Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Hot Springs in the Malay Peninsula

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Keywords: Hot spring, Malay Peninsula, drinking water.

ABSTRACT

More than sixty hot springs have been discovered so far in the Malay Peninsula and all of the hot springs are genetically related to tectonic activities. Most of the sources are located along the western flank of the Main Range Granite Batholith and concentrated along major fault zones. A few hot springs however, are located within sedimentary rocks which are in close contact with the granite batholith or along the granite-sedimentary rock contact.

The temperatures of the hot springs are less than 100^{o}C at surface. The flow rates of most hot springs ranged from 2 to 6 litres/second, except for the one at Tambun (Perak) which has a flow rate of about 20 litres/second,. The hot springs are mostly located at low elevations ranging from 3 meters to 200 meters above sea level in a variety of geographic environments such as along stream beds or emerging such as along cracks in bedrock surfaces or in swampy areas.

Chemical analysis of water from these hot springs showed that about 84% of the samples have high concentrations of F, and Na exceeding the permissible International Standards for drinking water. Samples from a few sites also have high concentrations of As. Seventeen sites emit a faint to strong H_2S odour. Only two of these hot springs meet all the requirements for drinking and mineral water

A large number of these hot springs, especially those that are easily accessible and in the vicinity of urban centers are turned into recreational resorts with hotels, hot spas, and swimming pools. None of these hot springs has been utilized for use as a source of geothermal energy and more investigations need to be carried out.

1. INTRODUCTION

In the Malay Peninsula, about sixty hot springs have been discovered so far, and 75% of them are in easily accessible areas. As such, it is possible that there may be some in the deep jungles, awaiting to be discovered. Most of the hot springs have been used for bathing and recreational purposes. Some of the hot springs which are located near to urban centres have been elaborately developed, with hotels, hot spas and swimming pools, whilst those that are in rural areas may only have a wooden bathroom. Those that are in inaccessible areas are often left undeveloped.

It is prudent that a review of these hot springs and their potential for commercialisation be carried out. .

2. OBJECTIVES OF STUDY

The main objectives of this study are to:

i). study the genesis of these hot springs,

ii). review the quality of the hot spring water,

iii). consider the various options in commercialising these hot springs.

3. PREVIOUS INVESTIGATIONS

Bott (1890) reportedly carried out the first documented investigations on thermal hot springs in Selangor and Malacca. He gave an account of the occurrences, chemical composition of the hot water and gaseous discharges from these hot springs.

Almost a century later, Ho (1979) conducted a geothermometric investigation on hot springs in Kedah and Perak. He measured the subsurface temperature using chemical geothermometric measurements.

In 1990, Abdul Rashid carried out a regional investigation on forty five hot springs in the Malay Peninsula. He conducted field measurements on the temperature, conductivity and pH of water from these hot springs. He also measured the flow rate of the hot springs. Samples of water from these hot springs were collected and analysed for their chemical and physical properties in the laboratory. These results were compared with the quality of some commercial mineral water from France, Indonesia, Scotland and Malaysia with the aim of determining if the water from the hot springs could be commercially exploited as mineral water.

4. GEOLOGY

As depicted in Figure 1, almost all the hot springs in the Malay Peninsula are located along the western flank of the Main Range Granite Batholith. These hot springs are located along a NNW-SSE alignment which represents the main tectonic trend of the Peninsula. Most of the hot springs are sited along major fault zones or shear zones. A few of these hot springs occur at the granite-sedimentary rock contact or in sedimentary rocks near to the granite batholith

Most of the hot springs are located in low-lying areas, usually along stream beds or emerging along cracks on bedrock surfaces, and in rare occasions in swampy areas. The lowest hot spring is located at an elevation of 3 m, while the highest, at 420 m.

5. RESULTS OF STUDY

Data on the fluid properties of most hot springs in the Malay Peninsula had been collected by the Geological Survey Department of Malaysia. These data include the chemical and physical properties of the fluid.

5.1 Surface Temperature

The surface temperature of the forty five hot springs (Abdul Rashid, 1980) was observed to be below 100^{o}C varying from 27^{o}C to 98^{o}C (Table1). Figure 2 shows the correlation between surface temperature and elevations of the hot

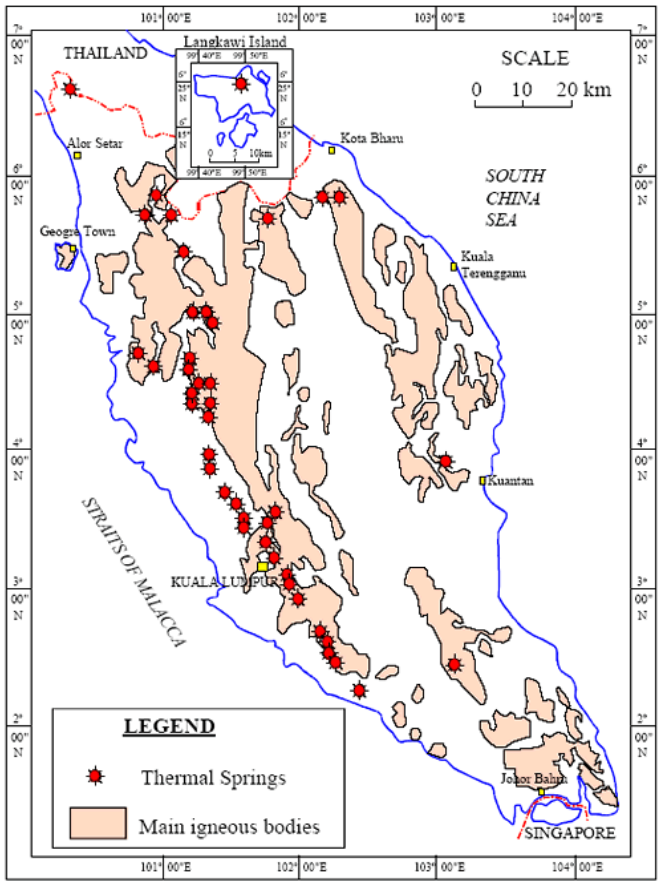

Figure 1: Hot spring locations in Malay Peninsula. (Source: Renewable Energy in ASEAN, 2005)

Table 1: Range of surface temperature and flow rate of hot springs in the Malay Peninsula

Parameter	Min.	Max.
Height above sea level (m)	3	420
Surface Temp. (^{o}C)	27	98
Flow rate (lit/sec)	0	20

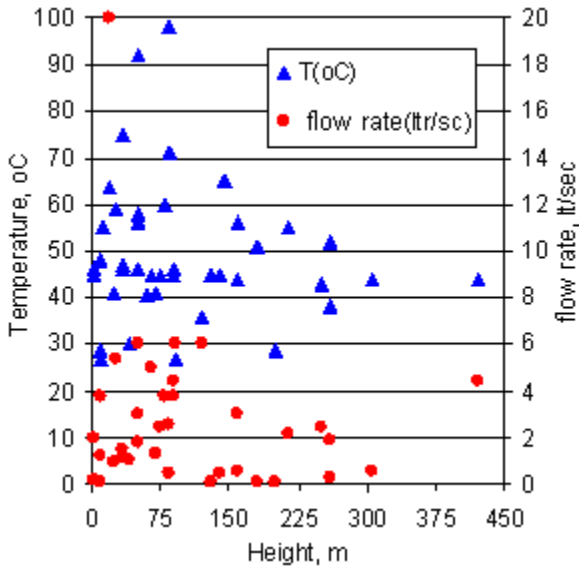

Figure 2: The distribution of temperature and flow rate of hot springs in the Malay Peninsula

springs. The average temperature of the hot springs is about 48.8°C.

It was observed that the low-elevation hot springs have higher surface temperatures varying between 70°C to 98°C, whilst the higher-elevation hot springs have temperatures of about 43°C.

5.2 Flow Characteristics

Most of the hot springs are present as small pools or puddles of hot water, with surface areas varying from 1 to 5 m^2. The discharge from these hot springs varied from as low as 0.1 litre/second to as high as 20 litres/second in Tambun (Perak). Most of the hot springs have rates varying between 2 to 6 litres/second averaging at 2.03 litres/second (Figure 2).

Three of the hot springs (Trong in Perak, Kampung Ayer Hangat in Pulau Langkawi, and Parit Gerisek in Johore) produced brackish to saline water. Probably, the close proximity of these three sites to the coast resulting in seawater intrusion had caused the water to be brackish or saline, having high conductivity values of 3,900 to 47,800 µmhos/cm at 25°C (Abdul Rashid, 1990).

Most of the hot springs had low conductivity values of less than 450 µmhos/cm at 25°C.

5.3 Odour Characteristics

The smell of hydrogen sulphide was detected in 17 hot springs. Four of them had a strong odour, while the remaining thirteen had a faint odour.

The hot springs with strong hydrogen sulphide odour are located in in Trong (Perak), Kampung Legong Baling, Pedas, and Kampung Sungai Bersih Hulu Sim. The ones with a faint hydrogen sulphide odour are located at Kampung Sira Ko Baling, Dusun Tua Hulu Langat, Semenyih, Kampung Ganun Alor Gajah, Kampung Air Panas Jasin, Parit Gerisek (Johor), Batu 9 Gombak (Kuala Lumpur), Batu 15 Tapah, Hulu Kampar and Kampung Hulu Geroh in Gopeng, Sungai Kelah Felda Land in Tanjung Malim, Bendang Lawa (Kelantan), and Tambun (Ipoh).

5.4 Chemical Characteristics

Forty nine water samples were collected from the 45 hot springs in the Malay Peninsula for the study of their chemical and physical characteristics.

Results (Table 2) showed that there is a wide range for certain elements such as Ca (0.8 to 1448 mg/l), Mg (0.5 to 450 mg/l), Na (1.4 to 8250 mg/l), K (0.5 to 275 mg/l), Cl (1 to 16200 mg/l), Al (0.1 to 573 mg/l), As (0.005 to 0.15 mg/l), and F (0.6 to 22.8 mg/l). Certain other elements have smaller range values such as Fe (0.1 to 1.1 mg/l), Mn (0.1 to 0.3 mg/l), P (0.1 to 0.4 mg/l), Cu (0.1 to 0.2 mg/l), Pb (0.1 mg/l), Zn (0.1 mg/l), Cd (0.1 mg/l), and Sr (0.1 to 0.6 mg/l).

Some of the compounds also have high variations, such as SO_4 (1 to 1120 mg/l), NO_3 (3 to 23 mg/l), SiO_2 (0.2 to 96 mg/l), and NH_4 (0.1 to 2 mg/l). In contrast, SO_3 has a constant value of 0.1 mg/l. The Total Solids (TS) and Total Dissolved Solids (TDS) also have a wide range, varying between 40 to 31512 mg/l and 36 to 30800 mg/l respectively. Likewise, the conductivity and pH also have a very large range, varying from 1 to 47400 µmhos/cm and 5.8 to 9.1 respectively. Some of the water are also contaminated with coliform bacteria with values ranging from 5 to 70 colonies/100 ml.

6. USES OF HOTSPRINGS IN THE MALAY PENINSULA

6.1 Recreational Purposes

Most of the hotsprings which are located in accessible areas are developed for recreational purposes. Some of the more popular hot springs such as the ones in Kampung Air Panas in Hulu Slim and in Tambun have up to 1000 visitors each on weekends. The hot waters are tapped and channeled into swimming pools and spas. Of the 45 hot springs studied, twelve are well developed, three are fairly well developed, thirteen are underdeveloped and the remaining seventeen are undeveloped.

It is anticipated that in the near future, more of these hot springs will be utilized for recreational purposes.

Table 2: Summary of the physical and chemical characteristics of hot spring water in the Malay Peninsula (49 samples)

Parameter	min	max
Ca, mg/l	0.8	1448
Mg, mg/l	0.5	456
Na, mg/l	1.4	8250
K, mg/l	0.5	275
Fe, mg/l	0.1	1.1
Mn, mg/l	0.1	0.3
CO_3, mg/l	1	20
HCO_3, mg/l	10	545
Cl, mg/l	1	16200
SO_4, mg/l	1	1120
NO_3, mg/l	3	23
F, mg/l	0.6	22.8
SiO_2, mg/l	0.2	96
As, mg/l	0.005	0.15
Al, mg/l	0.1	57.3
NH_4, mg/l	0.1	2
SO_3, mg/l	0.1	0.1
P, mg/l	0.1	0.4
Cu, mg/l	0.1	0.2
Pb, mg/l	0.1	0.1
Zn, mg/l	0.1	0.1
Cd, mg/l	0.1	0.1
Sr, mg/l	0.1	0.6
TS, mg/l	40	31512
TDS, mg/l	36	30800
pH, mg/l	5.8	9.1
COND., µmhos/cm	1	47400
COL., colonies/100ml	5	70

6.2 Geothermal Energy

At the moment, none of the discovered hot springs in the Malay Peninsula has been utilized for use as a source of geothermal energy. The full potential of these geothermal resources is yet to be investigated. However, investigations are now on going in the Poring Ranau and Semporna areas in Sabah, East Malaysia, to assess their potential.

6.3 Drinking or Mineral Water

With the rapidly growing population in the world, drinking water is becoming scarce and efforts have been made to tap river waters, groundwater and spring waters. In recent years, even polluted river waters or sea waters have been treated and converted to drinking water. The World Health

Organization had proposed standards for drinking water since 1958 and the standards had been revised every 10 to 12 years (WHO, 2007). In 2002, the Pan American Health Organization (PAHO) also established a guideline for drinking water to aid developing countries.

In recent years, bottled mineral water has become popular and it is now served in meetings, hotels, sport events and recreational places. The mineral water is usually obtained directly from springs, wells or boreholes. Different brands of mineral water are characterized by the content of certain minerals present and the manufacturer of each brand would usually maintain the consistency of the mineral composition. In 1997, Codex Alimentarius Commision (CAC) proposed a draft revised standard for natural mineral water under a joint Food and Agricultural Organization (FAO)/WHO food standards programme, whereby converting the regional standards into a worldwide standard. In 2003, Pakistan Food Hygiene Sectional Committee published the Pakistan Specification Standard (PSS) for bottled natural mineral water (Table 3).

A comparison was made between the chemical composition of hot spring waters in the Malay Peninsula with the standards for drinking water as set by WHO and PAHO, and for bottled mineral water by CAC and PSS.

Table 3: Standards for drinking water and bottled water

Substance	Drinking Water		Bottled Water	
	WHO	PAHO	CAC	PSS
Na,mg/l	20	-	-	30
Ca,mg/l	-	-	-	200
Mg, mg/l	-	-	-	100
K, mg/l	-	-	-	30
Cl,mg/l	250	400	-	250
Fe, mg/l	2	0.4	-	-
Mn, mg/l	0.4	0.5	2	0.5
Cu, mg/l	2	-	1	1
Zn, mg/l	3	-	-	-
Al, mg/l	0.2	0.3	-	-
As, mg/l	0.01	0.05	0.05	0.01
F, mg/l	1.5	1.5	2	1.5
NH_4, mg/l	1.5	-	-	-
SO_4, mg/l	500	500	-	100
NO_3, mg/l	50	50	50	10
pH	6.5-8.5	6-8	-	6.5-8.5
TDS, mg/l	-	1000	-	1000

6.3.1 Na

Studies showed that 87% of the hot spring waters have Na values higher than the WHO and PSS standards. The hot springs which meet the specifications are Mata Ayer Padang Besar (Perlis), Air Panas Keroh, Kampung Sira Gerik, Kampung Mata Ayer (Kelantan), Lian Seng Tong Temple and Ulu S. Periah (Perak).

6.3.2 Ca and Mg

The hot spring in Kampung Ayer Hangat (Langkawi Island) is the only one which has Ca and Mg contents above the PSS standard. This is due to the fact that the hot spring is near to the coast and is only 3 m above sea level.

6.3.3 K, Cl, and Total Dissolved Solid (TDS)

Three hot springs in Trong (Perak), Kampung Ayer Hangat (Langkawi Island) and Parit Gerisek (Johor) have levels of K, Cl and TDS above the recommended standards. These hot springs were also found to have brackish to saline waters due to their proximity to the coast and they are only 3m to 9m above the sea level.

6.3.4 Fe

Water from six hot springs (Kampung Ayer Hangat in Langkawi Island, Kampung Sira Ko Baling, Air Panas Keroh, Kampung Air Panas Gerik, Kampung Sira Gerik, Kampung Mata Ayer in Kelantan) have Fe contents higher than the PAHO standard of 0.4 mg/l. For commercial mineral water, the requirement is that Fe content should be less than 0.3 mg/l as the taste of Fe would not be noticeable at that concentration.

6.3.5 Mn, Cu, and Zn

Waters from all the 45 hot springs meet the specifications for Mn, Cu and Zn.

6.3.6 Al

Dissolved Al in water with near-neutral pH usually varies between 0.001 to 0.05 mg/l, but it can increase to 0.5-1.0 mg/l in more acidic waters or in water rich in organic materials. The concentration of Al in water should be monitored carefully as it has been proven that exposure to excessive Al is a risk factor for the development or acceleration of the onset of Alzheimer's disease (WHO, 1997).

Four hot springs in Kampung Ayer Hangat (Langkawi Island), Kuala Kubu Bharu, Pedas, and Sungai Danak Lasah have Al concentrations above the WHO Standards but the latter two meet the PAHO Standard.

6.3.7 As

Twelve hot springs have As contents above the WHO and PSS Standards of 0.01 mg/l. They are in Dusun Tua Hulu Langat, Kerling, Kampung Batu 7 Tapah, Kampung Air Panas Hulu Slim (Perak), Air Panas Setapak, Sungai Jin Hulu Kuantan, Batu 9 Gombak (Kuala Lumpur), Air Panas Hulu Yam, Sungai Tamu Batang Kali, Batu 15 Tapah, Hulu Kampar Gopeng, and Kampung Hulu Geroh Gopeng. The hot spring in Dusun Tua Hulu Langat has As content above the PAHO and CAC requirement of 0.05 mg/l.

6.3.8 F

About 84% of the hot springs have F contents above the WHO, PAHO, CAC and PSS Standards. Only seven hotsprings meet the specifications and they are at Kampung Ayer Hangat (Langkawi Island), Mata Ayer Padang Besar (Perlis), Air Panas Keroh, Kampung Sira Gerik, Kampung Mata Ayer (Kelantan), Lian Seng Tong Temple (Perak), and Ulu S. Periah (Perak).

6.3.9 NH_4 and SO_4

Except for the hot spring in Kampung Ayer Hangat (Langkawi Island) all other hot springs have NH_4 and SO_4 concentrations meeting the required standards.

6.3.10 NO_3

The hot spring in Kampung Ayer Hangat (Langkawi Island) is the only one that has NO_3 content above the PSS Standard. However, it meets the WHO, PAHO, and CAC Standards.

6.3.11 pH Level

The hot spring in Kampung Mata Ayer (Kelantan) has a pH level of 5.8 which is lower than the requirement in all the four standards. Twelve hot springs however, have a pH level higher than the maximum limit of 8.5. They are in Kampung Legong Baling, Kampung Labok Machang, Kampung Batu 7 Tapah, Kampung Air Panas Hulu Slim (Perak), Air Panas Setapak, Dusun Tua Hulu Langat, Air Panas Labis, Air Panas Hulu Yam, Sungai Tamu Batang Kali, Batu 15 Tapah, Kampung Kubu Legap Lasah, Sungai Danak Lasah, and S. Kelah Felda Land Tanjung Malim.

6.3.12 H_2S

There were no measurements takes for the concentration of H_2S in the hot spring waters in the Malay Peninsula. However, as reported earlier, seventeen hot springs emitted an odour of H_2S. The taste and odour threshold for H_2S in water has been estimated to be as low as 0.5 mg/l. It is unlikely for anyone to consume water with ever a faint H_2S odour (WHO, 1996).

7. CONCLUSIONS AND RECOMMENDATIONS

Several factors have to be considered before water from these hot springs should be tapped for drinking purposes. One of these is the fact that the flow rate of the hot springs is generally less than 6 litres/sec. In addition, 80% of the hot springs have Na and F contents above the standards of WHO, PAHO, CAC, and PSS. The hot spring at Kampung Mata Ayer almost meets all the requirements for drinking water and mineral water except for the fact that the water is too acidic, having a pH of 5.8 and its Fe content is high, having a value of 0.7 mg/l. Two other hot springs at Kampung Air Panas Keroh and Kampung Sira Gerik meet all the requirements for drinking and mineral waters except that the contents of Fe in the two springs are high, having values of 1.1 mg/l and 0.4 mg/l respectively. This however, is not a deterrent, as Fe in water can easily be removed by oxidation. Only two hot springs, namely Lian Seng Tong in Ipoh and Ulu Sungai Perak in Sungai Siput Selatan meet all the requirements for drinking and mineral water.

If the hot springs are to be utilized for recreational purposes, the high temperatures have to be regulated. The WHO has imposed a temperature limit of 40^{o}C for recreational purposes. Another factor to be considered is the rapid algal growth in hot springs. Algal growth however can be controlled easily by having a good hydraulic design and using disinfectant. Hot springs in easily accessible areas or near to urban centres should be fully developed for recreational purposes. Investigations should be conducted on hot springs with low flow rates to locate any other potential spring outlets.

Geothermal power is an important source of alternative energy. Investigations should be carried out to locate new hot springs along the foothills of the Main Range Granite Batholith.

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