. Results show inhibition properties on bacterial proliferation that seem related to H_2S concentrations. To further asses this phenomenon H_2S was added to thermal and natural mineral waters. The results strongly support a bactericidal role of H_2S in thermal spring waters used for recreational purposes. These observations open up new perspectives for a disinfectant role of H_2S in pool treatment and management.

1. Introduction

Hydrogen sulfide (H_2S) is a colorless, flammable gas with a "rotten egg" smell. It is one of the principal components in the natural sulfur cycle. Bacteria and fungi release H_2S during the decomposition of sulfur-containing proteins or by the direct reduction of sulfate (SO_4^{2-}). H_2S is also consumed by bacteria found in soil and water by the oxidation of hydrogen sulfide to elemental sulfur. Photosynthetic bacteria can oxidize H_2S to sulfur and sulfate in the presence of light and the absence of oxygen [1,2]. H_2S is commonly emitted from volcanoes, stagnant or polluted waters, hot springs, and underwater thermal vents. These natural sources account for about 90% of the total hydrogen sulfide in the atmosphere. Although H_2S has been studied for its toxic properties, several recent experimental evidences suggest that H_2S may play a prominent role in normal physiology and pathophysiology. Therefore, many therapeutic targets exist for H_2S therapy, including cancer, heart failure, organ transplant, peripheral artery disease, inflammatory bowel disease, Alzheimer's disease, acute myocardial infarction (MI), stroke, atherosclerosis, hypertension, erectile dysfunction, metabolic syndrome, diabetes, and thrombosis [3–8].

H_2S is dissolved in many thermal spring waters at variable concentration, used by centuries in different countries [9]. In general, spring waters have different chemical compositions, which can vary considerably depending on the location of the source (e.g. near the sea, volcanic, geothermic or mountain areas, etc.). The thermal waters are described as salty, sulfurous, bicarbonate, sulfated, carbonic, arsenical, or ferruginous, on the basis of their mineral composition [10]. The chemical concentration of thermal water is directly correlated to its therapeutic effects. To date, the chemical elements and mechanisms involved in the health benefits of hot springs remain still unclear [11].

Several authors reported bactericidal and antifungal activity from thermal spring waters with special focus on dermatological diseases [11–14]. Large importance has been dedicated to the pH level or to the presence of specific cations or anions in the water. The H_2S may be present under certain conditions as different reactive sulfur species. For example, the interaction between sulfur and oxygen radicals leads to the formation of subproducts, such as pentathionic acid ($H_2S_5O_6$), which may represent the source of the antibacterial and antifungal activity of thermal water on the skin [12–15]. This specific bactericidal activity can be particularly important in the management of thermal waters for recreational use [16]. Pools used for thermal baths in "salus per aquam" resorts (SPA) may be characterized by bacteria contamination due to overcrowding pool conditions. The microbiological risk is commonly countered by disinfection procedures. Chlorination or ozone treatments, largely adopted in conventional swimming pools, are not applicable to SPA pools or swimming ponds [17], due to the high level of reducing agents and salts present in natural thermal waters. Thus oxidative methods should not be applied in thermal waters as they may alter chemical components and,

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http://dx.doi.org/10.1016/j.microc.2012.10.022