Hygienic Water Audit Scheme as a Tool in the Fight against Legionella - problems and goals of the research project

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Abstract. Water and air they mean life, but their quality represents our health. The main aim of the article is to introduce our research project „Hygienic Water audit scheme as a tool in the fight against Legionella” in terms of specific requirements from companies to minimize the energy efficiency for elimination of microbiological contamination of water supply and air conditioning systems (replace thermal disinfection by another effective method). The issue of water contamination, resp. air of Legionella pneumophila, its appearance and impact on the design and operation of water supply and air conditioning systems is relatively young. Little known problem in Slovakia has in the context of the European Union a serious position as it causes high mortality. The aim of the interdisciplinary research is to analyze the current state of hospital buildings, of the individual factors on a working materials and working environment in terms of their potential for microbiological contamination.

1. Introduction

Microbiological contamination of water and air and health risks caused by germs that colonize technical systems causes various problems and illnesses. Among these conditions is Legionnaires' disease - Legionellosis. Caused by ubiquitous water bacteria Legionella pneumophila, having a diameter of 0.2 to 0.7 microns which is dangerous in the form of contaminated aerosol, which may be formed, for example during showering by inhalation. Are we taking Legionnaires’ disease seriously enough? The reported cases not only in hospitals are listed in [1]. Forty-Six Legionella infections have been diagnosed among patients of a hospital in the Lisbon area of Portugal since October 31, 2017. Four of the patients have died. Portuguese health officials suspect the source of the outbreak was the hospital’s potable plumbing system [1].

Our measurements showed that Legionella is present in the distribution of water [2] and air [3] in Slovakia. For the water supplier and the operator of the building is an obligation in the water system to ensure the prescribed quality and temperature at each sampling site, as well as providing air ducts from a hygiene point of view. Health flawless drinking water is provided for in the Act of NR- No. 247/2017 Coll. in Slovak Republic on protection, support and development of public health and on amendments to certain laws, which is valid from October 2017 [4].

Health risk is evaluated according to the quality indicators and hygienic limits. The quality of supplied drinking water to the public water supply and sanitation are responsible in our water companies. The quality of water supplied to consumers is monitored by regional public health within the meaning of Slovak Government Regulation no. 354/2006 Coll. [5]. Sample sites should be selected...
in areas or buildings where water flows from outlets that are normally used for human consumption. For domestic hot water use standard STN 83 0616 Hot water quality [6] is valid for that bacteriological and biological indicators. Hot water quality must meet the criteria for drinking water. Designers should respect the STN EN 806-2 Specifications for installations inside building conveying water for human consumption - Criteria for internal water pipes carrying potable water, Part 2 - Design [7] and as well as technical management TC 164 WI 164353 - Recommendations for prevention of Legionella growth for installations inside buildings conveying water for human consumption which specifies a standard in view of the presence of \textit{Legionella pneumophila} [8]. These fundamental rules are valid in all member states of the European Union. In the Czech Republic they apply the decree of the Ministry of Health. 252/2004 Coll. showing the desired parameters of the hot water, which should be supplied to the distribution points of over 50 °C, preferably above 55 °C.

United Kingdom adopted as a national standard method for assessing the impact of materials in contact with drinking water test MDOD (The Mean Dissolved Oxygen Difference) and is governed by regulations BS 6920.

The problem of safe ventilation equipment lies in the fact that often the focus has been only on their proper functioning and good condition, while control of hygiene and disinfection required is neglected. Directive Association of German Engineers VDI 6022 "Hygienic requirements for ventilation equipment - office and assembly areas" describes the necessary procedures for planning, the actual implementation, operation and maintenance of HVAC equipment in order to achieve the desired quality and hygiene of the indoor air [9]. While ANSI / ASHRAE 188-2015 provides basic requirements for these systems, but the overall execution and risk identification is already the owner of the building. [10] Among the possibilities for water protection against legionella we include for example: the ensuring sanitary water with chlorine dioxide, ozone, UV radiation, thermal disinfection, physical methods such as the use of filters and much more. It is necessary to examine methods to eliminate bacteria in addition to freight thermal disinfection, also is in the world a general need to define both efficient and safe technical measures in domestic hot water systems and air conditioning. Criteria for selection of a method, the use of combinations of methods, parameters for installation, pitfalls in implementation and a plan for subsequent environmental surveillance, their energy consumption will be discussed in detail. Improvement of the energy efficiency of disinfection methods is met as the selection of the most suitable, cost effective and risk elimination method for each case. [11].

2. Project objectives, methods and their prospects of success

Theoretical and experimental analysis of systems technology environment in connection with their possible microbiological contamination assess the possibility of eliminating health risks with regard to their energy consumption and evaluation in hygienic audit.

Our team is divided into experts in the field of water and air in buildings, in cooperation with environmental and material chemist experts. This team is composed of knowledgeable professionals, respectively, young scientists who already have experience of dealing with projects at national, respectively international level. They can guarantee the fulfillment of the objectives.

The goals were set as follows:
1. State of art regarding to the quality of supplied hot water to heat sources focused on hospitals in Slovak conditions.
2. Examination of the state of art regarding to the quality of supplied air conditioning equipment and indoor quality for user focus on hospitals.
3. Decomposition of the factors influencing the potential for microbiological contamination of the water supply and air.
4. Analysis of the impact of material base distribution systems technology environment for preserving the quality of the working material.
5. Analysis of the impact of age, biofilm and sediment in the pipes for preserving the quality of the working fluid.
6. Analysis of the possibilities of technical measures to eliminate potential microbiological contamination.
7. Analysis of the effects of selected methods to minimize the health risk in terms of their impact on the pipe material and energy consumption (cost-benefit analysis will be reported).
8. Draft set of decision criteria that reflect the effects of acceleration increase the bacterium *Legionella pneumophila* and selection of appropriate methods to eliminate the risk of contamination.
9. The draft methodology of determining the degree of importance of the criteria taking into account the effects of accelerating increase of microbiological contamination in the systems of from supplier to end user.
10. Processing model of risk analysis, defining boundary conditions and principles to minimize the microbiological contamination of water and air.
11. Implementation of the proposed methods for reducing the rate of bacteriological pollution in real systems technology environments by evaluating their effectiveness and energy efficiency.
12. Development of technical report and scheme of “Hygienic Audit” for safe design, operation and maintenance of hospital systems.

2.1. *Project stages*

The proposed methodology solutions, justification of selection and measure of the ability to meet the declared objectives. The project will benefit by the following characteristics:

- **Classification** - sorting the systematic factors related to *Legionella pneumophila* bacteria colonization in the water and air pipes, and the risks identification,
- **Methodology** - draft set of decision criteria, taking into account the effects of accelerating the proliferation bacteria causing legionellosis, including the determination of levels of importance criteria
- **Model** - Risk Analysis techniques for system protection, link with virtual microbiological contamination of the water supply, respectively air,
- **Know-how** - technological instructions as a set of experiences, knowledge and key information regarding the application of appropriate methods and technologies for the management of risks arising from the process of ensuring the supply of hygienic water users, respectively air. Variability solution is built directly into a sequence of steps to achieve project goals. Model of risk analysis preceded by analysing individual factors related to microbiological contamination of working materials (water and air) necessary for human life.

At different stages of the project we will use a variety of qualitative and quantitative methods: starting by study and critical analysis of available publications and carried out research on a subject which will be continuously updated throughout the study was performed.

2.2. *Project benefits to innovation*

The anticipated benefits of the project are planned on several levels:

- **State of art research**: which shows the rate of microbiological contamination of the water supply and air condition for hospitals in Slovakia
- **Theoretical level**: in terms of set goals, assess their analysis of the factors accelerating the reproduction of the bacteria *Legionella pneumophila*, in terms of investor, operator and user of vulnerable systems technology environment
- **Methodology level**: will be processed by methodological model of risk analysis associated with the solution of safe design, operation and maintenance of systems of Environmental Engineering
- **Practical level** of benefits: it is planned to verify the model of risk analysis, as well as the proposed methods of reducing the level of bacteriological contamination in real systems technology environments by evaluating their effectiveness, with special regard to energy efficiency solutions.
3. Current state of art
The main goal of our project described in this paper is to find out the microbiological contamination level in selected hospitals. The selection was directly aimed at risky departments in hospitals (geriatrics, gynecology clinic, clinic of pneumoniae etc.) where the factors that encourage bacteria growth can occur and be dangerous for patients with weakened immunity. We started with 20 samples from 4 hospitals in first stage (Table 1). Nowadays the sampling continues and more than 20 samples are prepared for the examination.

As it is set in STN ISO 11731-part 2 [12] for Legionella presence all water samples were analysed. Hospital 1, 2, 4 were in all cases negative. In number 3 all 5 samples were positive. We can see the results in table 2. Now we continue with sample collection in other hospitals. In case of positive findings we are planning to apply the hygienic water audit scheme to proof it in practice.

### Table 1. Hospital survey – stage 1 (source shower heads)

| Hospital | Water samples | Source | CFU/100ml |
|----------|---------------|--------|-----------|
| Hospital 1 | Department of long-term illness | shower | 1200 |
| Hospital 2 | Department of Gynecology | shower | 3400 |
| Hospital 3 | Department of Gynaecology | shower | 1600 |
| Hospital 4 | Geriatrics and Gerontology | shower | 4600 |

Positive samples only confirmed the need of such research and prevention, to protect public health.

4. Conclusion and Discussion
The presented project is gradually taking the shape depending on the level of science and technology, health and other fields of science. The issue of water contamination, respectively air *Legionella pneumophila*, is relatively young and its appearance and also their integration and impact on the design and operation of systems technology environment - especially water supply and air conditioning equipment. In this project we use know-how of Slovak and foreign companies focused on technical measures to eliminate the health risks of supplied water and air. The research team aims to develop a custom solution that will build on the strengths of known approaches and to eliminate weaknesses detected in real operation.

Outputs and benefits of the project will be a contribution to knowledge, classification and propose suitable measures as a platform of so called Hygienic audit using experimental measurements and
parameters of cold, hot water and air quality. In terms of specific requirements to minimize the energy efficiency of thermal plants will be processed by model of risk analysis and technological process, providing hygienic harmlessness supply water and air. To improve energy efficiency targets and reduce water usage should be assed at the design stage if possible and all energy saving measures should be risk-assessed for their impact on Legionella control. In previous research, positive legionella bacteria in up to 8% of water samples taken in the exchange stations were identified. Since thermal disinfection, referred as a measure in the first place, is unsystematic and energy-intensive solution, verification of other progressive options that are less energy-consuming for suppliers, but also for users with no risk were done. The scientific report upon request from main heat suppliers in recent years just confirmed that the European Union preferred method of eliminating bacteria by periodic thermal disinfection increased financial and time requirements of the system and does not correspond with the concept of reducing energy consumption being introduced throughout the European Union. It is necessary to examine other possible methods for bacteria elimination in addition to unsystematic thermal disinfection, also is in the world a general need to define technical measures in hot water systems and air conditioning. Heat distribution systems of water and air in our larger and older buildings have many common health deficiencies as age of material, composition, lack of control, neglected maintenance, etc. Each disinfection technology has strengths and weaknesses, limits and different costs. Slovakia has not implemented across the board targeted collection and evaluation of the supply air on the content of Legionella pneumophila, which is why our aim of mapping out the real situation and proposed solutions in buildings caused to health.

Principal investigator and the team has been dealing with this issue of contamination of working materials in the building for years. Selection of the appropriate technology depends on the individual needs of the operator, water quality and requirements for operation and maintenance of equipment, but it is feasible to bring into practice the general rules that we have the ambition to put into practice than the recommended / required "hygiene audit water and air", with similar output structure as in energy certification - classification of buildings according to the degree of health risk and the necessary technical measures.

Potable hot and cold water quality and air quality must by ensured by using a regular monitoring scheme as Hygienic water audit to ensure public health safety. This tool should help the hospitals to control the legionella risk and set the best solution for their case if needed.

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