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GEOTHERMAL BATHS, SWIMMING POOLS AND SPAS: EXAMPLES FROM ECUADOR AND ICELAND

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ABSTRACT

Geothermal resources have been used for bathing since antiquity in many parts of the world. Selected examples of historical uses are presented along with present day examples from Ecuador and Iceland. While the drive for bathing remains unchanged, bathing practices have evolved into refined cultural traditions and sophisticated therapeutic treatments that rely on modern technology for proper execution.

1. INTRODUCTION

It must be seen as likely that humans started making use of natural hot springs for bathing early on, as there are examples of other primates doing the same in current times. The snow monkey, which is spread over much of Japan, is well known for taking advantage of geothermal springs in Jigokudani Park to keep warm in the winter in the mountains near Nagano city (Aasgaard, 2012). Much like humans, it uses the hot springs for socializing and relaxation, and it does not take a vivid imagination to picture early humans in a similar setting (Figure 1).

FIGURE 1: Japanese macaques (snow monkeys) taking a geothermal bath (SnowJapan, 2014)

Through recorded history, there are various accounts of the utilization of geothermal water for bathing and remnants of such use have been passed on from antiquity. Such bathing has been used for recreation, relaxation, socializing, therapy, and as part of spiritual practices by cultures in many parts of the world (Kępińska, 2003).

In Italy, the Etruscans developed a tradition of bathing in thermal waters (Kępińska, 2003). This tradition was passed on to the Romans who also built on Greek traditions to develop a refined bathing culture that was spread around the empire. Over a thousand thermal baths existed in the capital during the peak period of bathing in the 3rd century A.D. and military camps were built in the vicinity of geothermal springs for massages and healing wounded soldiers (Kępińska, 2003). In the middle of the 1st century A.D., the Romans built a temple by the hot springs in modern day Bath in England and a town, that became known as Aquae Sulis, was gradually built up in the next decades (City of Bath, 2014). The baths from which the modern city draws its name were constructed around 70 A.D. as a grand bathing and socializing complex and are currently one of the best preserved Roman remains in the world (Figure 2), with 1,170 m^3 of 46°C hot water filling the baths every day (VisitBath, 2014). The Greek motto "health through waters" came to be known as "salus per aquis" in Rome and has been abbreviated as *spa* in modern times (Kępińska, 2003).

Wang Ji-Yang (1995), reports that the Huaqing hot spring by the foot of Mt. Lishan close to Xi'an city in China has been utilized for 3000 years. In 747 A.D., the most luxurious imperial palace of the Tang dynasty was built around the spring and the love story of Emperor Tang Xuanzong and his concubine Yang Guifei, who spent much of their leisure time in the hot baths (Figure 2), is well known in China. Aside from recreational activities, the historical use of hot springs in China has mainly been focused on therapeutic treatment (Wang, 1995).

In Iceland, there are several accounts in the literature of early usage of hot springs for bathing and it must be seen as likely that the first settlers started such utilization in the 9th and 10th centuries. In medieval times, the best known example is that of Snorralaug (Figure 2), a geothermal bath believed to have been built by historian, chieftain and saga-writer Snorri Sturluson. A contemporary thirteenth century account mentions Snorri's use of the bath, which is supported by archaeological evidence. Excavations have revealed a circular pool 4 m in diameter and about 0.9 m deep that was fed by a stone conduit from a nearby hot spring (Fridleifsson, 1995). Fridleifsson (1995) suggests that the idea for the conduit was brought from Italy with Icelandic pilgrims.

Kępińska (2003) notes that in Japan, geothermal sources gave birth to the construction and development of many spas visited by noblemen for therapeutic and recreational purposes. Through the centuries, the contribution of different dynasties led to the refinement of practices and in 1710, the first medical books describing baths in hot springs, their curative properties, and the offered treatments were published (Kępińska, 2003). In modern times, the onsen bathing tradition is a popular feature of Japanese tourism.

In South America, the pre-Incan Caxamarca culture built an important city by the hot springs that later became known as Baños del Inca (Inca baths). The place at that time consisted of buildings that were one of the principal residences of the Caxamarca chiefs, who used the hot springs for healing and the worship of water (Figueroa Alburuqueque, 2005). As the Incas gained influence in the region, the baths by Cajamarca became one of the principal residences of Inca chiefs prior to the arrival of the Spanish conquistadors. This is where Inca Emperor Atahualpa first heard of the Spanish invasion of 1531-1532, and some sources say that he was aroused from the baths to receive the news. Kępińska (2003) reports that a great number of Inca palaces and temples were built near natural geothermal ponds and hot springs that were equipped with bathing facilities supplied with hot and cold water through a system of pipelines (Figure 2).

Through time, bathing practices in different parts of the world have evolved into refined cultural traditions (e.g. Japanese onsen and Turkish bath) and sophisticated therapeutic practices (balneology and spa treatments). In this paper, some examples are given of the modern use of geothermal waters for bathing in Ecuador and Iceland, the birth countries of Atahualpa and Snorri Sturluson (both powerful leaders with a common taste for geothermal bathing, meeting their fate at the hands of emissaries of foreign powers).

FIGURE 2: Reconstructions of the Roman Baths in the City of Bath in England (upper left) (VisitBath, 2014), the Crabapple pool built for Lady Yang Guifei by the Huaqing hot spring near Xi'an in China (upper right) (China International Travel CA, 2012), Snorri's pool in Reykholt in Iceland (lower left) (Hurstwic, 2014), and the intact Tambomachay site by Baños del Inca in Peru as passed on to modernity (lower right) (Andean Travel Web Guide to Peru, 2010)

2. EXAMPLES FROM ECUADOR

Today, utilization of geothermal resources in Ecuador is restricted to direct uses, that is, for bathing resorts, balneology and swimming pools. A total installed capacity of 5.16 MWt and an annual energy output of 102.4 TJ/yr has been estimated in 2010 (Beate and Salgado, 2010), with a slight increase in recent years. In general, therapeutic benefits provided by medicinal mineral hot springs have been exploited in most resorts and spas in Ecuador. However, significant alternate uses remain unknown by Ecuadorian society. Currently, several projects for direct use in fish hatchery, greenhouse heating, space heating, and industrial applications are being researched by universities and public research institutions. A map containing the locations of known hot springs in Ecuador is presented in Figure 3.

The following sections describe some of Ecuador's bathing resorts and spas.

2.1 The Aguas Hediondas ecotouristic complex

The Aguas Hediondas ecotouristic complex is located near the border between Ecuador and Colombia. The hot springs come from Chiles Volcano, and feed four geothermal pools, with water temperatures ranging between 40-56°C. The water has a white-yellow appearance due to its high sulphur content, giving rise to its name, which in Spanish means "Smelly Waters". Villagers from Tufiño adduce therapeutic properties among other benefits of bathing in these hot springs. Admission tickets are sold for 1 USD.

Location: 24 km W of Tulcán city, 7 km W of the village of Tufiño
Elevation: 3580 m a.s.l.

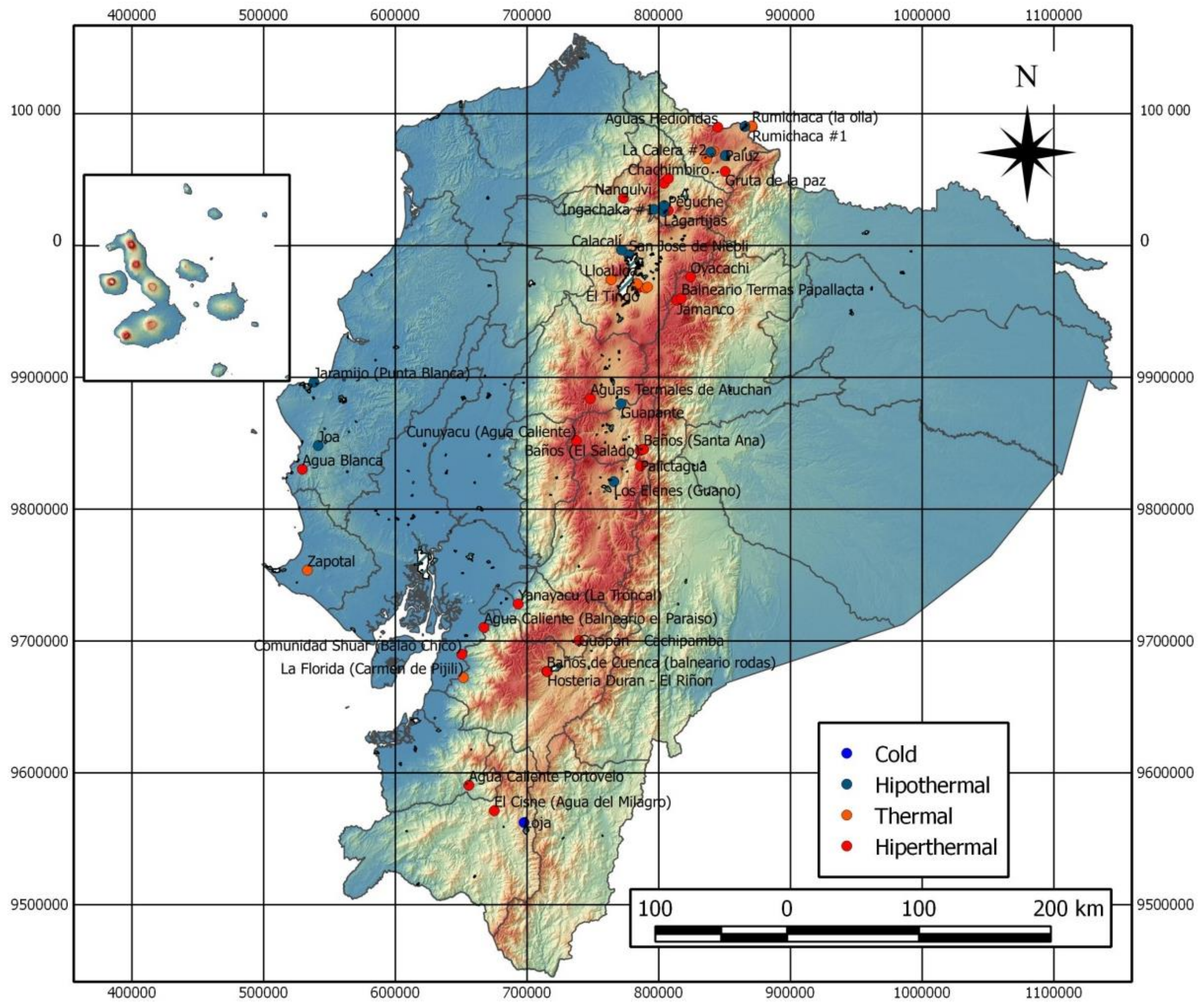

FIGURE 3: Map of geothermal hot springs in Ecuador (Burbano et al., 2013)

Hot spring temperature: 52.5°C
Hot spring type: Sodium – Sulphate (Table 1)

2.2 El Salado hot springs

The city of Baños de Agua Santa, commonly reffered as "Baños" is located in the foothills of Tungurahua Volcano. The city got its name from the hot springs located in the surroundings, and has become one of the most visited places in Ecuador. The hot springs feed five resorts and spas, which offer different low temperature geothermal derived services. The water type is mostly mineralized with sulphate and chlorine contents. Health improvements have been attributed from bathing in these hot springs.

Location: 30 km SW of Ambato city, 2 km E of Baños de Agua Santa
Elevation: 1820 m a.s.l.
Hot spring temperature: 45.6°C
Hot spring type: Chloride – Sulphate – Alkali (Table 1)

2.3 Piedra de Agua hot spring and spa

The Parish of Baños de Cuenca has the hottest springs in the country, which emerge from a side travertine hydrothermal deposit. These springs represent the likely lateral outflow of the Quimsacocha geothermal system, at about 20 km to the SW of Cuenca (Beate and Salgado, 2010). Piedra de Agua is one of the most complete and modern resort and spa in the area, built almost entirely from limestone extracted from the travertine hydrothermal deposit (Figure 4). Unique geothermal derived services are offered to the public, such as volcanic mud baths, steam box bath, and Turkish baths. A detailed description of each service is displayed in the resort´s website. One particularity is the underground thermal baths, which are built inside man made caves. Exploitation of geothermal resources for bathing in the area started in 1928.

Location: 7 km SW of Cuenca city, Baños de Cuenca Parish
Elevation: 2700 m a.s.l.
Hot spring temperature: 74.5°C
Hot spring type: Chloride – Bicarbonate – Alkali (Table 1)

FIGURE 4: Piedra de Agua resort facilities and geothermal bathing pools (Piedra de Agua, 2014)

2.4 Termas Papallacta hot spring and spa

The hydrothermal value of Termas de Papallacta's hot springs comes from the Chacana caldera, which has been persistently active through all the Quaternary period (the last 2-3 million years). The springs are near-neutral alkaline chloride waters with anomalous high concentrations of boron and arsenic, typical of a high temperature water-dominated geothermal system. The Termas de Papallacta resort has five pools for general bathing and private individual pools for hotel guests (Figure 5). It also has a ground source heat pump system that provides space heating mainly in the social areas of the hotel.

Location: 60 km E of Quito city, Papallacta Parish
Elevation: 3300 m a.s.l.
Hot spring temperature: 54.2°C
Hot spring type: Chloride – Sulphate – Alkali (Table 1)

The chemistry of the waters supplying the four resorts is presented in Table 1.

FIGURE 5: Papallacta resort facilities and geothermal bathing pools

TABLE 1: Chemistry of Aguas Hediondas, El Salado, Piedra de Agua, and Papallacta hot springs (Inguaggiato et al., 2010; Burbano et al., 2013)

Name		**Aguas Hediondas**	**El Salado**	**Piedra de Agua**	**Papallacta**
Type		Sodium-Sulphate	Chloride-Sulphate-Alkali	Chloride-Bicarbonate-Alkali	Chloride-Sulphate-Alkali
Location	Longitude	-78,43304	-79,06177	-78,15328	-77,90592
	Latitude	- 1,40618	-2,92243	0,36495	0,80966
Elevation (m.a.s.l.)		3601	1927	2704	3278
pH		4,60	6,40	6,83	7,08
T (°C)		52,5	45,6	74,5	54,2
C.E. (us/cm)		1850	6770	4130,00	2170
Li (meq/l)		0,040	0,093	0,357	0,20
Na (meq/l)		8,75	24,19	28,20	12,28
K (meq/l)		1,03	2,12	1,39	0,16
Ca (meq/l)		4,54	19,60	9,78	8,31
Mg (meq/l)		3,95	66,98	1,98	0,14
F (meq/l)		0,230	0,00	23,72	0,100
Cl (meq/l)		3,49	22,59	23,72	11,32
Br (meq/l)		0,003	0,00	0,032	0,03
SO_4 (meq/l)		16,99	63,24	4,79	7,75
HCO_3 (meq/l)		*0,00	25,60	10,50	1,65
d18O (‰ V-SMOW std)		- 11,7	- 11,7	- 11,4	-11,8
dD (‰ V-SMOW std)		- 87	- 80	- 80	-80
SiO_2 (mg/l)		*126,60	*147,1	*73,55	*0,00

3. EXAMPLES FROM ICELAND

Iceland is located on top of the Mid-Atlantic Ridge and the resulting volcanism and seismicity give rise to numerous high- and low-temperature geothermal fields (Figure 6). Although some Icelanders made use of geothermal hot springs for recreation, relaxation and bathing since well before the days of Snorri Sturluson, such activity did not become engrained in the culture until the 20th century, when man-made geothermal pools and easier access to natural pools allowed it. Many of the geothermal swimming pools that were constructed in the early part of the century were located in the vicinity of natural hot springs, which called for minimal effort in accessing the resource and water conveyance. Many of these were intended for swimming instruction, which was considered important for a nation reliant on fishing. Over the following decades, the number of man-made pools increased with the establishment of district heating systems around the country, mandatory swimming instruction in elementary schools, improved economic conditions and an increasing appetite for "swimming" among the public. In 2010, there were 163 recreational swimming centers operating in Iceland, out of which 134 used geothermal heat totaling close to 1,400 TJ (Bjornsson et al., 2010; Figure 7). There are also many natural pools in varying conditions to be found around the country (Snaeland and Sigurbjornsdóttir, 2010), a few therapeutic centers and spas, and a geothermal beach was opened by the cold North Atlantic Ocean in 2000. In the following sections, examples are presented of each category.

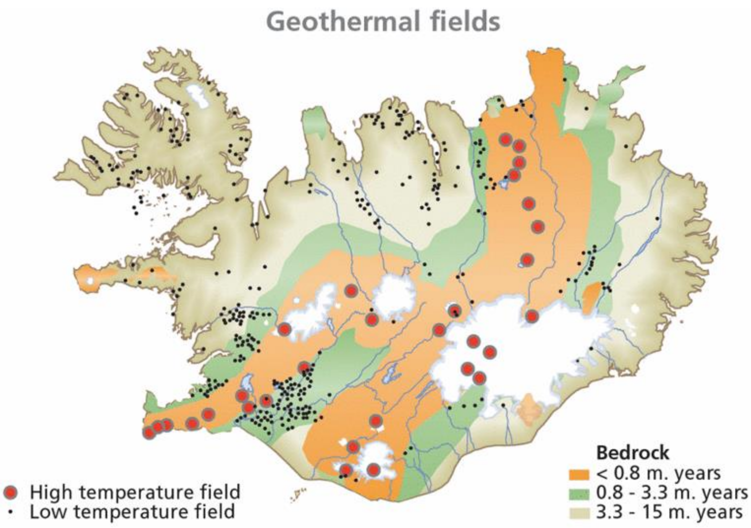

FIGURE 6: Geothermal fields in Iceland (NEA, 2014)

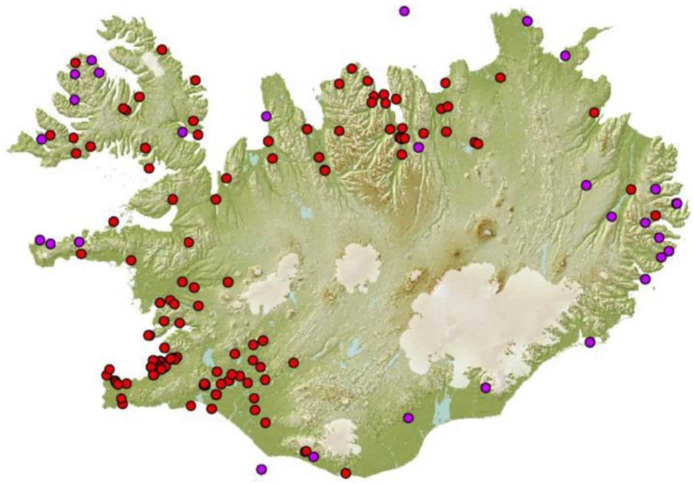

FIGURE 7: Swimming centers in Iceland in 2008 (Haraldsson and Ketilsson, 2010). Red circles indicate geothermal pools, whereas purple circles indicate pools heated by other energy sources (electricity, oil, or wastes)

3.1 Swimming pools – Laugardalslaug

Swimming centers in Iceland are used for mandatory swimming instruction for students, competitive swimming practice, recreation, relaxation, and socializing. They are attended by all age groups in all seasons and have become an important part of Icelandic culture. Although many Icelanders associate health benefits to frequenting the pools, there is not a great focus on water chemistry or balneological aspects among the guests. Access to hot tubs of different temperatures, jaccuzzis and steam baths is highly valued, however.

A regulation is in place regarding sanitary practices in swimming and bathing centers, which defines allowable temperatures, chlorination levels, pH values, water circulation time, cleansing requirements, and the water exchange rate. The temperature of pools used for swimming shall be in the range of 27-29°C, whereas the temperature of thermal pools including childrens' pools should be 30-34°C, and relaxation pools and hot tubs can have temperatures of 34-44°C (MENR, 2010). In accordance with the regulation, swimming centers are placed into three categories depending on sanitation measures. All new swimming pools must fulfill the requirements of category A, which call for an automated control system for all major parameters. Older pools may fall into categories B or C, for which more lenient sanitary requirements are made. According to guidelines published by the Environment Agency of Iceland, all swimming centers need an operation license from the respective health authorities (EAI, 2012).

In a typical modern day setup, the water enters a swimming pool through ducts on the bottom and rises to overflows on the surface edges of the pool, from where it passes through a sand filter and a buffer tank before being recirculated (Figure 8). Heat is added either by mixing district heating water directly into the circulation (open system) or through heat exchangers (closed system). A control system injects CO_2 and chlorination agents as needed to maintain pH values and disinfectant levels within a set range. The sand filter is back-flushed according to need, as indicated by differential pressure measurements.

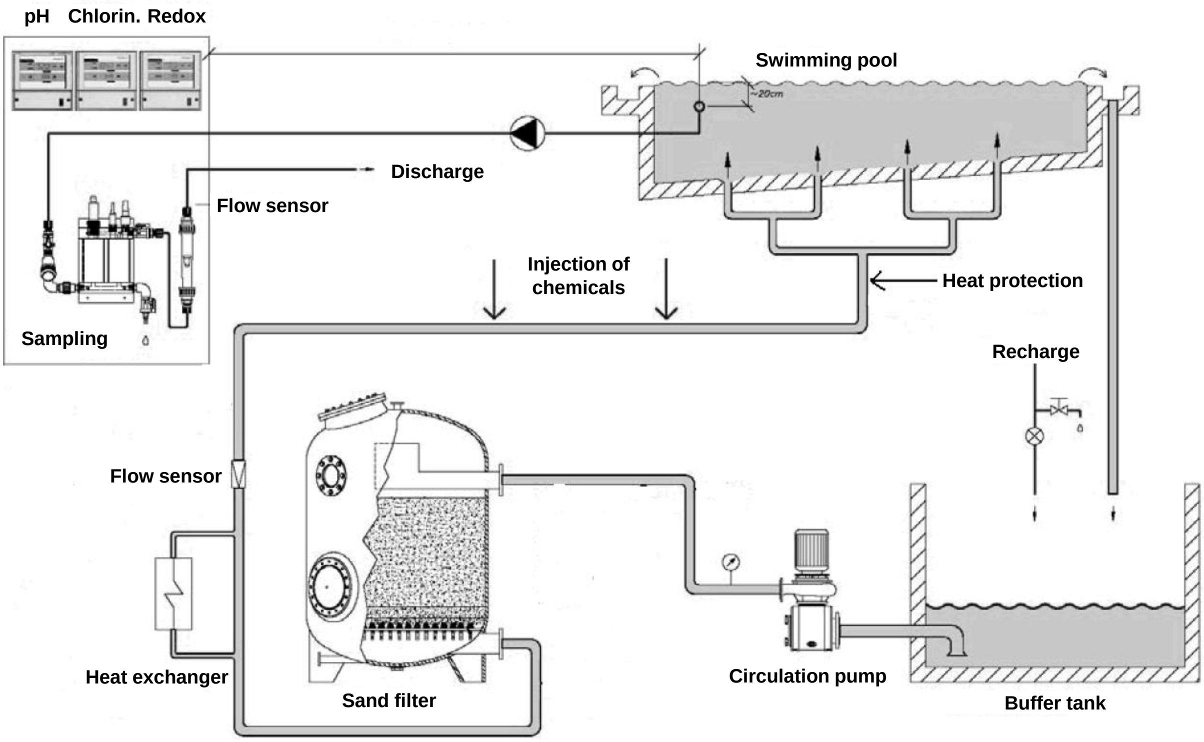

FIGURE 8: Typical setup for a modern day closed circulation swimming pool (modified from Haraldsson and Ketilsson, 2010; Courtesy of Ólafur Gunnarsson)

One of the first man-made swimming pools in Iceland was constructed in the heart of the capital, Reykjavik, in 1907-1908 (City of Reykjavik, 2014a). The Laugardalslaug swimming pool has since grown to become the largest conventional swimming center in Iceland, with large outside and indoor swimming pools designed for training and swimming competitions, a dedicated kids' pool with a water slide, and several relaxation ponds and hot tubs with varying temperatures and massage jet options (Figure 9). One of the hot tubs is filled with brackish water, while "conventional" pool water is used for other tubs and pools. In general, swimming pool water is either water from a district heating system that may have considerable mineral content or heated ground water with low mineral content – or a mix of the two. Table 2 lists the different pools and tubs of Laugardalslaug, and their main defining physical parameters.

FIGURE 9: Laugardalslaug – Laugardalur swimming pool (City of Reykjavik, 2014b)

TABLE 2: Main defining parameters of the pools and tubs of Laugardalslaug (City of Reykjavik, 2014a; Swimming in Iceland, 2014)

	Shape	**Depth (m)**	**Area (m^2)**	**Volume (m^3)**	**Temperature (°C)**	**No. of lanes**
Main pool (outside)	Rect. (L=50m)	0.80-1.76	1,100	2,730	28	8
Kids' pool (outside)	Irregular	0.80	400	320	32	N/A
Relaxation pond (outside)	Circular	0-0.40	15.9		32	N/A
Massage bath (outside)	Irregular		30	17	39	N/A
Hot tub 1 (outside)	Circular		7.0	5.6	38	N/A
Hot tub 2 (outside)	Circular		7.0	5.6	40	N/A
Hot tub 3 (outside)	Circular		7.0	5.6	42	N/A
Hot tub 4 (outside)	Circular		7.0	5.6	44	N/A
Sea tub (outside)	Irregular				40	
Competition pool (inside)	Rect. (L=50m)		1,250			10
Kids' pool (inside)	Rect. (L=25m)	<1 m				4

Outdoor swimming pools in the cold climate of Iceland demand a lot of heat to maintain optimal temperatures and they could hardly be maintained in such numbers if not for the fact that Iceland enjoys the lowest district heating prices in Europe (Haraldsson, 2014). The City of Reykjavik maintains 7 swimming centers that were visited by almost 2 million guests in 2010, out which nearly 800,000 visited Laugardalslaug (Hjaltalín, 2011). By end of year 2011, the estimated operation and maintenance costs for the year amounted to 1,477 million ISK, which translates to 14.3 million USD (adjusting for inflation using the consumer price index as reported by Statistics Iceland and the average exchange rate for February 2014 as reported by the Central Bank of Iceland). The expected income from ticket sales was 567 million ISK (5.5 million USD), meaning that the City would subsidize the total costs by 910 million ISK (8.8 million USD) (Hjaltalín, 2011). This shows clearly the importance attached by many Icelandic municipalities in running swimming centers for public benefit. In 2014, the advertised admission prices were as shown in Table 3.

3.2 Nature pools – Landmannalaugar

There are many natural or semi-natural pools in Iceland. Some have been entirely made by Nature, while most have been touched by man to varying degrees: access has been made easier, facilities constructed, dams raised, ditches dug, water conveyed etc. What these pools have in common is the close connection to Nature experienced by guests.

TABLE 3: Admission prices for swimming centers in Reykjavik (City of Reykjavik, 2014c)

Service	**Price (ISK)**	**Price (USD)**
Kids (6-18 years)		
Single ticket	130	1.14
10 tickets	900	7.89
6 months card	6,000	52.59
12 months card	10,000	87.64
Adults		
Single ticket	600	5.26
10 tickets (valid for 36 months)	4,100	35.93
6 month card	16,500	144.61
12 month card	30,000	262.93

Landmannalaugar (People's pools) is an example of a Nature bath in the interior of Iceland that is visited by over 100,000 guests every year (Snaeland and Sigurbjornsdóttir, 2010). Warm brooks originating from a nearby lava field have been dammed to create the pools, which have an elevation of 593 m and are surrounded by colorful rhyolite mountains (Figure 10). The water temperature ranges from 34 to 41°C (Snaeland and Sigurbjornsdóttir, 2010). Despite the lack of facilities for changing clothes and the possibility of parasite attacks, the pools remain popular among Icelanders and foreigners alike.

FIGURE 10: Landmannalaugar (Eskimos, 2014)

3.3 Spas – Blue Lagoon

While Icelanders mostly visit the pools for recreation, relaxation, socializing, and athletic reasons, some geothermal spas are to be found around the country. The most prominent example is without a doubt the Blue Lagoon, which has gained world recognition in the past decades.

The Blue Lagoon was formed in 1976 (Gudmundsdóttir et al., 2010) as effluent geothermal water was discharged from the Svartsengi power plant into the adjacent lava field. In the following years, people suffering from the psoriasis skin disease discovered beneficial effects from bathing in the lagoon. As the word spread, the group of dedicated visitors grew larger, resulting in the construction of the first public bathing facilities and the opening of a special clinic for psoriasis patients in the period 1987-1995 (Blue Lagoon, 2014a). In 1999, the current facility was opened (Figure 11), with enlargement and redesign taking place in 2007 (Gudmundsdóttir et al., 2010). Over the nearly 4 decades since its formation, the Blue Lagoon has grown to become a major Icelandic tourist attraction.


FIGURE 11: The Blue Lagoon with the Svartsengi power plant in the background (left) (Hnefill, 2012) is rich in silica mud which has beneficial effects on the skin (right) (Photo: L.S. Georgsson)

The lagoon fluid is a mixture of sea- and groundwater coming from a depth of 2000 m, where the temperature is around 240°C (Blue Lagoon, 2014b). The fluid is rich in silica, which starts to polymerize and precipitate as the fluid cools and at the 37-39°C water temperature within the bathing section of the lagoon, a white silica mud layer forms on the bottom. The dermatological benefits of bathing in the lagoon are partly attributed to this white precipitate, which guests apply to their skin (Figure 11). Additional benefits derive from photosynthetic blue-green microalgae that thrive in the water (Suryata et al., 2010) – especially in summer when the organisms enjoy near perpetual daylight which can result in the lagoon changing its characteristic blue-white color to green.

TABLE 4: Concentrations of major substances in the Blue Lagoon

Substance	Concentration	
	mg/kg[a]	meq/kg
SiO_2	251	
Na	7,643	332.3
K	1,117	28.6
Ca	1,274	63.5
Mg	0.60	0.05
SO_4	31.8	0.66
Cl	15,740	443.4
F	0.18	0.01

a: From (Blue Lagoon, 2014c)

Table 4 shows the concentration of major substances in the Blue Lagoon (Blue Lagoon, 2014c). Due to its partial seawater origin, the fluid has a high salinity of 2.5% as evident from the high concentrations of chloride, sodium, calcium, and potassium. This high salinity contrasts with more conventional swimming pool water that has originated as groundwater or from low temperature geothermal reservoirs, as well as with the waters of the 4 hot springs and spas in Ecuador reported on in Table 1 (1 kg of water at 37-39°C is very nearly equivalent to a liter of water at the same temperature). However, the Blue Lagoon has a lower concentration of magnesium, sulphate and fluoride compared to the pools in Ecuador.

3.4 A geothermal beach – Nauthólsvík

In the summer of 2000, a new geothermal beach was opened in Reykjavik (Figure 12). The idea was to elevate the temperature of a small part of the North Atlantic Ocean with discharge water from the Reykjavik district heating system. To this end, two stone barriers were constructed into the Nauthólsvík cove, with a small opening between them to allow water in and out. Geothermal water flows into the lagoon between the barriers, elevating the ocean water

FIGURE 12: The Nauthólsvík geothermal beach (Nordic Adventure Travel, 2014)

temperature by a few degrees, so that the temperature of the lagoon can become as high as 18-20°C in the summer time (Snaeland and Sigurbjornsdóttir, 2010). The combination of warm ocean water and white sand, which has been imported from other parts of the country, allows for the creation of a beach atmosphere reminiscent of more southerly latitudes. The geothermal beach has proved popular with Icelanders, who also take advantage of a geothermal hot tub and a steam bath by the beach.

4. CLOSING REMARKS

The use of geothermal resources for bathing and swimming, for the purposes of personal hygiene, athletic practice and competition, recreation, relaxation, socializing, and therapeutic treatment has deep roots in human history and has evolved in different parts of the world to refined practices that have to some extent been shared in modern times, although different cultures may have certain distinct traditions. In Ecuador, geothermal bathing has mostly been focused on relaxation and therapy, and the country has a great potential for more wide-spread use of geothermal resources for this purpose. In Iceland, a stronger focus has been placed on swimming and recreation, although the other factors are important as well, and attendance to swimming centers is quite wide-spread due to a large-scale build-up of swimming centers in the 20th century. Although the pleasures of bathing in geothermal water have undoubtedly remained much the same through the centuries in all corners of the globe, modern day technology has made it possible for ever greater numbers to enjoy a geothermal bath, in better conditions. Many countries have taken advantage of this, while others have a great potential that awaits application.

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