C1) Safe water supply in buildings. The importance of risk prevention

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Abstract

According to the Bonn Charter Framework, a safe water supply should be based on management control systems, included in a Water Safety Plan (WSP), making use of the best available scientific knowledge and the context of the different countries where they are to be implemented. Safe water supply systems in buildings are particularly important and special attention needs to be given to problems such as microbiological contamination, which is becoming more and more frequent in Mediterranean countries due to global warming and climate changes. The basic procedure to guarantee water safety involves identifying risks to the supply systems, to prevent such situations as biofilm formation, cross contamination or other kinds of contamination due to lack of maintenance. This paper describes the case of a Portuguese spa resort – *Termas das Caldas da Rainha* – where regular water analyses revealed the presence of *Legionella* in the spa water used for treatment. The procedures to disinfect the system took almost two years and included chemical and thermal disinfections, changing pipes, structural changes, monitoring, etc.. In spite of the absence of a WSP that would include all the technical measures required, it should be noted that the necessary risk prevention was basically achieved through the analytical control implemented. Thanks to that, and as confirmed by an epidemiological research carried out, no human case of *Legionnaire*'s disease has been reported.

Keywords

Water supply; thermal installation; *Legionella;* Water Safety Plan.

1 Introduction

In the international context of the Bonn Charter Framework, safe water supply should be based on management control systems, included in a Water Safety Plan, considering the best available scientific knowledge and the circumstances of each country.

Efficiency is ensured through the structure of the system, with assignment of responsibilities and the establishment of relations between the various process phases, from captation to domestic distribution.

Water safety management in the various systems generally implies drawing up drinking water quality safety schemes to assess system risks and mitigate them, and to measure water quality by monitoring relevant standards.

2 The water safety plans and the situation in Portugal

2.1 Water safety plans and *Legionella*

Safety plans, with supplementary surveillance and/or independent inspections, offer adequate risk assessment, giving priority to defining minimisation and control mechanisms. Three essential stages are:

1 – Hazard evaluation and risk assessment;
2 – The specification of monitoring and control plans to ensure risk minimisation;
3 – Development of efficient management systems and operating schemes, with the prediction of possible emergency scenarios and strategies for tackling them.

In terms of monitoring, microbiological parameters are especially relevant, the more so since climate change predictions envisage alterations that are likely to potentiate micro-organism proliferation, as a function of the ambient temperature. Climate change could have repercussions for water distribution system fixtures and fittings in buildings, heightening the risk of bacterial colonies and putting the quality of drinking water at risk.

This situation can be noted in relation to *Legionella Pneumophila* which is a ubiquitous bacterium in natural ecosystems. It occurs in lakes, rivers, wells, springs and streams and can develop opportunistically in certain artificial environments, such as urban water supply systems, whenever there are favourable conditions for it to multiply.

Some natural environmental parameters restrict the colonisation and multiplication of bacteria, while other artificial ones favour their increase and spread. Natural conditions propitious to their occurrence are linked with water temperatures of between 20 and 45ºC, high algae and protozoa (such as *amoebae*) concentrations and the presence of certain nutrients, like iron and nitrogen. In artificial systems the main factors encouraging their development are: the presence of nutrients, formation of biofilms, dead points or water stagnation, temperatures between 20 and 50ºC and the by-products of corrosion.

Legionella is basically associated with two diseases: Legionnaire's Disease, or Legionellosis, and Pontiac fever. The first is the commoner manifestation of infection. It develops as a typical pneumonia, having an incubation period of 2 to 10 days. It appears as an acute form, and can be fatal. Table 1 gives a comparison of the two forms of illness associated with *Legionella* (Silva-Afonso, A, and Lança, I., 2006).

It should also be noted that 48 species of *Legionella* have been found to date, with around 65 serogroups, 20 of which are linked to disease in humans. Only the latter can cause illness in people exposed to contaminated water (Silva-Afonso, A., and Lança, I., 2007). As this is a ubiquitous bacterium, risk is generally assessed on the basis of "colony forming units" per unit of volume (CFU/ml).

Table 1 – Typical features of *Legionella Pneumophila* illnesses

	Legionnaires Disease	Pontiac Fever
Occurrence	1-5%	95%
Incubation period	2—10 days	One or two days
Symptoms	Fever, cough, muscle pain, chills, headache, chest pain, vomiting, diarrhoea, confusion, coma	Fever, cough, muscle pain, chills, headache, chest pain, confusion
Effect on lungs	Pneumonia	Pleurisy. No pneumonia
Effect on other organs	Kidneys, liver, intestinal tract, nervous system	None
Deaths	15-20% (up to 80% in susceptible persons)	None

Legionella is an airborne infection (respiratory), spread by inhaling bacteria-contaminated water droplets (aerosols or sprays), and it is important to note that it is not spread by personal contact nor by eating contaminated food. Cases have been reported, however, of inhalation followed by ingestion of contaminated water.

2.2 The situation in Portugal

Policies to prevent *Legionella* are relatively recent in Portugal, and its control is not a parameter usually considered in monitoring schemes. As there is as yet no specific legislation, prevention measures have tended to be implemented through the intervention of public health services. This intervention includes risk assessment and intervention in systems where pools of *Legionella* may form be easily spread.

These interventions have taken place in health facilities (hospitals and health care units), catering establishments and municipal amenities (baths, ornamental fountains, sprinkler systems, etc...). There have been public information campaigns (awareness leaflets) and handbooks on control and disinfection procedures have been published, focusing on risk assessment and management.

In addition, efforts have been made to train public health technicians at various levels, bearing in mind their involvement in terms of diagnosis, epidemiology and the environment. In terms of doctors, attention has been drawn to the importance of diagnosis and notification of cases of Legionnaires' disease, like the Compulsory Notifiable Disease, and the European Working Group for Legionella Infections (EWGLI). In relation to public health doctors, the main interlocutors with the general public, emphasis is placed on competence in the sphere of epidemiological surveys and inspections/audits of premises and facilities.

Other agents in the sector also play a relevant part in this domain. Nurses, for instance, are involved in epidemiological surveys, while environmental health officers work in the area of environmental enquiries and sample collection (prevention programmes). Finally, the importance of the input of service technicians who maintain equipment, especially in health care provision units, cannot be understated.

As in other countries, the Portuguese public health authorities are compiling databases of the amenities and facilities at risk, paying particular heed to situations where their location is liable to cause outbreaks of contamination. Although only in the very early stages, routines for the prevention of *Legionella* are beginning to be established, in private and public establishments alike, with special reference to health care provision units and spa resorts.

3 Case study

3.1 Introduction

A case that occurred in Portugal, in the "Hospital Termal das Caldas da Rainha" (Figure 1), may be regarded as a typical example of *Legionella Pneumophila* associated risk management. It took several interventions to correct the problem, and these were carried out between August 2004 and January 2006.¨

Figure 1 – "Hospital Termal das Caldas da Rainha". Appearance today

Even though there was no formal WSP, the procedures undertaken basically conformed with those that should be included in such a plan. The lack of human contamination by *Legionella* in this particular case demonstrates the importance of implementing this type of plan, and its efficacy.

3.2 Background information on the "Hospital Termal das Caldas da Rainha"

The sulfurous waters of Caldas da Rainha have been famed since earliest times. They were used by the Romans, as various archaeological documents confirm.

Founded in 1485 by the queen, D. Leonor, the Hospital Termal das Caldas da Rainha is the oldest of its kind in the world. It has been in existence for five centuries (Figure 2).

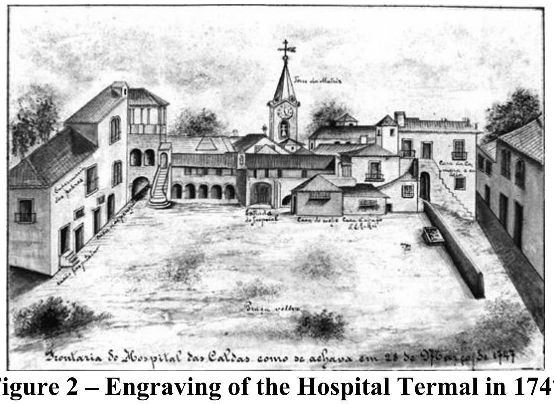

Figure 2 – Engraving of the Hospital Termal in 1747

Historical records show that D. Leonor, wife of the king, D. João II, was travelling in the region in 1484 when she saw a group of local people bathing in warm, muddy water. She ordered the carriage to stop and asked to know what was going on. She was told that it was treatment. They told her that those waters were held to be miraculous; they could soothe pain and heal wounds, and there had even been cases of paralysed individuals who walked again.

The queen was suffering at the time from an ulcer on her chest that would not close, and she resolved to try these waters (Figure 3). Her ulcer healed in just a few days. In the light of this, she ordered a building to be erected there, with a view to treating the sick - the Hospital Termal das Caldas da Rainha (Figure 4), also known as the Hospital Termal Rainha D. Leonor.

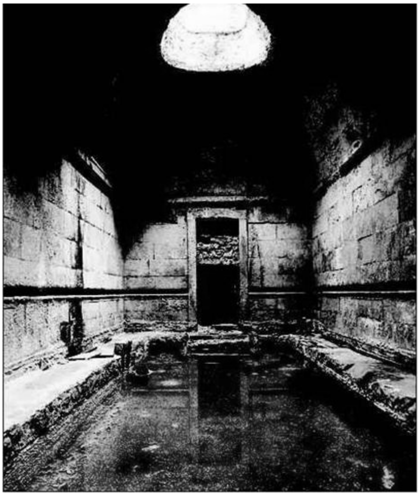

Figure 3 – 15th century pool where queen D. Leonor was treated (now a historical monument)

Figure 4 – Hospital Termal (19th century)

The spa is famous for the qualities of its waters, which are particularly indicated for treating arthrosis, inflammatory rheumatism, gout, post-trauma sequelae, sinusitis, chronic rhinitis, chronic laryngitis, chronic bronchitis and bronchial asthma.

3.3 The facilities

The Caldas da Rainha spa water contains calcium sulfide, sodium chloride, is sulfated, sodic, has magnesium and hydrogen sulfide and is slightly fluorated. It is warm (34º/35º), rich in mineral salts (about 3 000 mg/l), almost neutral (pH=6.9) and bacteriologically fit for spa purposes.

The spa facilities include simple immersion baths (Figure 5) and air bubble baths, maniluvium douche, pediluvium douche, Vichy douche, nasal douche (Figure 6), pharyngeal spraying, simple and sonic aerosols, etc.

Figure 5 - Aquatherapy

Figure 6 - Inhalotherapy

The spa water plumbing system has been overhauled over the years. But there are still old sections and dead points, and old fixtures (some even classed as having historic heritage value, to be preserved), all of which increases the risks arising from consolidated bacterial colonisation.

There are new two mains pipes which are used alternately, so that each can be disinfected with ozone, every day. These two mains pipes bring the spa water to a substation (SE2), whence it is distributed to the new baths/Vichy bathing area and the other facilities. This substation is disinfected with steam at 120 ºC, and all the downstream pipes are made of stainless steel.

Before the inhalations, there is a further disinfection (substation SE1) with water vapour at 80ºC and neutral disinfectant, phosphated with cationic surfactants – not anionic – P3, (P3 and hypochlorite have been used alternately since 2004).

3.4 Case description

Despite the various regular disinfecting procedures, the hospital was closed in 1997 when contamination with *Pseudomonas aeruginosa* was found during routine analysis. It remained closed for four years. Once it was re-opened in 2001, a safety plan was put in place. This included a physical-chemical and microbiological monitoring plan and a maintenance scheme, under which specific disinfecting procedures were implemented in the piping to get rid of bacterial colonies.

Legionella was one of the parameters looked for, and it was not found until 23 July 2004. In fact there were several positive analyses for this bacterium on that date (in substation SE2, in the tank of substation SE1 and in the inhalations).

Once these results were known (12 August), and considering the kind of contact with aerosols that all the amenities undergo, the Public Health department, through the Health Authority, ordered the immediate suspension of the Hospital's activity and a disinfection programme with sodium hypochlorite was started. The Hospital remained closed until safe analytical results were obtained (about six months later).

In fact, after the closure, all the procedures and the entire facility were examined, and it was decided to carry out shock treatments, disinfecting the whole system (paying particular heed to the water tanks and the sections where stagnation might occur). The disinfection system was reviewed (including ozonisation) and corrective measures (especially in SE1) implemented in terms of construction, to hygienise the facilities with the use of protective equipment and systems.

The disinfection procedures implemented after the review were strengthened.

The next analytical results were not very encouraging, since *Pseudomonas aeruginosa*, mesophils and *Legionella Pneumophila* were all found, indicating the presence of persistent contamination.

New structural measures were therefore undertaken, and these were extended as time passed. In November 2004 a number of additional interventions were concluded, which included replacing steam pipes and iron plumbing, replacing metal tanks and accessories, ventilation and cleaning, replacement of filters, fixing leaks, discharge drainage, etc.

But analytical control still showed the presence of *Legionella* on this date. This situation led to another assessment and the emergency strengthening of measures defined, but not yet implemented, notably the replacement of the mains pipes. This had been systematically delayed for reasons of cost.

The second phase of intervention thus involved replacing the mains pipes and various other measures, such as the repair of tanks, fitting filters and replacing fixtures.

Once the mains pipes were replaced with stainless steel pipes, the disinfection (ozonisation) process was restructured. After analytical control with 3 negative analyses in a row, the contamination was finally deemed to have been beaten.

The establishment was granted leave to re-open in February 2006, and the system has remained suitable for use as a spa since then.

4 Conclusions

Even though a highly complicated intervention in an at-risk facility (in a very critical place) was involved, fight against the *Legionella* contamination in the Hospital Termal das Caldas da Rainha did in fact succeed, and no contamination has been found since then.

To confirm this outbreak-free situation, an epidemiological study was carried out on patients who had been treated between 23 July and 12 August. The survey adopted the standards established by the European Working Group for Legionella Infections (EWGLI) and led to the conclusion that indeed no human contamination with *Legionella* had occurred.

This outcome was undoubtedly the result of the safety procedures that were introduced in the facility, in particular the microbiological monitoring of water quality, a procedure that permitted the prompt detection of the problem.

This showed that the water safety in the various parts of the amenity would be effectively ensured through the water safety plans (WSP), a fundamental part of which is the identification and conservation of the network, compliance with maintenance methodologies and a proper monitoring programme (with parameters appropriate for water quality and its use characteristics).

The lack of cases of Legionellosis has obviously also resulted in the firm decision to close the facility, which was one of the hardest safety measures to implement, on account of the serious economic losses it would entail.

5 References

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