Scientific discussion of selected viruses including COVID-19 in hot springs

1st **Yuly Sánchez**
PhD Candidate,
Escuela Colombiana de Ingeniería "Julio Garavito"
Bogotá, Colombia
yuly.sanchez@escuelaing.edu.co

2st **Mehrab Mehrvar**
Professor, Department of Chemical Engineering
Ryerson University
Toronto, Canada
mmehrvar@ryerson.ca

3st **Lynda McCarthy**
Professor, Department of Chemistry and Biology
Ryerson University,
Toronto, Canada
L3mccart@ryerson.ca

4st **Edgar Quiñones**
Professor and Director of PhD Program, Universidad de Cartagena,
Cartagena, Colombia
equinonesb@unicartagena.edu.co

5st **Luis Cheu**
Director of PhD in Engineering
Escuela Colombiana de Ingeniería "Julio Garavito"
Bogotá, Colombia
luis.rodriguez@escuelaing.edu.co

6st **Jairo Romero**
Director of center for environment studies
Escuela Colombiana de Ingeniería "Julio Garavito"
Bogotá, Colombia
jairo.romero@escuelaing.edu.co

***Abstract*— The objective of this study is to discuss selected viruses including COVID-19 and their potential elimination processes in hot springs. Studies in Colombia are limited and this scientific discussion provides necessary information regarding these viruses. This includes studies both in Colombia and international levels on the following subjects: i) the presence of viruses in hot springs, ii) the non- oxidative water treatment in hot springs, iii) the elimination strategies of viruses; and iv) the influence of COVID-19 in hot springs. The results of this discussion indicate that in order for thermal waters to guarantee the elimination of the viruses originating from faecal and non-faecal derived, and the COVID-19 virus, a monitoring scheme is required to identify an effective disinfection of waters to control these pathogens.**

Keywords—hot springs, viruses, faecally-derived, non-faecally derived, COVID-19.

I. INTRODUCTION

Hot springs are used for recreational, therapeutic, and medicinal purposes [31], and potentially benefit people's health by improving blood pressure, and to treat respiratory diseases, low-grade inflammation- and stress-related pathologies[16], pain, rheumatoid arthritis [36], osteoarthritis of the knee [14], psoriasis, and atopic dermatitis [29]. Hot springs also contain microorganisms that may contribute to other diseases. Thus, hot spring regulations are needed and the minimum thermal water quality standards in Colombia are in a draft law and currently only a water-exchange strategy is carried out as a system of "disinfection" treatment.

The Guidelines for Canadian Recreational Water Quality defined the viruses as submicroscopic organisms, much smaller in size than bacteria [21]. They are constructed of a nucleic acid core composed of either RNA or DNA and is surrounded by an external protein shell called a capsid. The pathogenic viruses of concern for recreational waters are enteric viruses—viruses that infect the human gastrointestinal tract and are shed in human faeces [21]. Viruses responsible for waterborne diseases are found in swimming pools, lakes, ponds, thermal pools / spas, rivers, and hot springs. These microorganisms enter the waters through contamination of faecal matter, body fluids (saliva, mucus), or skin flakes, by symptomatic or asymptomatic carriers [4]. The viruses that may be present of non-faecal origin are transmitted by direct person-to-person contact or indirectly, through respiration and physical contact with contaminated surfaces, as in the case of the new virus severe acute respiratory syndrome coronavirus (SARS – COV2) or COVID-19.

II. METHODOLOGY

In discussing the presence of viruses in medicinal thermal waters (hot springs), various sources available in the open literature were reviewed i) Adenoviruses, Hepatitis A, Noroviruses and Enteroviruses in hot springs, ii) COVID-19 in hot springs, iii) water treatment and iv) measures for controlling covid-19 in swimming pools and hot springs. The studies were required to meet pre-defined eligibility criteria.

The review endeavours to focus on viruses and measures for controlling COVID-19 in swimming pools and hot springs. Therefore, studies that did not report viruses in hot springs were excluded.

Further to the aforementioned eligibility criteria, of the reviewed 230 articles, only 16 articles were relevant on the topic of virus in hot spring. In addition, information was harvested from official national and international websites.

III. PRESENCE OF VIRUSES IN HOT SPRINGS

The main pathogenic microorganisms found in recreational waters are bacteria, viruses, fungi, and protozoa. (Figure 1), from human, animal, or natural microorganisms waste that exists in recreational waters [21].

The World Health Organization's (WHO) "Guidelines for Safe Recreational Water Environments" [37] presented the possible microbial dangers observed in swimming pools and similar environments, where it showed the viruses that can be of faecally-derived and non faecally- derived origins, as shown in Figure 1.

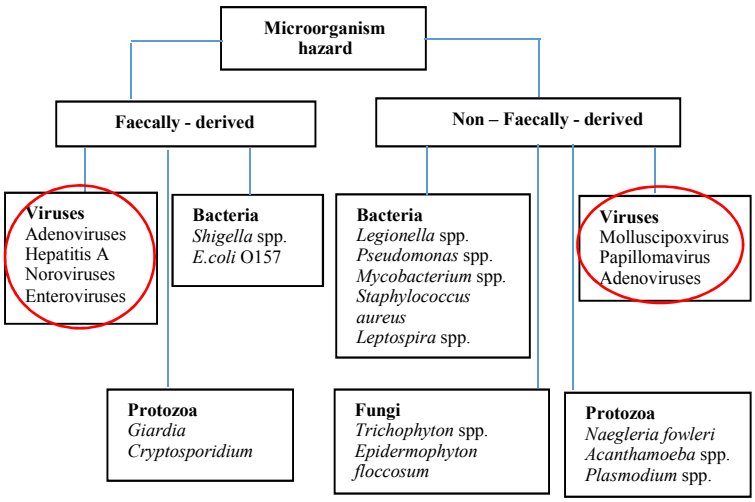

Figure 1. Possible microbial hazards in swimming pools and similar environments [37].

A. Faecally-derived microorganisms

Accidental faecal discharges can occur in recreational waters or hot springs, which can be caused by bathers, the entry of animals, or occur naturally. Faecal contamination in the water and around the pool contribute to pathogenic bacteria, viruses, fungi, and protozoa, and can be acquired by ingestion, inhalation, or contact [37].

Viruses

a) Adenoviruses

Human adenoviruses (HAdV) are DNA viruses found in recreational waters. Human adenovirus 41 (HAdV-41) is the most common serotype detected and is a leading cause of acute diarrheal disease [32].

According to the Guidelines for Safe Recreational Water Environments of WHO "there are over 50 types of adenoviruses, and while some may cause enteric infections and are therefore, shed in faeces, they are also associated with respiratory and ocular symptoms and non-faecally-derived transmission [37].

Types 40 and 41 cause gastroenteritis in young children, but there is no documented association with waterborne transmission" [37].

A study conducted in the hot spring areas of Taiwan found that the highest prevalence of HAdVs was in the public area and bathing in hot spring facilities. Of the 57 samples modified in the study from four different geological sites, 16 samples (28.1%) contained HAdV-41 [32].

b) Hepatitis A

The Guidelines for Canadian Recreational Water Quality defined the "Hepatitis A virus (HAV) as a small (25–28 nm), non-enveloped RNA virus whose major target organ is the liver. The majority of HAV infections are asymptomatic. Illness is most frequently reported among adults. Symptoms include malaise and fever, followed by nausea, vomiting, abdominal pain and, ultimately, jaundice. Infection is typically self-limiting" [21].

In 1997, 7 cases of hepatitis A were reported in Australia in young men (age range 8–15 years) [34], who had been in an outdoor pool treated with hydrogen peroxide. In that study, the virological analyzes of water samples were not analyzed [4].

c) Noroviruses

The Guidelines for Canadian Recreational Water Quality defined the "Noroviruses as small (27–30 nm), non-enveloped RNA viruses. Norovirus infection is considered to be the leading cause of viral gastroenteritis outbreaks (from all sources) in the United States and the United Kingdom. The primary symptoms of illness are diarrhoea, vomiting, headache and muscle ache. The onset of projectile vomiting is considered a characteristic trait of norovirus infection. Asymptomatic infections with norovirus are rare" [21].

d) Enteroviruses

The Guidelines for Canadian Recreational Water Quality defined the "Enteroviruses as a large group of small (20–30 nm), non-enveloped RNA viruses belonging to the family Picornaviridae. Members of this group include polioviruses, coxsackieviruses, echoviruses and several yet unclassified enteroviruses. Many enterovirus infections are asymptomatic. The symptoms and severity of illness vary considerably among the individual virus types and serotypes. The most commonly observed health effects are vomiting, diarrhoea, febrile flu-like symptoms, malaise, respiratory disease, headache and muscle ache" [21].

In 1964, the presence of the Coxsackie BL virus, pathogenic enterovirus, was revealed in a congested area in the city of Toronto, Canada, with an influx of bathers [22].

In June 2015, Centers for Disease Control and Prevention (CDC) [6] published a comprehensive set of science-based and best-practice recommendations to reduce risk for illness and injury at public, treated recreational water venues. During the

period from 2011 to 2012, only 175 cases of Norovirus and 32 cases of Adenovirus were reported in recreational water.

According to WHO [37], viruses cannot multiply in water and therefore, their presence must be a consequence of contamination and biological host. When bathers increase faecal discharge, it is best to ban pool use until contaminants are inactivated and have adequate disinfection treatment.

B. Non-Faecally derived microorganisms

The WHO [37] established that the main source of the spread of viruses and fungi in swimming pools and similar environments is from infected bathers. Viruses include molluscipoxvirus (which causes molluscum contagiosum), and papilloma virus (which causes benign skin tumours and warts), while various species of fungi of the genus *Trichophyton* (which cause superficial fungal infections of hair, nails and skin), and *Epidermophyton floccosum* are transmitted by direct person-to-person contact or indirectly through physical contact with contaminated surfaces.

The most important means for controlling the spread of infection is to educate bathers about diseases, emphasizing the importance of limiting contact between infected and uninfected people, and if infected receiving prompt medical treatment. Frequent cleaning and disinfection of surfaces in facilities prone to contamination can also reduce the spread of disease [37].

C. Other viruses

While the current study focussed on viruses in medicinal thermal waters, it is of interest to note that viruses exist in extreme environments not utilized by humans and will be briefly mentioned here.

In acidic spring (87 to 93°C, pH 1.5) in Pozzuoli, Italy, a new family of viruses known as *Ampullaviridae* infect archaea of the genus Acidianus, was found.[20]. Two genomic fragments of novel, positive-strand RNA viruses that infect archaea were first discovered in an acidic hot spring in Yellowstone National Park (YNP). These hot springs harbour low-complexity cellular communities dominated by several species of hyperthermophilic archaea. [3].

Viral sequences were retrieved from six metagenomes of acidic and high temperature hot springs from Italy, Iceland and YNP (USA), revealing a wide distribution of four archaeal viral families, *Ampullaviridae, Bicaudaviridae, Lipothrixviridae* and *Rudiviridae*. [19].

There is also a report from Japan about the novel features of medusavirus, a large DNA virus newly isolated from hot spring water. [39].

D. Water treatment in hot springs

The control of viruses and bacteria in recreational waters is achieved with adequate treatment, influenced by adequate disinfection with chlorine or other disinfectants [37].

Most thermal waters have lost their natural properties due to the addition of chemicals like chlorine and other chemicals. Only some natural thermal water pools retain their natural physical and chemical properties [35].

The chemical disinfectants that are used most frequently include chlorine (hypochlorite or, chlorinated isocyanurates), chlorine dioxide, bromochlorodimethylhydantoin (BCDMH), ozone and ultraviolet (UV) radiation (with ozone and UV usually being used in combination with a chlorine- or bromine-based disinfectant), and UV radiation alone [2]. Water treatment practices vary widely around the world, as do the levels of chemicals that are currently considered to be acceptable in order to achieve adequate disinfection while minimizing user discomfort [37].

In Colombia, the regulations for hot springs are insufficient and do not have specific parameters for water quality. Article 6 of Decree 554 of 2015, of the Ministry of Health and Social Protection establishes, [9] "The general physical - chemical and microbiological parameters of the water will not be required of the ponds that store thermal waters and therapeutic uses. The Ministry of Health and Social Protection will define these parameters".

In countries such as Canada and Germany, the disinfection of thermal waters is carried out with recirculation systems. (Table I) [1, 17].

The natural flow pools lined with natural rocks do not use chemicals where the conditions of a natural body of water are purified by biological and physical treatment. They are often not subject to regulations like health inspections [1].

The regions of Galicia and Murcia in Spain only allow water to be renewed for thermal water treatment [15,23] and countries like Cuba do not specify any treatment of its waters [11] (Table 1).

Table 1 presents a compilation of international regulations for the treatment of thermal waters, where water renewal or water disinfection is carried out.

TABLE I. INTERNATIONAL REGULATIONS OF SOME COUNTRIES FOR HOT SPRING TREATMENT

SPAIN			**CUBA**	**WHO**
Galicia	***Cataluña***	***Murcia***	***Estatal***	***Mundial***
Order of November 5, 1996 [15]	Decree 271 of 2001, of October 9 [5]	Decree 55 of July 11, 1997 [23]	NC 93-09:85 NC 93-28:88 [11]	Guidelines for safe recreational water environments, volume 2, 2006. [37]
The renewal of all water must be guaranteed in the appropriate time.	The products or methods used for disinfection must be stated.	Continuous water renewal	Does not establish treatment	In some natural spas utilizing thermal and mineral waters it may not be possible to treat the water in the usual way (i.e. by recycling or disinfection) because the agents believed to be of benefit, such as sulfides, would be eliminated or impaired. These natural spas, therefore, require non-oxidative methods of water treatment.

CANADA		PORTUGAL	GERMANY
Ontario	*Alberta*	*National*	*National*
Recreational Water Reference Document, 2019 [24]	Alberta Regulation 204/2014 [1]	Ordinance No. 1220/2000 of December 29 [25]	DIN 19643-1 Treatment of water of swimming pools and baths [17]
Adequate disinfection of water is one of the most important factors to help reduce risk of illness.	A pool must be operated and maintained by the owner or the owner's agent, if any, or the pool operator so that the water it contains is microbiologically, chemically and physically safe for use.	Preservation of the quality of the water up to the points of its use.	Disinfection with chemical agents.

The treatment of hot springs without external chemical agents include the following:

Water exchange: It consists of making a replacement of the hot springs in swimming pools [30], occurs in regions of Galicia and Murcia in Spain [15,23]. In case, where the aquifer is small, it is unsustainable [28].

Ozone utilization: According to the WHO [31], it is an oxidizing and disinfecting agent for the treatment of swimming pool water; it is generated on site and is potentially dangerous, especially for operators. Thus, it is not suitable for use as a residual disinfectant. In recreational water treatment, it is common to combine UV treatment and ozonation for disinfection [8]. The ozone that is generated by ultraviolet (UV) radiation is used for the treatment of spa and swimming pool waters (mainly residential) and others by technology based on what is established in the German standard DIN 19643-1 [17, 27] "Treatment of water of swimming pools and baths"

UV radiation: The UV radiation process purifies the circulating water, without leaving a residual disinfectant [2, 31]. It inactivates microorganisms and breaks down some contaminants. Ultraviolet light disinfection is a viable and beneficial alternative to chlorination for both water and wastewater treatment [2,13].

There are many studies on hot springs that show the efficiency of using non-oxidative disinfection methods such as UV radiation for the inactivation of potential pathogenic species of dermatophyte fungi, including *T. mentagrophytes and T. rubrum* [33].

E. COVID - 19

According to the Centers for Disease Control and Prevention (CDC), there is no evidence that the virus that causes COVID-19 can be transmitted to people through water in swimming pools, hot tubs, or playgrounds. Furthermore, the proper functioning of these aquatic sites and disinfection of the water (with chlorine or bromine) should inactivate the virus [7].

Matthew Miller, a professor of biochemistry at McMaster University in Hamilton, Canada, who studied the new coronavirus, stated that "the risk of contracting the pool water virus is very low," because viruses like COVID- 19 are different from viruses like polio or other pathogens like cholera that are spread in water [10].

When the coronavirus pandemic started, authorities all around the world ordered the closure of all swimming pools, hot spring, and beaches for recreational use as a sanitary precautionary measure to prevent the spread of COVID-19.

José Rodrigo Toro Montes, mayor of Santa Rosa de Cabal - Colombia, announced the temporary closure of the city's thermal parks, as a measure to prevent the spread of the Coronavirus [26]. In Canada and other countries, the same measure was taken [10].

The risks associated with COVID-19 are related to the interaction among people. According to the WHO [38], a person can get COVID-19 from contact with someone who is infected with the virus. The disease is spread mainly from person-to - person through droplets that fly out of an infected person's nose or mouth by coughing, sneezing, or talking.

F. Measures for controlling covid-19 in swimming pools and hot springs

Currently, the European Waterpark Association, an association of water parks and spas in Europe, is presenting a two-stage reopening plan for governments and authorities to implement [12]. Other countries such as China, United States, Australia, and Austria are following the same. This reopening plan includes the following:

Stage 1: Reopening of waterparks and spas with reduced visitor numbers.

- The cashiers will be protected by cough screens.
- Demarcate at 1.5 m intervals, the pay area, sauna booths, in front of slides or other attractions, and restaurant tables. Only 2 people maximum at the tables (except for families).
- Only 2/3 of the lockers will be occupied (only one guest at a time).
- Saunas will not be enabled.
- In the self-service restaurant area, only drinks and packaged foods can be taken.
- Water courses are only allowed if a minimum distance of 1.5 is maintained.
- Cleaning and hygiene plans must be adapted to the increased requirements of virus prevention.
- General massages and physical therapy treatments can only be offered if this is again allowed in general physical therapy practices.
- You must inform spa guests of notices about increased virus requirements.
- Soap dispensers must be attached to sinks (if not available) and filled in regularly. [12].

Stage 2: Reopening of waterparks and spas in normal operation.

- The simultaneity factor (the number of bathers present at the same time) is specified by the number of available lockers.
- The distance and hygiene measures must be kept until the responsible authorities revoke the contrary. [12].

According to the "Guidance for swimming pools and whirlpools", the government of Alberta in Canada [18], it is more restrictive in social distancing, which establishes 2 m and a prior reservation and additionally recommends the following:

- If wrist-bands are required, the operator should use self-applied bracelets and provide waste containers at the facility exit point for their disposal.
- Provide hand sanitizer (60% alcohol or higher) at entry and exit points, and encourage patrons to also bring their own.
- Limit the use of pool toys for flotation aids and lessons only.
- Clean and disinfect shared equipment and launder any rental towels between each use.
- Patrons should not share uncleansed towels, goggles, or any other equipment other than with family members.
- Chlorinated pool water is an effective disinfectant and the risk of transmission from contact with properly treated pool water is considered minimal. Salt water pools are also chlorinated. [18]

IV. CONCLUSIONS AND RECOMMENDATIONS

In the revised international regulations, thermal water treatment is carried out to control microorganisms and viruses in thermal waters and only "naturally flowing thermal waters" do not use chemical products if the conditions of a natural body of water is purified by biological and physical treatment. These hot springs are not subject to regulations such as health inspections [1].

The results of the present scientific discussion indicate that, in order for thermal waters to guarantee the elimination of viruses originating from faecal and non-faecal derivatives and the COVID-19 virus, a monitoring scheme is required to identify the effective disinfection of the waters to control pathogens. In cases where maintaining natural properties are required, non-oxidative methods such as UV, ozone treatments, etc are used.

The proper treatment of hot springs depends not only on the operators of the swimming pools, but on the culture of the bathers, promoting the use of the shower and bath before the pool.

The risks associated with COVID-19 are related to person-to-person interaction through drops coming out of an infected person's nose or mouth when coughing, sneezing, or talking. [38]. In the case of the facilities of swimming pool centers, spas, and hot springs that go to the bathing areas, it is important to have a collective awareness of respect for social distancing, daily cleaning, and comprehensive disinfection of surfaces and common areas [12,18].

The efficiency of eliminating viruses in hot springs depends on the disinfection of their waters. Conventional procedures, such as chlorination and its chemical derivatives, are commonly used in thermal water pools for recreational use. However medicinal uses avoid using them so as not to alter the physical-chemical characteristics of the thermal water and preserve its natural properties.

Frequent replacement of hot springs is the most common treatment in Colombia to preserve the quality of the hot springs, due to the constant outcrop of the water, which controls the microbiological quality of the water, which is not yet regulated.

Studies on viruses in hot springs continue to be investigated.

ACKNOWLEDGMENT

The financial support of the Canadian Queen Elizabeth II Diamond Jubilee Scholarship Program (QES), Ryerson University, and University of Cartagena is greatly appreciated.

REFERENCES

[1] Alberta (Canada) Public Health Act. Public Swimming Pools Regulation. Alberta Regulation 204/2014. Available online: https://www.qp.alberta.ca/1266.cfm?page=2014_204.cfm&leg_type=Regs&display=html. (Accessed on 30 March 2020).

[2] Barrera, M., Mehrvar, M, Gilbride, K.A., McCarthy, L.H., Laursen, A.E., Bostan, V., Pushchak, R. "Photolytic treatment of organic constituents and bacterial pathogens in secondary effluent of synthetic slaughterhouse wastewater". Chemical Engineering Research and Design. Vol. 90, pp 1335–1350, 2012.

[3] Bolduc, B., Shaughnessy, D.,Wolf., Y, Koonin, E., Roberto, F., & Young, M. "Identification of Novel Positive-Strand RNA Viruses by Metagenomic Analysis of Archaea-Dominated Yellowstone Hot Springs". Journal of Virology. Vol. 86, pp 5562 – 5573, 2012.

[4] Bonadonna, L. and La Rosa, G. "A Review and Update on Waterborne Viral Diseases Associated with Swimming Pools". International Journal of Environmental Research and Public Health. Vol.16, pp 166 – 177, 2019.

[5] Cataluna (Spain) Department of Health and Social Security. Decree 271 of October 9, 2001. "By establishing the technical-sanitary requirements for balneotherapy and hydrotherapy services". Available online: https://global.economistjurist.es/BDI/class/descarga.php?id=36341. (Accessed on 30 March 2020).

[6] Centers for Disease Control and Prevention. "Morbidity and Mortality Weekly Report (MMWR)". (2015). Outbreaks of Illness Associated with Recreational Water — United States, 2011–2012. Available online: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6424a4.htm. (Accessed on 20 June 2020).

[7] Centers for Disease Control and Prevention. "Coronavirus Disease 2019 (COVID-19)- Section Water". Available online: https://www.cdc.gov/coronavirus/2019-ncov/faq.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fphp%2Fwater.html#COVID-19-and-Water. (Accessed on 20 June 2020).

[8] Cheema, W., Kaarsholm, K. and Andersen, R. "Combined UV treatment and ozonation for the removal of by-product precursors in swimming pool water". Journal Water Research. Vol. 110, pp141-149, 2017.

[9] Colombia Ministry of Health and Social Protection. "Article 6, Decree 554". (2015). Available in: https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=61202. (Accessed on 20 May 2020).

[10] CTV News Canada. "Is it safe to swim in a pool during the COVID–19 pandemics?". June 8 of 2020. Available online:https://www.ctvnews.ca/health/coronavirus/is-it-safe-to-swim-in-

a-pool-during-the-covid-19-pandemic-1.4975060. (Accessed on 10 June 2020).

[11] Cuba. (1998). NC93-09:85, NC 93-28:88. Sanitary water control subprogram. Available online: http://www.sld.cu/galerias/pdf/sitios/rehabilitacion-bal/subprograma_control_sanitario_del_agua.pdf. (Accessed on 30 March 2020).

[12] European Waterpark Association E.V., Global Wellness Institute, (2020). "Two-Stage Plan of the European Waterpark Association E.V. for the Reopening of Waterpark and Spas". Germany. Available online: https://globalwellnessinstitute.org/wp-content/uploads/2020/04/Two-Stage-Plan-of-the-European-Waterpark-Association-for-the-Reopening-of-Waterparks-and-Spas2-27.pdf. (Accessed on 20 May 2020).

[13] Fang, Z., Mehrvar, M and Mozafarri, F. "Mixing time in an agitated multi-lamp cylindrical photoreactor using electrical resistance tomography". Journal of Chemical Technology & Biotechnology. Vol. 83, pp 1676–1688, 2008.

[14] Fioravanti,A.,Giannitti,C.,Bellisai,B.,Iacoponi,F.,Galeazzi,M."Efficacy of balneotherapy on pain, function and quality of life in patients with osteoarthritis of the knee". International Journal of Biometeorology.Vol.56, pp 583-590, 2012.

[15] Galicia (Spain) Ministry of Health and Social Services. Order of November 5, 1996. By which the sanitary authorization of the spa establishments of the Autonomous Community of Galicia is regulated. Available online: https://www.xunta.gal/dog/Publicados/1996/19961120/AnuncioE01A_es.html. (Accessed on 30 March 2020).

[16] Gálvez, I., Torres, S. and Ortega, E."Balneotherapy, Immune System, and Stress Response: A Hormetic Strategy?". International Journal of Molecular Sciences. Vol. 19, pp 1-19, 2018.

[17] Germany. DIN 19643-1. "Treatment of water of swimming pools and baths –Part 1". Available online: https://www.beuth.de/de/norm/din-19643-1/2936483 (accessed on 20 February 2020).

[18] Government of Alberta, 2020. "COVID-19. Guidance for Swimming Pools and Whirlpools". Available online: https://www.alberta.ca/assets/documents/covid-19-relaunch-guidance-swimming-pools-and-whirlpools.pdf. (Accessed on 20 May 2020).

[19] Gudbergsdóttir, S.,Menzel, P., Krogh, A., Ypung Mark, & Peng Xu. "Novel viral genomes identified from six metagenomes reveal wide distribution of Archaeal viruses and high viral diversity in terrestrial hot springs". Environmental Microbiology. Vol. 18, pp 863 – 874, 2016.

[20] Häring, M., Rachel, R., Peng, X., Garret t, R., & Prangishvili, D. "Viral Diversity in Hot Springs of Pozzuoli, Italy, and Characterization of a Unique Archaeal Virus, Acidianus Bottle-Shaped Virus, from a New Family, the Ampullaviridae". Journal of Virology. Vol. 79, pp 9904 – 9911, 2005.

[21] Health Canada. "Guidelines for Canadian Recreational Water Quality". Third Edition. pp 1-101, 2012.

[22] McLean D.M., Larke R.P.B., McNaughton G.A., Best J.M., Smith P. "Enteroviral Syndromes in Toronto, 1964". Can. Med. Assoc. J. Vol. 92, pp 658–661, 1965.

[23] Murcia (Spain) Department of Health and Social Policy. Decree 55 of July 11,1997. On the sanitary conditions of Spas, Thermal Baths and Thalassotherapy Establishments and the application of Peloids. Available online:https://www.murciasalud.es/legislacion.php?id=15238&idsec=1935. (accessed on 30 March 2020).

[24] Ontario (Canada) Ministry of Health and Long-Term Care., (2019). "Recreational Water Reference Document". Available online: http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/reference/recreational_water_en.pdf. (accessed on 30 March 2020).

[25] Portugal Ministries of Economy and Health. (2000). "Ordinance No. 1220/2000 of December 29". Establishes rules regarding the conditions that natural mineral waters and spring waters, in catchment, must obey in order to be considered bacteriologically proper. Available online: https://dre.pt/pesquisa/-/search/662105/details/maximized. (Accessed on 30 March 2020).

[26] RCN Radio, (2020). "Thermal water complexes in Risaralda closed due to contagion alert". Available online: https://www.rcnradio.com/colombia/eje-cafetero/cierran-complejos-de-aguas-termales-en-risaralda-ante-alerta-de-contagios. (Accessed on 10 Jun 2020).

[27] Rip G. "Chemistries of Ozone for Municipal Pool and Spa Water Treatment. Facts and Fallacies. Rice International Consulting Enterprises". Journal of the Swimming Pool and Spa Industry .Vol 1, pp 25–44, 1995.

[28] Romano Spica V. (2017). " Hot spring water in pool: The personalization of treatment from MFDNA Fingerprinting to nanotechnologies". Public Health Unit – University of Rome "Foro Italico", Italy. Present in 7th International Conference on Swimming Pool and Spa, Greece.

[29] Ronni, W.; Orion, E.; Matz H."Balneotherapy in dermatology". Dermatologic Therapy, Vol. 16, pp 132–140, 2003.

[30] Sánchez Y., & Cheu L (2019). "Estado del arte de la calidad del agua termal". ACOFI. Available in: https://acofipapers.org/index.php/eiei2019/2019/paper/view/3018. (Accessed on 20 May 2020).

[31] Sánchez, Y., & Chivata, N. (2017). "Detection of presence of Pseudomona aeruginosa and control measures in thermal waters". Present in 7th International Conference on Swimming Pool and Spa, Greece.

[32] Shih, Y., Tao, C., Tsai, H., Huang, W., Huang. T., Chen, J., Chiu, Y., Hsu, T., and Hsu, B. "First detection of enteric adenoviruses genotype 41 in recreation spring areas of Taiwan". Environmental Science and Pollution Research. Vol. 24, pp18392–18399, 2017.

[33] Sisti, M, Pieretti, B, De Santi, M & Brandi G." Inactivation of pathogenic dermatophytes by ultraviolet irradiation in swimming pool thermal water". International Journal of Environmental Health Research. International. Vol. 24, No. 5, pp 412–417, 2014.

[34] Tallis G., Gregory J. (1997). "An outbreak of hepatitis A associated with a spa pool". Communicable Diseases Intelligence. Vol. 21.353–354.

[35] Valeriani, F., Marika, L and Spica, R. "Recreational Use of Spa Thermal Waters: Criticisms and Perspectives for Innovative Treatments". International Journal of Environmental Research and Public Health. Vol. 15, pp 1- 22, 2018.

[36] Verhagen, A.P, Bierma-Zeinstra, S.M, Boers, M, Cardoso, J.R, Lambeck J, de Bie R.A, de Vet H.C. "Balneotherapy (or spa therapy) for rheumatoid arthritis (Review)". Cochrane Database. pp. 1-52, 2015.

[37] WHO (2006). World Health Organization. "Guidelines for safe recreational water environments. Swimming pools and similar environments". Volume 2. Available online: http://apps.who.int/iris/bitstream/10665/43336/1/9241546808_eng.pdf (accessed on 29 September 2019).

[38] WHO, World Health Organization (2020). How is COVID-19 spread?. Available online: https://www.who.int/es/emergencies/diseases/novel-coronavirus-2019/advice-for-public/q-a-coronaviruses. (accessed on 10 Jun 2020).

[39] Yoshikawa, G., Mathieu, R., Song, C., Kayama, Y., Mochizuki, T., Murata, K., Ogata, H., & Takemura, M."Medusavirus, a novel large DNA virus discovered from hot spring water". Journal of virology. Vol 93, pp 1 – 25, 2019.