

Characteristics of mineral water from nature hot springs in Ranong province, Thailand

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Abstract

Background: There is interest in characteristics of mineral waters from two famous hot springs in Ranong province, Thailand, including Raksawarin and Porn-Rang hot springs. **Aims:** To objective is to determine characteristics of thermal mineral waters of Ranong region and describe its classification and therapeutic indications. **Material and Methods:** Mineral waters were collected from Raksawarin and Porn-Rang hot springs. All analyses were conducted according to American Public Health Association. Temperature was measured in the field at the time of sample collection. Analyses of fecal coliforms and total bacterial count were performed. Physical-chemical analyses were used to evaluate pH, total dissolved solids (TDS), and conductivity. Total hardness was measured in the laboratory by titration. Metals (Al, Si, Fe, Mn, Pb, Cd, Ni, Cu) were measured by graphite furnace atomic absorption spectroscopy (GFAAS); major ions (Ca, Mg, Na, K, Cl, F, HCO₃⁻, SO₄²⁻) and nutrients (NH₄⁺, PO₄⁻, NO₃⁻) were measured by ion chromatography technique. **Results and Discussion:** The mean of pH, TDS, and conductivity values observed for hot springs were met to reference value of Thai tap water standard by WHO guideline. Neither hot spring contained fecal coliform bacteria. Chemical parameters were also within standard excepted aluminum concentration. Potassium levels from mineral waters were also high. Ranong mineral spring water can be thermal waters and define to hot waters. Ranong mineral spring water can be define to fresh and low sodium water. **Conclusions:** Our suggestions regarding this mineral water indication were properly for external use and may concern in case of drinking.

Key words: hot spring, mineral water, mineral water characterization, water quality parameters

Introduction

The use of water for medical treatment is probably as old as mankind and is a common practice in several countries for treatments such as hydrotherapy and balneotherapy. Hydrotherapy involves the use of common water, whereas balneotherapy employs natural thermal mineral water either in a spa or not. Spa treatment consists of a “cocktail” of different treatments including hydrotherapy, balneotherapy, and climatotherapy.^[1-4] Increased body temperature

from hot mineral water lowers blood pressure and is believed to influence mineral metabolism and body blood chemistry. Thus, mineral water treatment to relieve pain is widely used for the treatment of chronic arthritis, fibrositis, neuritis, sciatica, or fractures and sport injuries.^[5-7] In experimental studies, mineral water can improve disturbances of biliary tract and digestive tract symptoms,^[8,9] modulate skin inflammation and antioxidant enzyme activities,^[10] and improve skin

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regeneration and treatment.^[11-13] The use of spas is popular for both treatment and preventive therapy worldwide, especially in Europe and Japan and also in Thailand.^[14,15]

Natural mineral waters can be divided into table waters, dietetic waters, and healing waters. Healing waters possess pharmacological and clinical properties related to prevention and treatment of specific pathologies. They are used in thermal establishments, under medical control, for drinking, inhalations, irrigations, baths, and mud. The main classification parameters for mineral waters are rate of flow, temperature, freezing point, dry residues at 180°C, predominant ion compositions, and predominant biological activity.^[16] Chemical composition and mineralization are of greater importance while considering mineral water classification.^[17]

The interest of Thai government and corporates in the use of geothermal waters for medical and leisure purposes has been growing in recent years. Ranong is one of Thailand's southern provinces on the west coast along the Andaman Sea. Eighty percent of its area is covered with forests and 67% is mountainous. Earlier, the major industry was tin mining, but most mines are now closed. Nowadays, white clay mining (for the production of porcelain) and fishing are the main industries, along with rubber and cashew nuts. Many tourist places are in traveler's sight; one of most popular are hot springs, two of which are Raksawarin and Porn-Rang. Currently, we are interested in the characteristics of mineral waters from Raksawarin and Porn-Rang hot springs, such as its temperature, physical parameters, chemical composition, and microbiological quality. In the present paper, our research was undertaken in order to determine physicochemical composition of thermal mineral water in Ranong region according by APHA recommended standard procedures^[18] and to describe its classification and therapeutic indications. The qualities of mineral water from two aquifers were compared with reference values in guidelines for drinking water quality.^[19]

Materials and Methods

Location and description of the study area

Raksawarin hot springs and Park Arboretum are situated 2 km east of Ranong town. There are three main spring wells: father, mother, and child. The water from each of these springs is considered so pure that it was used during important ceremonies to celebrate the 60th birthday of King Bhumibhol, Thailand's current monarch. Porn-Rang hot springs located in Ngao National Park are far larger and more elaborate

than Raksawarin hot springs in Ranong town. The springs of Porn Rang are spread over a relatively vast area and include over a dozen different pools of varying temperatures, some completely natural and others that have been built into manmade pools with ladders and everything. Mineral water is collected from father well of Raksawarin hot spring (because mother and child wells are too deep to collect samples from) and from original aquifer of Porn-Rang hot springs.

Experimental planning, water sampling, and analysis

The research was conducted in two stages: physical analysis at the site of sampling and microbiological, physical-chemical, and chemical analyses performed in the laboratory. All analyses in this study were conducted according to the international standard methods of APHA.^[18] Field sampling was undertaken in accordance with APHA standard methods directly at the output of the hot springs, and plastic tubes were used for the purpose. Polyethylene or glass bottles, which were new, washed, and rinsed with deionized water, were used to collect samples for laboratory analysis. Samples were collected for analysis from the hot springs within 3 days (triplicate sampling) in January 2016. For bacteriological analysis, 250-ml glass flasks were autoclaved (121 C/30 min) before use. Analyses of fecal coliforms (multiple tube method) and total bacterial count (pour plate method) were performed in accordance with APHA.

Physical-chemical analyses were performed to measure pH, total dissolved solids (TDS), and conductivity (Orion 115) using a calibrated instrument. Temperature was measured in the field at the time of sample collection. Total hardness was measured in the laboratory by titration method using Eriochrome Black T. Metals (Al, Si, Fe, Mn, Pb, Cd, Ni, Cu) were measured by graphite furnace atomic absorption spectroscopy (GFAAS) (Agilent SpectraAA-400Z, Agilent Technologies, USA). Major ions (Ca, Mg, Na, K, Cl, F, HCO₃⁻, SO₄²⁻, S²⁻) and nutrients (ammonia, NH₄⁺, total phosphorus; total nitrogen) were measured using ion chromatography technique (Thermo Fisher Scientific Inc.). All parameters were analyzed in accordance with APHA.

Data analysis

Descriptive and inferential statistical methods were used to analyze the data using SPSS 12.0. The values of continuous variables were presented as mean. The parameter values of mineral water from both hot springs were compared with standard levels of water quality parameters from WHO guidelines for drinking water quality.

Results

Physical and physical-chemical properties and microbiological analyses of mineral water from the two hot springs are shown in Table 1. The thermal water temperatures of father well of Rahsawarin hot spring and original aquifer of Porn-Rang hot springs were averaged at 65.3 and 61.5 °C, respectively. The means of pH, TDS, and conductivity values observed for Rahsawarin and Porn-Rang hot springs throughout the analysis period met the reference values of Thai tap water standards given by WHO guidelines. Neither hot spring contains bacteria, especially fecal coliform bacteria, which was also within the Thai tap water standards. Only the hardness of mineral water from the two hot spring was slightly higher than the standard value. The chemical contents including heavy metals

are represented in Table 2. Chemical parameters of mineral water from the two hot springs were also within the excepted aluminum concentration, which was 9-13 times higher than the standard normal range. Fluoride level in Rahsawarin hot spring water was higher than the Thai tap water standard (<0.7 mg/l) but still within the level of mineral water recommendation (<1.0 mg/l). Potassium levels of mineral water were also high (150-189 mg/l); however, there was no reference value of potassium in the Thai tap water standard to compare it with.

Discussion

Ranong hot springs had lower thermal values when compared with the fountains of Soffioni Boriferi-Tuscany (Italy) of 130 °C, Japan (BEPU) of 100 °C, or Argentina,

Table 1: The physical and physical-chemical properties and microbiological analyses of mineral water from two Ranong hot springs

Source of mineral water	Temperature (°C)	pH	TDS (mg/l)	Hardness (mg/l)	Conductivity (mS/m)	Fecal coliforms (MPN/100 ml)	Total bacterial count (MPN/100 ml)
Rahsawarin hot spring	65.3	7.74	230	350	4.58	ND	ND
Porn-Rang hot springs	61.5	7.56	210	304	3.50	ND	ND
Thai tap water standard*	--	6.5--8.5	500	300	5--50	ND	ND

*Values in agreement with WHO 2011.¹⁹
ND, not detected.

Table 2: Chemical composition of mineral water from two Ranong hot springs

Compound (mg/l)	Rahsawarin hot spring	Porn-Rang hot springs	Thailand tap water standard*	Recommendation and mineral water classification**
Sulfide (S ₂ -)	0.004	0.003	--	--
Bicarbonate (HCO ₃ -)	5.7	4.3	--	>600
Calcium (Ca)	20.6	18.7	--	>150
Magnesium (Mg)	0.51	0.36	--	>50
Fluoride (F)	0.89	0.12	<0.7	<1.0
Sodium (Na)	13.8	10.2	<200	<20
Potassium (K)	150	189	--	--
Chloride (Cl)	23.2	18.3	<250	<200
Sulfate (SO ₄)	12.1	8.1	<250	>200
Silica (Si)	75	68	--	--
Nitrate (NO ₃)	ND	ND	<50	<45
Phosphate (PO ₄ -)	ND	ND	--	--
Ammonia (NH ₄)	ND	ND	--	--
Aluminum (Al)	130	95	<0.9	--
Iron (Fe)	0.01	0.004	<0.3	<0.5
Manganese (Mn)	ND	ND	<0.1	<0.3
Copper (Cu)	ND	ND	<2.0	<1.0
Nickel (Ni)	ND	ND	--	--
Lead (Pb)	ND	ND	<0.01	--
Cadmium (Cd)	ND	ND	<0.003	--

*Values in agreement with WHO 2011.¹⁹

**Reference from Petracchia et al. (2006).¹⁶

ND, not detected.

Rosary of La Frontera of 97 °C.^[20] Requirements for bathing water are as follows: the mineral content of water used for leisure purposes must not exceed 30 g/l (in temperatures ranging from 24 to 30 °C), while that of water used for therapeutic purposes must not exceed 50 g/l (in temperatures ranging from 28 to 42 °C). By our results, Ranong hot springs were okay for bathing and may cause concern in case of drinking according to the Thai tap water standard guidelines of WHO.¹⁹ Ranong springs have low seasonal variations, like natural mineral waters, and are defined as perennial. On the basis of temperature, Ranong mineral spring water can be thermal water (temperature higher than 20°C) and may be defined as hot water (higher than 40 °C).^[16] In terms of the amount of dissolved substances (water mineralization), Ranong mineral spring water can be define as fresh water (with mineral content below 1 g/l).^[21] According to the recommendation by Petraccia *et al.*,^[16] mineral water from Ranong hot spring was low on sodium (less than 20 mg/l). However, we were concerned about the high levels of aluminum and potassium in Ranong hot springs. So, in view of this mineral water indication, we suggest that this water is suitable for external use such as hydrotherapy, balneotherapy, and climatotherapy.

This occurrence may related to mining in the area, which may rich in potassium feldspars (KAlSi₃O₈). Bordepong *et al.*^[22] reported mineralogical, chemical composition, and ceramic properties of clay deposits from southern Thailand and concluded that Ranong clay contained SiO₂ and Al₂O₃, which are necessary for the manufacturing of ceramic products. Supplied line reconstruction of mineral water from their aquifers, especially from urban progress and various other activities around points of resurgence and under recharge areas. For this reason, aluminum and potassium in grounds of mining area flowed and contaminated the mineral water. However, no related symptoms of aluminum toxicity were seen in people living near the hot spring area and consuming the mineral water from the springs.

Aluminum (Al) is a very common component of the Earth's mineral composition. It is not essential element for life and a constituent of rather inert minerals. Therefore, it has often been regarded as not presenting a significant health hazard. Aluminum may contribute to the inception and advancement of Alzheimer's disease (AD) by causing excessive inflammatory activity within the brain and speeding the rate of brain aging.^[23] Trivalent Al reacts with water to produce bidentate superoxide coordination spheres [Al(O₂)(H₂O)₄]⁽⁺²⁾ and Al(H₂O)₆⁽⁺³⁾, which after complexation with O₂^(•-) generate Al superoxides [Al(O₂^(•-))(H₂O)₅]⁽⁺²⁾.

Semireduced AlO₂^(•-) radicals deplete mitochondrial Fe and promote generation of H₂O₂, O₂^(•-), and OH^(•). Thus, it is the Al⁽⁺³⁾-induced formation of oxygen radicals that accounts for the oxidative damage leading to intrinsic apoptosis. Also, there is no clear evidence to show that the use of Al-containing underarm antiperspirants or cosmetics increases the risk of AD or breast cancer. Metallic Al, its oxides, and common Al salts have not been shown to be either genotoxic or carcinogenic. Aluminum exposures during neonatal and pediatric parenteral nutrition (PN) can impair bone mineralization and delay neurological development.^[24] Further study needs to repeat determination of water parameters in more aquifers of two hot springs and also in longer period and surveillance for aluminum-related toxicity in people in this area.

High potassium levels in mineral water from Ranong hot springs may be a concern for intake due to health hazards and effects. High dietary salt is a risk factor for high blood pressure, independent of body weight, sex, and age.^[25,26] Nevertheless, for several years, there has been evidence that not only sodium reduction but also an increase in potassium intake shifts blood pressure to a more preferable level.^[26,27] One of the most effective dietary modifications to treat and prevent hypertension was the "dietary approach to stop hypertension" (DASH) trial, which confirmed the assumptions of the blood pressure-lowering effect of a diet rich in fruits, vegetables, and low-fat dairy products and low in saturated and total fat.^[26,27] Since this type of diet is also a good potassium source, it might be speculated that the blood pressure-lowering effects were also, at least partly, due to increased potassium intake.^[26,29] The American Heart Association estimated that increasing potassium intake would lower the incidence of hypertension in Americans by 17% and increase the life expectancy by 5.1 years.^[26,30,31] On the other hand, dietary potassium depletion can raise blood pressure in normotensive humans,^[26,32] which is associated with an impaired ability to manage acute sodium load and sodium retention.^[26,33] Furthermore, in hypertensive patients, a low-potassium diet (16 mmol/day) raised mean arterial pressure by 6 mmHg compared with a high-potassium diet (96 mmol/day) in a trial lasting 10 days.^[26,34] Several epidemiological studies in the last few years found an association between potassium intake or status (mainly serum potassium levels) and risk for diabetes.^[26,35] It was implied that the consumption of large amount potassium in mineral water from the two Ranong hot springs could be beneficial to normal and hypertensive people and contraindicated for diabetes mellitus patients. Other contraindications of waters with low content of minerals are water retention, renal insufficiency, and cardiocirculatory decompensation.^[16]

Conclusion

Ranong springs were defined as perennial. Based on the temperature, Ranong mineral spring water can be thermal water or may even be defined as hot water. Ranong mineral spring water can be defined as fresh water with low sodium content. However, we were concerned about the high levels of aluminum and potassium in the Ranong hot springs. So, in view of this mineral water indication, we suggest that this water is suitable for external use such as hydrotherapy, balneotherapy, and climatotherapy and may not be fit for drinking.

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Conflicts of interest

There are no conflicts of interest.

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