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Risk Management in the Water Industry †

Zuzana Zemanova *, Sarka Krocova and Patrik Sirotiak

Faculty of Safety Engineering, VSB—Technical University of Ostrava, 700 30 Ostrava, Czech Republic; sarka.krocova@vsb.cz (S.K.); patrik.sirotiak@vsb.cz (P.S.)

* Correspondence: zuzana.zemanova.st@vsb.cz

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Abstract: Extraordinary events have always threatened us. The continuity of drinking water supplies cannot be exposed to such risks. When dimensioning water supply systems, it is necessary to consider the use of preventive measures, which include risk management. The following article is the basic scope of this issue and presents risk management procedures in the water industry.

Keywords: risk management; water supply systems; water industry

1. Introduction

Water industry is a prerequisite for the sustainable development of life on Earth [1]. However, the supply of water to villages and towns cannot be taken for granted, as the infrastructure is vulnerable to several risks, both natural and anthropogenic, that can affect water supply. Events threaten the continuity of drinking water supplies are numerous every year around the world [2]. An example is the situation in 1998 in Australia, when the treated water for Sydney had high cryptostoadia values. This event let to the introduction of regulations that require risk analysis to identify potential hazards in the drinking water supply system [3]. Some areas are susceptible to drought, others to flooding, and each may be at risk of a shortage of drinking water needed for life. For these reasons, the issue of water has become a hot topic in the Czech and global environment [4].

Scientific knowledge and technical possibilities must be used to cope with the situations that arise. In the Czech Republic, Kročová and Pokorný [5] and Tuhovčák and Ručka [6] have addressed the issue of water supply infrastructure. The comparison of drinking water supply systems and water supply systems was discussed in the article by Czech and international authors [7], in which they confirm the importance of searching for best practices leading to better results. It is important in the future to consider that water supply may be compromised, which would have a negative impact on the population. Therefore, it is necessary to prepare for such events by appropriate planning or construction and rehabilitation of infrastructure [8].

To protect citizens, facilities, or production systems, we need to know the local risks. These can be identified, and subsequent recommendations and measures can be formulated to prevent or reduce damage, based on risk management. The aim of risk management is, according to Kročová [9], "to keep the system under consideration functional and within the given scope for as long as possible". This will ensure the protection of protected interests such as the life and health of a person but also reduce economic losses. The result can then be the faster recovery of infrastructures important for the functioning of society [9].

2. Operational Safety Risks to Drinking Water Supplies—Description of the Problem

Safety is the state of being able to withstand threats that can be expected with a certain probability. However, its protection is not absolute; there will always be some risk of events that threaten the system [10]. Our world and the threats are evolving, which requires us,

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citizens, and those who protect us, namely the security system and the integrated rescue system, to constantly adapt [11].

We can see risk at every point in the distribution system. The population depends on the supply of drinking water, and if it cannot be delivered, an emergency or crisis situation arises [9]. The functionality of the system and the supply of drinking water can be compromised for a variety of reasons. Natural factors have affected the technical infrastructure since its inception. In terms of natural hazards, these are mainly water movements, run-off, or landslides. In the context of climate change, it is clear that they will increase in intensity and frequency, as pointed out, for example, by the authors of [12].

Partial Conclusions

The response to risk is a key part of the protection of critical infrastructure, especially for natural events [13]. In contrast, anthropogenic hazards cannot be forecast in this way, so more consideration needs to be given to alternatives for maintaining operations in the extraordinary events. The hazard level of an emergency, as well as the type, is specific to each region of a country.

3. Risk Analysis in the Water Industry

The water supply infrastructure system is susceptible to a number of natural and anthropogenic risks at every stage that cannot be predicted. The continuity of supply cannot be exposed to such risks when we do not know what may happen. A more reliable approach is needed. Mathematical models are often used in the design and operation of water supply systems, and risk analysis methods are often applied [14].

Currently, several methods for risk analysis have been developed for different technological systems. Examples include the checklist method, ETA or FTA, the FMEA method, HACCP, HAZOP, the risk matrix method, or SWOT.

It is important that the methods meet the needs of the analysis for the government department, municipalities, and water system operators. The used method must provide results in a form that will present the character of the risk and how to deal with it and must ensure the repetition of its process, the monitoring of the analysis process, and the verifiability of the results.

Risk analysis has a brief history, particularly in the water industry, dating back to the turn of the millennium. As a result of the extreme floods in 1997, 2002, or 2013 in Europe [14,15], especially in the Czech Republic [16], the issue of drinking water supply in crisis situations started to receive more attention. The risk assessment issues were addressed and regular problems and failures of the individual elements of the water supply infrastructure were also considered.

Partial Conclusions

An important prerequisite for the selection of a risk analysis method concerns what results are expected from the method. This problem can be seen particularly in the neglect of the water sector at the present time, when crisis planning experts are focusing on other elements of critical infrastructure. The authors Řehák and Hromada [17] deal with the resilience of critical infrastructure and focus on strengthening the resilience of the energy sector. The water sector also needs to continue to be addressed, investigated, and protected.

4. Supporting Methodologies

Supporting methodologies have been developed for the needs of the water supply industry, which serve to perform a risk analysis of the water supply system.

4.1. Water Safety Plans

The WHO is an organization with the goal of spreading health care around the world to give everyone a chance at life and wellbeing. According to their priorities, the organization has been promoting Water Safety Plans (WSP) since 2004 [18], where the authors describe

this procedure. The WSP methodology is similar to the HACCP method, which has been used mainly in the food industry since the 1960s. However, the question remains as to why food safety has been prioritized over the safety of the drinking water supply.

Currently, WSP is implemented in a number of European and non-European countries such as Iceland, Bangladesh, New Zealand, and England [19,20]. With these examples, there is a demonstration of use in both developed and developing countries.

The implementation of WSP in the Czech Republic is the focus of a study [21], which specifies the factors that facilitate the implementation of WSP. As a result, it was found that the implementation is influenced by the quality of the process of developing these procedures. The expected benefits of risk assessment include improved water quality, reduced accidents, the improved protection of water resources, reduced disease in the drinking water user population, improved monitoring, the improved understanding of the entire supply system, the reduced costs of corrective action, and the better positioning of supervisory authorities to control the operator. The disadvantages are mainly for the operator, who incurs higher economic and administrative costs.

4.2. WaterRisk

The issue of risks in drinking water supply has been discussed for many years. However, the food sector has always been given more emphasis. When the issues of water quality and water control started to emerge, it was certain which area would lead the way. However, the HACCP method was not simply applied to the drinking water supply. For this reason, water experts began to address the issue of developing a new risk analysis method and created the WaterRisk project. The aim of the project was to create a methodology for the development of WSP in the conditions of the Czech Republic. Risk analysis in the field of water supply is a time-consuming and professionally demanding process; that is why the Methodological Proposal for the preparation of risk assessment of drinking water supply systems according to the Act on the Protection of Public Health [22] was created and together with it a software application with the same name, in which the created methodology was digitalized. The aim was to simplify the risk analysis process for water supply operators, as it was clear that one day it would be necessary to prepare it [23].

The advantage of the method is that specific information about the water system is not needed. However, some input information is required, which is known to the operator. If some input information is not available or is incorrect, this is not a problem for the method. Then, it is necessary to determine which objects will be analyzed. Their description must be provided. The method contains predefined undesirable states that are linked to a specific element of the system under consideration. It is a demonstration of a system fault. A diagram of the risk analysis process can be seen in Figure 1. The method defines fifty-eight undesirable conditions, which are divided according to their nature into natural, social, and technical hazards. Hazard identification is conducted for each object separately and then risk analysis is carried out, where hazard values K1 are determined as negligible and K5 as very high. Based on the resulting K values, corrective measures are determined.

The advantage of using WaterRisk is, in particular, the possibility of using an application whose outputs is exported to a PDF document, so it can be easily attached to the operating rules. The application process itself is shown in Figure 2.

The proposed risk mitigation measures can be exported from the application and can be further worked on, especially in connection with the development of the recovery financing plan. The advantage can also be seen in the improvement of problem areas and undesirable conditions. Another advantage is the creation of a risk matrix when using the application for risk analysis, which shows the initial state of risks in the system before and after the implementation of measures. The selected procedures try to free the worker from their subjective actions and use a multicriteria approach [24].

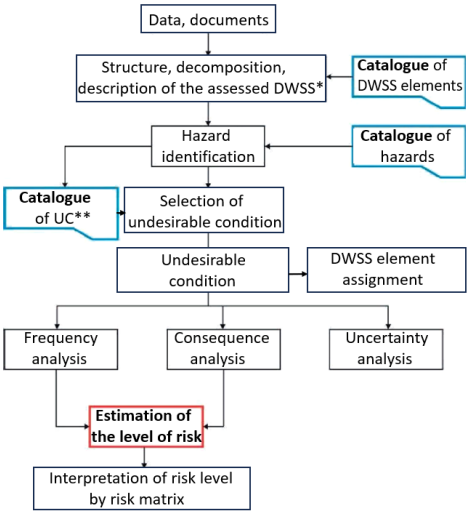

Figure 1. Diagram of the WaterRisk analysis ([24], edited). * Drinking water supply system; ** undesirable condition.

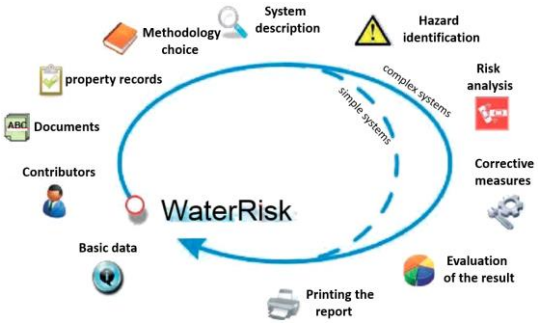

Figure 2. WaterRisk user interface ([24], edited).

5. Discussion

The purpose of risk analysis is to create assumptions to prepare for events that have a negative impact on the system. Methodologies that are suitable for water systems have been described above. The authors report the positive impacts of performing risk analysis in the drinking water supply sector in [9,16]. By conducting a risk analysis and making it mandatory in national legislation, there has been a reduction in cases where established water supply practices have not been followed and thus a reduction in cases of public illness. Conducting risk analysis in the water sector is an important tool for ensuring continuous improvement of water quality. Since risk analysis is performed with minor modifications in an equivalent manner worldwide, it is easier to understand local problems.

However, it is also necessary to consider the potential pitfalls in the actual development of the risk analysis. These are mainly economic pressure, the desire to simplify problems, subjective aspects, and others, as mentioned, for example, in [25]. The authors focus on the pitfalls of implementing risk analysis in the water industry in this article. Ensuring the functionality of the water system is necessary even though it is not economically attractive. According to their research, the solution to a given risk analysis should be sufficiently familiar with the problem since risks are identified and evaluated by a specific person or group of people. For this reason, it is necessary to ensure that the subjective bias of the problem is eliminated. Failure to do so could result in the production of a non-descript document that will not lead to further action by the risk management system.

According to [20], the key prerequisites for managing a successful risk analysis are the participation of the governing bodies of the public administration and the simultaneous participation of the work teams. Some authors believe that safety in the water sector

can be ensured via the consistent enforcement of legislation with the cooperation of all stakeholders [21].

In the water sector, the methods commonly used for risk analysis have been modified, as it is a very specific field. The development of the risk analysis itself does not need to be an obstacle if carried out correctly. It is important to reflect on the fact that the water industry is not just a normal business, but a service to us, the population, who depend on water, and therefore, it is not appropriate to take an economic approach.

If, based on a risk analysis, the preconditions for emergencies are already in place, it is important to prepare for them from a crisis management perspective. If staff ignore risks, conceal them, or fail to assess them properly, this could have catastrophic consequences.

6. Conclusions

The risks cannot be completely avoided. They can only be reduced to an acceptable level by applying preventive measures. The acceptable level is variable for different systems. However, it is always important to protect life and health. In the field of water infrastructure, the primary objective is therefore to transport water in the quantity and quality required to the public. And while sometimes precautionary measures may seem meaningless, by applying the right combination of measures, we can achieve the desired protection. This is because the system must involve both the objects and the line structures of the water supply infrastructure and those who work with and operate the infrastructure.

Although the area of natural and anthropogenic risks has been studied for many years, there is a lack of sufficient solutions in the water infrastructure. There are not many authors that deal with this issue. In the future, the issue should be adequately incorporated into emergency planning of state and local governments, as a reduction or interruption of drinking water supply is a major threat to both the population and critical infrastructure elements.

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