SPA, SPRINGS AND SAFETY

Yaowalark Sukthana[1], Amorn Lekkla[1], Chantira Sutthikornchai[1], Paitoon Wanapongse[2], Athasit Vejjajiva[3] and Somchai Bovornkitti[3]

[1]Department of Protozoology, Faculty of Tropical Medicine, Mahidol University. Bangkok; [2]Office of Atoms for Peace, Ministry of Science and Technology, Bangkok; [3]The Academy of Science, The Royal Institute, Bangkok, Thailand

Abstract. Natural mineral water has long been used worldwide for bathing and health purposes. At present, Thailand is famous for health spas and natural hot springs among local people and tourists. Due to possible risks of exposure to harmful agents, we studied hazardous pollutants at 57 natural hot springs from 11 provinces in northern, central, eastern and southern Thailand. Pathogenic, free-living amebae of the genera *Naegleria* and *Acanthamoeba*, which can cause central nervous system infection, were found in 26.3% (15/57) and 15.8% (9/57), respectively. Dissolved radon, a soil gas with carcinogenic properties, was present in nearly all hot springs sites, with concentration ranging from 0.87- 76,527 Becquerels/m^3. There were 5 water samples in which radon concentration exceeded the safety limit for drinking. *Legionella pneumoniphila* (serogroups 1,3, 5, 6, 7 10 and 13) were found in samples from 71.9% (41/57) of studied sites. Because spas and natural springs are popular tourist attractions, health authorities should be aware of possible hazards and provide tactful measures and guidelines to ensure safety without causing undue alarm to foreign and Thai tourists.

INTRODUCTION

Since the Bronze Age, some 5,000 years ago, natural mineral water has been used for bathing and health purposes. Many hot springs have also been used for religious rites in Egypt and by Jews in the Middle East. The Greeks, Turks, and Romans were famous for their spa development and use. The word "spa" represents S = Salud, P = Per, A = Aqua, which means "Health through Water", originating from a town in southern Belgium. There, an iron master used a spring of iron-containing water to cure his ailments in 1326. He founded a health resort at the spring called Espa, which in the Walloon language means "fountain". Since then, Espa or "Spa" has been used in the English language for common health resorts around the world (Lund, 1996). Remains of Roman baths have been found at Exeter, Devon, Triponiumin in England; Timgad in Algeria; Arles, Glanum Thermes de Cluny in France; Baden-Baden in Germany; Benevento, Campania Cefalu in Italy and Prestatyn in Wales.

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 chronic arthritis, fibrositis, neuritis, sciatica or for treatment of fractures and sport injuries. Today, the use of spas has become popular for both treatment and preventive therapy worldwide, especially in Europe and Japan (Sarnoff, 1989).

Spas can be classified into 7 types according to American Spa Association (Sarnoff, 1989). There are Intensive fitness spas, Rejuvenation spas to look fresh and young, Weight-loss spas, Athletic camps, New Age retreats where people can renew their psychic, spiritual, and physical well-being, Mineral springs or "magic mud" spas and Medical spas. Thai spas feature Thai traditional massage, facial and body treatment with Thai medicinal herbs. Water usage at Thai spas is almost always from tap water. However, natural hot spring water is becoming increasingly popular for spa businesses in Thailand.

Water has a positive effect on health, but it also has its adverse effects. According to Guidelines for Safe Recreational Water Environments (WHO, 2001), possible hazards associated with recreational water are physical, chemical and microbiological (fecal and non-fecal derived organisms). Among many hazardous contaminants, radon and non-fecal organisms such as *Legionella* (a gram-negative non-motile bacteria) as well as *Naegleria* and *Acanthamoeba* (free-living amebae) are of our interest. WHO classifies radon, produced by the decay of radium, as a carcinogen. The US Environmental Protection Agency (US EPA) estimates that radon in indoor air causes more than 20,000 deaths each year in the United States, and is the second-leading cause of lung cancer after smoking. Radon is present in some spring waters, such as those at Hot Springs, Arkansas.

Correspondence: Yaowalark Sukthana, Department of Protozoology, Faculty of Tropical Medicine, Mahidol University, 420/6 Rajvithi Road, Bangkok, Thailand. Tel: 66 (0) 2354-9100 ext 1830; Fax: 66 (0) 2643-5601 E-mail: tmymv@mahidol.ac.th

Legionella causes a serious form of pneumonia called legionnaires' disease, first discovered in 1976 after an outbreak in Philadelphia during a convention of the American Legion (Meyer and Finegold, 1980; Kramer and Ford, 1994; Marston *et al*, 1994; Stout and Yu, 1997; Abu Kwaik *et al*, 1998). Free-living amebic infections, although rare, are recognized as causes of fatal infections in both immunocompetent and immunocompromized persons. *Naegleria fowleri* causes primary amebic meningoencephalitis (PAM), a rapid and fulminant central nervous system (CNS) infection in normal hosts. *Acanthamoeba* causes chronic or subacute granulomatous amebic encephalitis (GAE) in immunosuppressive persons and keratitis in contact lens wearers. They are commonly present in soils and surface waters worldwide, with cases reported from diverse locations such as Europe, Australia, New Zealand, Thailand, Africa, India, Korea, Japan, Peru, Venezuela, Panama and the United States. Warm water above 30^{o} C is where these pathogens multiply.

At present, Thailand is famous for health spa and natural hot springs among local people and tourists. Since there may be possible risks of exposure to harmful agents, we studied the contamination of possible hazardous pollutants in water from natural hot springs in many parts of the country.

MATERIALS AND METHODS

This was a cross-sectional study. Water samples from 71 sites of natural hot springs, adjoining man-made bathing facilities, hot spring ponds and pools from 12 provinces in northern, central, eastern and southern Thailand were collected (Figs 1-4). The temperature and pH of the water of each point of collection were recorded. Five hundred ml of water as well as sediments, algae mat and scrapings of biofilm on rock surfaces were collected by sterile bottle for detection of *Legionella* and free-living amebae. This was done by dipping a 500-ml bottle into the water, filling it, then immediately capping it with an air -tight seal for detection of radon contamination.

Legionella culture and serogroups identification was performed at the laboratory unit of the National Institute of Health, Department of Medical Science, Ministry of Public Health. (Praveenkittiporn *et al*, 2004). Study of free-living amebae (*Acanthamoeba* and *Naegleria*) contamination by using fresh direct smear and trichrome staining were performed at Department of Protozoology, Faculty of Tropical Medicine, Mahidol University (Sukthana *et al*, 2004). The laboratory of the Office of Atoms for Peace in Bangkok determined the radon concentration using a

Figs 1-4- Natural hot springs, adjoining man-made bathing facilities and hot spring pound.

circular airtight system (ATS) (Wanapongse *et al*, 2004).

RESULTS

The temperature and pH of the water samples from 71 sites of natural hot springs varied from 28° - 65°C and 6-8, respectively. Table 1 shows the radon concentration in the north, south, central and eastern parts of Thailand. There were 5 sites from the north with radon level exceeding the concentration recommended for safe drinking water by the USA Environment Protection (US EPA), which is 11,000 Bq/m^3. However, there was not any radon concentration exceeding the safety level for natural hot springs (40,000 Bq/m^3). High radon concentration was found in Mae Hong Son and Chiang Rai Provinces in the north. This might be related to the type of rock underneath the hot spring sites. Radon emissions could be inhaled and pose a threat to those who regularly use natural hot springs in these areas.

Table 1
Radon concentration in natural hot spring water from the north, south, central and eastern parts of Thailand.

Sites	Rn conc (Bq/m$^{3)}$
Northern part	
Mae Hong Son Province	
Ta Py, Pai district	1,274.9
Mueang Pang, Pai disdrict	17,071.3
Pa Bong, Pai disdrict	20,848.2
Nong Hang, Khun Yuam district	3,589.4
Muang Pae, Mueang district	3,388.1
Mae Sa-nga, Mueang district	3,911.2
Mae Umlong, Mae Sariang district	76,527.4
Chiang Rai Province	
Pong Namron, Mae Chan district	4,653.1
Pong Prabaht, Mueang district	14,702.4
Pa Serd, Mueang district	1,167.8
Huay Maag Liam, Mueang district	3,272.7
Pu Fuang, Mae Suai district	11,787.9
Pong Namron, Baan Khajan	3,512.6
Chiang Mai Province	789.5
Lampang Province	9,562.5
Southern part	
Nakhon Si Thammarat Province	21.2 - 32.9
Surat Thani Province	31.5 - 7,219
Phatthalung Province	0.9 - 16.9
Trang Province	9.7 - 48.2
Phang-Nga Province	2.7 - 61.5
Ranong Province	2.7 - 61.5
Chumphon Province	4,514.4
Central part	
Phetchabun Province	1.8 - 27.4
Kamphaeng Phet Province	0.6 - 43.4
Lop Buri Province	14.5 - 130.8
Eastern part	
Chon Buri Province	8.9

Table 2 showed the contamination of non-fecal, bacteria and free-living amebae. We paid attention to *Legionella, Naegleria* and *Acanthamoeba.* There was 63.4% *Legionella* contamination, 24.6% and 13.1% positive for *Naegleria* and *Acanthamoeba*, respectively. The serogroups of *Legionella* contamination were serogroups 1, 2, 3, 4, 5, 6, 9, 10, 14.

Legionella are gram-negative, non-spore-forming, motile, aerobic bacilli. Under natural conditions, they are approximately 0.3–0.9 μm and 2–20 μm or more in size. *Legionella* are natural inhabitants of fresh water. Sources of inoculum may include water or high vacuum air conditioning (HVAC) equipment. Inhalation of contaminated aerosols appears to be the sole route of exposure. *Legionella* spp can cause two distinct syndromes: Legionnaire's disease and Pontiac fever, collectively referred to as legionellosis (APHA, 1989). Legionnaire's disease is a form of pneumonia. General risk factors for the illness include males aged 50 years or older, chronic lung disease, cigarette smoking and excess consumption of alcohol. Specific risk factors include frequency of spa use and length of time spent in or around spas. Although the attack rate is less than 1%, the mortality among hospitalized cases can be as high as 15%. Pontiac fever is a non-pneumonic, non-infectious, non-fatal, influenza-like illness due to Legionella. The attack rate can be as high as 95% in the total exposed population. Patients with no underlying illness or condition recover in 2–5 days without treatment. Ninety percent of cases of legionellosis are caused by *L. pneumophila*. Most cases of legionellosis associated with recreational-water use appear to be associated with spas (Groothuis *et al*, 1985a; Althaus, 1986). Outbreaks in swimming pools and ambient recreational waters have never been reported (Marston *et al*, 1994). Spa water and associated equipment create an ideal habitat for the selection and proliferation of *Legionella*.

Legionnaire's disease is worldwide in distribution and mostly associated with spa bath and hot springs water (Groothuis *et al*, 1985b, Breiman and Butler, 1996). In Japan, hot springs and public bath water represented one-third of the estimated source of *Legionella* infection from April 1999 to July 2000

(National Epidemiological Surveillance of Infectious Diseases: available at http://hcinfo.com/outbreaks-news.htm). In Thailand, there have not been any reports of legionnaire's disease, but 3 cases of legionnaires' disease associated with travelers to Bangkok have been identified by the Public Health Laboratory Unit, UK (Slaymaker *et al*, 1999).

Water samples from Lop Buri Province in central Thailand were the first recorded sources of *Naegleria* and *Acanthamoeba* contamination (Sukthana *et al*, 2004). Contaminated samples were also found in the south (Table 2), but none were found in the north. *Naegleria fowleri* is a free-living ameba (*ie*, it does not require the infection of a host organism to complete its life cycle) present in fresh water and soil. The life cycle includes environmentally resistant encysted and trophozoite forms. Trophozoites have broad pseudopodia movement, with a large single karyosome nucleus without peripheral nuclear chromatin granules and cysts are spherical, 8-12 μm in diameter (Fig 5). *N. fowleri* is thermophilic, preferring warm water and reproducing successfully at temperatures up to 46˚C. In water, concentrations of the amebae increase as they feed on aquatic bacteria. *N. fowleri* causes primary amebic meningoencephalitis (PAM). Infection is acquired by exposure to polluted water in ponds, swimming pools and artificial lakes (Martinez and Visvesvara, 1997; Szenasi *et al*, 1998). Victims are usually healthy young children and adults who have had contact with water about 7-10 days before the onset of symptoms (Visvesvara, 1999). Infection occurs when water containing the organisms is forcefully inhaled or splashed onto the olfactory epithelium, usually from diving, jumping or swimming underwater. The amebae then make their way into the brain and central nervous system. Symptoms of the infection include severe headache, high fever, stiff neck, nausea, vomiting, seizures and hallucinations. The infection is not contagious. For those infected, death occurs usually 3-10 days after exposure. PAM is an extremely rare disease. Wellings *et al* (1977) has estimated that only one case of PAM occurs for every 2.6 million exposures to water containing *N. fowleri*. About 200 cases of *Naegleria* infection have been reported worldwide (Martinez, 1985; De Jonckheere, 1987; Kilvington and Beeching, 1997). The first reported case of PAM in Thailand was a 5-year old boy from the northeastern part (Jariya *et al*, 1983). Since then, about 12 cases of PAM have been reported from all over the country (Charoenlarp *et al*, 1988; Sirinavin *et al*, 1989; Poungvarin and Jariya, 1991; Sangruchi *et al*, 1994; Viriyavejakul *et al*, 1997; Wanachiwanawin, 2001). More than two-thirds of cases were children. Disease occurred during summer months and the majority had a history of swimming and water exposure.

Table 2
The contamination of non-fecal derived microorganisms in natural hot spring water.

Microorganisms	+ve Legionella and serogroup	+ve Free-living amebae (%)	
		Naegleria	*Acanthamoeba*
Eastern part			
2 Provinces, 6 sites (Chon Buri, Chanthaburi)	50 % (3/6)	-	-
Southern part			
7 Provinces, 49 sites (Nakhon Si Thammarat, Surat Thani, Patthalung, Phang-Nga, Ranong, Chumpon)	69.4 % (34/49) serogroups 1,2,3,5,6,9,10	22.2 % (10/45)	0.8% (4/45)
Central part			
3 Provinces, 16 sites (Lop Buri, Phetchabun, Kamphaeng Phet)	50% (8/16) serogroups 1,3,4,6,14	31.3 % (5/16)	25 % (4/16)
Total	63.4% serogroups 1,2,3,4,5,6,9,10,14	24.6%	13.1%

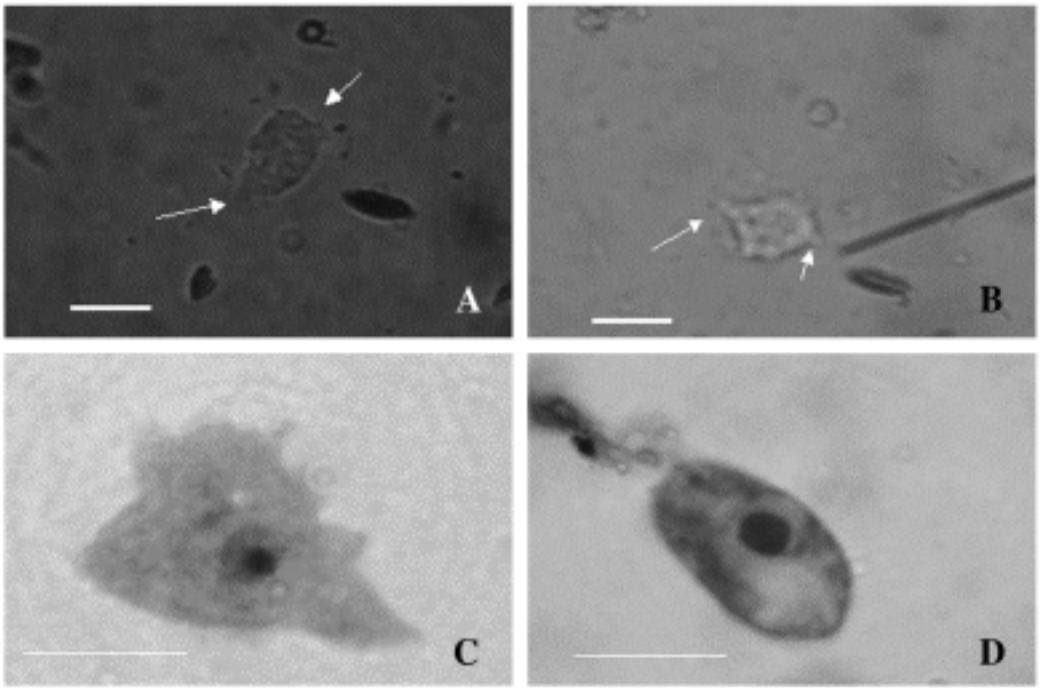

Fig 5- Free-living amebae trophozoites of water from hot spring; A and B: Saline fresh smear, note broad pseudopodia of *Naegleria* (A) and spiky pseudopodia of *Acanthamoeba* (B). Bar = 10 μm, 400×.
C and D: Trichrome stain showing large single karyosome nucleus without peripheral nuclear chromatin granule. Bar = 10 μm, 1,000×.

Several species of free-living *Acanthamoeba* are human pathogens (*A. castellanii*, *A. culbertsoni*, *A. polyphaga*). They can be found in all aquatic environments, including chlorinated swimming pools. Under adverse conditions, trophozoite (Fig 5) form a dormant encysted stage. Cysts measure 15-28 μm, depending on the species. *Acanthamoeba* cysts are highly resistant to extremes of temperature, disinfectants and desiccation. The cysts will retain viability from -20˚C to 56˚C. When favorable conditions occur, such as a ready supply of bacteria and a suitable temperature, the cyst excysts and trophozoites emerge to feed and replicate. All pathogenic species will grow at 36˚-37˚C, with an optimum of about 30˚C. Although *Acanthamoeba* is common in most environments, human contact with the organism rarely leads to infection. Human pathogenic species of *Acanthamoeba* cause two clinically distinct infections, affecting the brain and the cornea, respectively (Martinez and Visvesvara, 1997; Szenasi *et al*, 1998). *Acanthamoeba* spp are responsible for granulomatous amebic encephalitis (GAE), a subacute or chronic infection that can occur in people who are immunosuppressed as a result of acquired immune deficiency syndrome (AIDS), chemotherapy, or drug or alcohol abuse. GAE is invariably fatal. The route of infection in GAE is unclear, although invasion of the brain may be via the blood following a primary infection elsewhere in the body, possibly the skin or respiratory tract. GAE is extremely rare; only slightly more than 100 cases have been reported worldwide (Martinez and Visvesvara, 1997). A recent history of contact with water has not been seen in patients with GAE (Marshall *et al*, 1997). Several species of *Acanthamoeba* can also produce a chronic sight-threatening ulceration of the cornea called acanthamoeba keratitis, mostly in previously healthy individuals who wear contact lenses or those with minor corneal abrasions. Infection follows the colonization of the internal surface of the contact lens. The primary source of acanthamoebic infection of the cornea in contact lens wearers is thought to be tap water that is used to clean storage cases or to prepare solutions. However, acanthamoeba keratitis may also be transferred via hot tubs, chlorinated swimming pools and air conditioning units (Marshall *et al*, 1997).

Nowadays, spas and natural hot springs are increasing worldwide. The former Soviet Union now has 3,500 spas and some 5,000 reconditioning centers, all administered and run by the state. Similarly, in the former Czechoslovakia, there are 52 mineral water health spas and more than 1,900 mineral springs. Every year, about 220,000 citizens are granted free spa treatment for three weeks, paid by the national health insurance program (Lund and Freeston, 2000). In Japan, over 1,500 spas exist and 100 million visitors use them every year. There are over 115 major geothermal spas in the USA and many smaller ones along with thousands of hot springs (Lund and Boyd, 2000). In Thailand, the spa and health business is perhaps the fastest growing market. Thailand's spa industry is worth US$ 85 million, and has grown 64% in three years. During 2001/2002, Thai spas had an estimated 3.3 million customers, of whom 80% were from abroad (Intelligent Spas).

To maintain growing spa business, it is necessary to reduce risk of infection. Reducing the occurrence of causative agents can be achieved through proper cleaning, maintenance, filtration and disinfection of spa water. Users should be aware that the risk of infection increases with time spent in the spa or with immersion of the head. HVAC systems serving the pool or spa facilities should be cleaned and disinfected regularly. Increased health awareness by providing tactful measures and guidelines to ensure safety without causing undue alarm to foreign and Thai tourists are necessary.

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