Environment and its Influence on Aquatic Ecosystems Industrial Landscape

Šárka KROČOVÁ[1)], Vladimír ČABLÍK[2)], Darja KUBEČKOVÁ[3)], Małgorzata KRYLOW[4)], Kamila ROUCHALOVÁ[5)]

[1)] VSB-Technical University of Ostrava, Faculty of Safety Engineering, Lumirova 13, 1875, 703 00 Ostrava-Vyskovice, Czech Republic
[2)] VSB-Technical University of Ostrava, Faculty of Mining and Geology, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic
[3)] VSB-Technical University of Ostrava, Faculty of Civil Engineering, L. Podeste, 1875, 708 33 Ostrava-Poruba, Czech Republic
[4)] Cracow University of Technology, Faculty of Environmental Engineering and Energy, Warszawska 24, 31-155 Cracow, Poland
[5)] Ing.; VSB - Technical University of Ostrava, Faculty of Mining and Geology, Department of Environmental Engineering; ORCID 0000-0001-6965-2662

http://doi.org/10.29227/IM-2023-02-57

Submission date: 16-11-2023 | Review date: 29-11-2023

Abstract

The environment is changing considerably with the increase of the human population. In many cases, especially in urban and industrial agglomerations, the limit values for long-term positive sustainability are already achieved. Air and aquatic ecosystems are the most endangered areas of the environment. Given that water is a life and its contamination endangers the health and lives of humans, fauna and flora, the following article focuses on how to identify security risks and then eliminate them to an acceptable level using scientific methods and technical options.

Keywords: *industrial agglomerations, environment, landscape management, risk elimination*

1. Introduction

Gradually, but at an unstoppable pace, the human population is concentrated in various magapoles and industrial landscapes. Countryside is gradually depopulated and very often becomes only a recreational area and a place of farming.

In agriculture, there have been major changes in the last decades of the last and this century. Agricultural activity now requires only a fraction of people compared to the first half of the 20th century due to the use of modern technology and working methods. However, this change does not only bring benefits, but concentrating a large number of people on a relatively small area overloads the environment (UNFPA, 2011; Malikova et al., 2021). The most serious of the whole range of environments of different types of regions are the aquatic ecosystems.

2. Aquatic ecosystems and industrial landscapes

Aquatic ecosystems are very fragile and vulnerable areas of the natural environment. They tend to be highly vulnerable due to natural phenomena or anthropogenic events (Kročová, 2017). In terms of the natural occurrence and vulnerability of aquatic ecosystems in industrial landscapes, these systems can be divided into the following areas:

- Surface water,
- Groundwater.

Surface waters

Surface running or accumulated water is the primary prerequisite of the technical-operational function of each industrial landscape. From these waters, see Figure 1., water is taken for industrial use or the fire protection of the premises, and at the same time the cleaned industrial wastewater is discharged.

From an environmental point of view, surface waters are the most vulnerable natural element in an industrial landscape. Most natural effects or anthropogenic events can cause their vulnerability, see the text in Chapter 3.

Groundwater

Depending on the geological subsoil, groundwater is also endangered by the industrial landscape. In particular, there are shallow aquifers of the soil environment or water leading to more distant groundwater sources for water supply systems at various degrees of threat, see Figure 2.

Inadequate management of hazardous substances in the industrial landscape almost always causes contamination of groundwater with harmful substances and consequently their use for treatment to drinking water or for direct use for drinking purposes from individual wells of natural persons is endangered.

3. Environmental threats in industrial agglomerations

In addition to the factors mentioned in the previous chapter, there are other natural and anthropogenic hazards in the industrial landscape that combine with each other (Kubečková and Kročová, 2017).

In simple terms, the following scenarios can be considered as the main security threats in the industrial landscape.

Natural influences

- floods,
- hydrological drought,
- in sloping land, landslides.

The three basic natural phenomena will tend to intensify in the coming climate change and be the cause of a number of emergencies. At the same time, they tend to trigger the following anthropogenic emergencies (Kročová and Václavík, 2017).

Anthropogenic events

- leakage of chemicals from operating systems,
- accidents of equipment leaking out of dedicated equipment and safety corridors,

Fig. 1. Local water flow in industrial landscape (photo Krocova S.)
Rys. 1. Lokalny przepływ wody w krajobrazie przemysłowym (fot. Krocova S.)

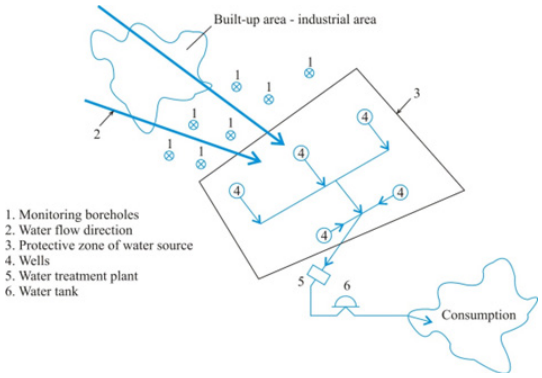


Fig. 2. Diagram of the spring and monitoring wells
Rys. 2. Schemat źródła i studni monitorujących

- Gradual penetration of harmful or hazardous substances into aquatic ecosystems.

The elimination of the consequences in question is one of the most serious and extraordinary events to be addressed by the public administration and its specialized bodies (Kročová and Kavan, 2019). Without a timely and particularly comprehensive solution to the issue, the original natural environment, landscape and agricultural economy will be seriously threatened in the coming years.

At present, there are many ecological crises in the world that need to be given increased attention.

By selecting suitable indicators (indicators) we can identify and identify the state of the environment according to its individual components (air, water, soil, rocks, biota) and on the basis of observed development trends we can even assess in advance the perspectives of further development of the environment (Kováčová and Vacková, 2014). In order to be fast and efficient, solutions must be based on option is to use the FMEA method and the security risk checklist method. sufficient risk knowledge and appropriate methods, including the use of an appropriate method. One of the possibilities of solution also lie in international cooperation and can have a multifunctional character, focusing not only on standard protection of waters of natural origin, but also in the field of water supply. The development of the current type of water supply in border areas can also stimulate the development of local infrastructure and consequently more economical use of local territories of neighboring states. Cooperation may also be wider than a cross-border nature (Malerova et al., 2017; Dvofacek et al., 2022).

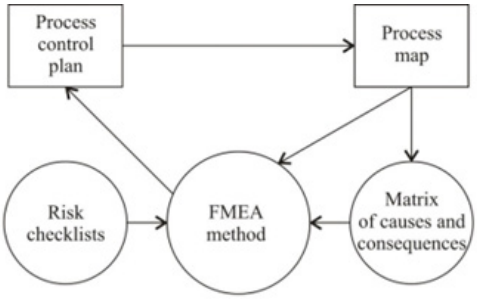
4. Elimination of natural and anthropogenic risks

Optimal for these systems is the use of the Failure Mode and Effects Analysis (FMEA) method and the checklist methods, which, in conjunction with other activities and tools, create sufficient scope for analysing the risks of almost any infrastructure System or the natural environment.

In order to achieve maximum relationships between inputs and outputs of the task being solved, it is necessary to work with parameters that can influence the added value and key inputs that must be controlled in the management process. Process control is usually carried out through a process detailed map and is divided into individual steps, see Figure 3.

The process map, see Figure 4. must, however, be elaborated into all the circuits addressed by the natural environment of the industrial landscape. With its help, the solver can, through the use of the mind map, extensively document the security risks of the whole system and then find ways to eliminate them.

A variant of Environmental FMEA is used to price environmental impacts, it consists of environmental risk assessment defined, as a process of qualitative and quantitative analysis of the linear potentials and coefficients of potential risks in a project, as well as the sensitivity or vulnerability of the surrounding environment. EFMEA was developed in response to the need to find a simpler and faster method of assessing environmental impact than Life Cycle Assessment. (Wiśniewska, 2022). According to the idea of sustainability, it is necessary to combine these two factors, i.e.: product quality and environmental impact, one traditional FMEA method is not suitable for this, so a Fuzzy QE-FMEA method based on fuzzy logic is proposed. This method is more flexible in assessing the criticality of failures, as well as more consistent and logical and the results obtained are more accurate. This method enables failure risk assessment, ranking



Basic definitions:
- **FMEA** - forms the basis for the analysis of risks occurring in water supply systems
- **Checklists** - define the basic dependencies - what can happen, what is the probability and what are the consequences
- **Matrix** - limits the evaluated process steps and FMEA inputs
- **Process map** - defines the chronology and sequence of individual processes of the water system
- **Process control plan** - is a constantly living document responding to new facts and environments

Fig. 3. Cross-links of processes for threat analysis by aquatic ecosystems

Rys. 3. Wzajemne powiązania procesów analizy zagrożeń w ekosystemach wodnych

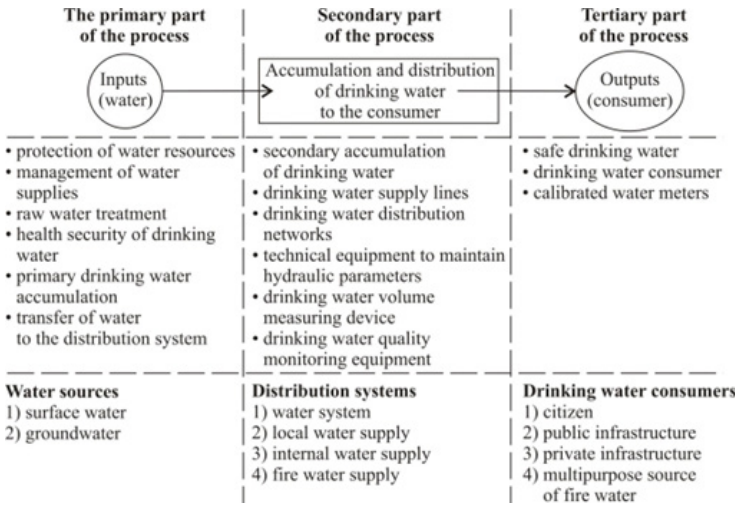


Fig. 4. Schema of an alternative detailed process map to solve a task

Rys. 4. Schemat alternatywnej szczegółowej mapy procesu do rozwiązania zadania

and prioritisation based on expert opinion, expertise and experience, analysis. (Rimantho and Hatta, 2018; Pacan and Siwiec 2023).

Risk analysis in the process of designating and establishing protection zones for water intakes in Poland.

The European Commission, in Directive No. 2020/2184, abbreviated as DWD - Drinking Water Directive), has included provisions for risk assessment and risk management, which consists of (Directive No. 2020/2184):

- risk assessment and risk management of the catchment areas for abstraction points of water intended for human consumption.
- risk assessment and risk management of the supply system
- risk assessment of the domestic distribution systems.

It is evident from the provisions of the Directive that when carrying out an assessment, it is necessary not only to consider the current status, but also to identify trends and predict what may happen in the future (contribute to the degradation of natural water resources). The assessment should take into account the possibility of future problems arising as a result of a new o hazard (e.g. resulting from a steady upward trend in the concentration of some substance (Directive 2020/2184).

It follows from the Directive's provisions that, when carrying out an assessment, it is necessary not only to consider the current status, but also to identify trends and predict what may happen in the future (contributing to the degradation of natural water resources). The assessment should take into account the possibility of future problems arising as a result of a new o hazard (e.g. resulting from a steady upward trend in the concentration of some substance).

Based on the provisions of the 2020 DWD, the following sequence of procedures should be adopted in the risk assessment process:

- identification of natural and anthropogenic (point and area) sources of pollution and hazardous situations and events;
- determination of the hazards (factors or water status) and the vulnerability of the waters to their occurrence (including their transport in time and space);

- the estimation of the probability of each hazardous event and the severity of the consequences resulting from the hazards, and evaluation, with the aim of assigning a value to each identified risk to enable it to be categorised, with appropriate prioritisation (Mulik and Zimoch, 2022)

In Poland, the Water Law Act (Prawo wodne, 2017) introduced regulations for the establishment of protection zones for water intakes and imposed, inter alia, the obligation to perform a risk analysis for underground and surface water intakes and to submit it to the relevant provincial governor. Risk assessments must be carried out by water supply and sewerage companies, but also by owners of water intakes carrying out collective water supply tasks, as well as by individual owners if they supply water for human consumption as part of commercial, service or industrial activities or to public buildings. (Prawo wodne 2017, Woźnicka and Lidzbarski, 2022) This law recommends (although it is not mandatory) that the method used in the risk analyses and health risk assessments carried out as part of the preparation of Water Safety Plans described in the Regulation of the Minister of Health of 7 December 2017 on the quality of water intended for consumption should be used to carry out a risk analysis for a water intake (Rozporządzenie Ministra Zdrowia, 2017). According to the provisions of this ordinance, water and sewerage companies and other entities supplying or using water from an individual intake should perform a risk assessment based on the PN-EN 15975-2 standard. According to this standard, a risk management system, is a process that includes the identification of hazards and possible hazardous events and the assessment and control of risks that may occur throughout the drinking water supply chain from intake to consumer. Risk assessment involves the process of analysing and evaluating risks by estimating the likelihood of hazardous events and the severity of the consequences if they occur (Mulik and Zimoch, 2022).

The advantage of drawing up a risk analysis for an intake is that it has to be updated periodically (, which allows necessary action to be taken if new risks emerge. The effect of updated assessments is to introduce protection zones for the intake, which are a safety measure. The prohibitions and prohibitions applicable to these areas should depend on the risk analysis carried out, which must first take into account health and environmental aspects, as highlighted by the World Health Organisation guidelines (WHO, 2014), followed by: economic aspects, economic sustainability (Mulik and Zimoch, 2022).

Conclusion

The environment is the most valuable thing one can sustain or damage. The highest risk of damage arises especially in industrial landscapes and urban agglomerations. In the upcoming climate change, aquatic ecosystems are the weakest link in the general environment. As water is life, aquatic ecosystems must be protected to minimize the risk of almost irreversible damage. This article responds to the threats and at the same time outlines the ways and alternative processes to minimize the threats.

Literatura – References

1. DVOFACEK, J., MALIKOVA, P., SOUSEDIKOVA, R., HEVIANKOVA, S., RYS, P., OSICKOVA, I. Water production as an option for utilizing closed underground mines. Journal of the Southern African Institute of Mining and Metallurgy. Volume 122, Issue 10. Page571-577. DOI:10.17159/2411-9717/1439/2022.
2. Directive (Eu) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption. <https://eur-lex.europa.eu/eli/dir/2020/2184/oj> (dostęp 23.03.2023).
3. KOVÁČOVÁ, L., VACKOVÁ M. Achieving of environmental safety through education of modern oriented society. In: 14th SGEM GeoConference on Ecology, Economics, Education And Legislation. SGEM2014 Conference Proceedings. Vol. 2, 3-8 pp. (2014), ISBN 978-619-7105-18-6 / ISSN 1314-2704, doi:10.5593/SGEM2014/B52/S20.001.
4. KROČOVÁ, Š. Industrial Landscape in the Period of Hydrological Drought. Inżynieria Mineralna - Journal of the Polish Mineral Engineering Society. 2017, roč. 18, č. 1, s. 29-32. ISSN 1640-4920.
5. KROČOVÁ, Š., KAVAN, Š. Cooperation in the Czech Republic border area on water management sustainability. Elsevier. Volume 86, July 2019, Pages 351-356.
6. KROČOVÁ, Š., VÁCLAVÍK, V. Water-use in the context of the approaching climate change. In IOP conference series: Earth and environmental science. Volume 92. Bristol : IOP Publishing, 2017, s. 0125032. ISBN 0-000-00000-0.
7. KUBEČKOVÁ, D., KROČOVÁ, Š.Long-term sustainability of the landscape in new climatic conditions. In IOP conference series: Earth and environmental science. Volume 92. Bristol : IOP Publishing, 2017, s. nestrankovano. ISBN 0-000-00000-0.
8. MALIKOVA, P., CALABKOVA, K., HEVIANKOVA, S., HALFAR, J., KOTALOVA, I., VALOVA, B. Simultaneous Recovery of Struvite and Irrigation Water for Agricultural Purposes Obtained from Dewatering Liquor through Electrodialysis. WATER. Volume 13, Issue 22. Article Number3280. DOI:10.3390/w13223280.
9. MALEROVA, L., POKORNY, J., KRISTLOVA, E., WOJNAROVA, J. Using of mobile flood protection on the territory of the Moldova as possible protection of the community. IOP Conference Series: Earth and Environmental Science. 2017, roč. 92, s. 12039. doi: 10.1088/1755-1315/92/1/012039. ISSN 1755-1307, 1755-1315.
10. MULIK B., ZIMOCH I. (2022) Ocena i zarządzanie ryzykiem w przepisach UE dotyczących zaopatrzenia w wodę, Strefy ochronne ujęć wód podziemnych – analiza ryzyka i projektowanie. Część 1 Analiza ryzyka dla ustanowienia stref ochronnych ujęć wód podziemnych. Wyd. Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, Warszawa ISBN 978-83-67567-31-2.
11. PACANA, A.; SIWIEC, D. (2023) Method of Fuzzy Analysis of Qualitative-Environmental threat in improving products and processes (Fuzzy QE-FMEA). Materials, 16, 1651. <https://doi.org/10.3390/ma16041651>.
12. PN-EN 15975-2:2013-12 – Bezpieczeństwo zaopatrzenia w wodę do spożycia. Wytyczne dotyczące zarządzania kryzysowego i ryzyka. Cz. 2: Zarządzanie ryzykiem.
13. RIMANTHO D. and HATTA M. (2018). Risk analysis of drinking water process in drinking water treatment using Fuzzy FMEA approach. ARPN Journal of Engineering and Applied Sciences, volL. 13, No. 8, 2947-2956.
14. Rozporządzenie Ministra Zdrowia z dnia 7 grudnia 2017 r. w sprawie jakości wody przeznaczonej do spożycia przez ludzi (Dz.U. 2017 poz. 2294).
15. UNFPA. INFORMATION AND EXTERNAL RELATIONS DIVISION OF UNFPA AND UNITED NATIONS POPULATION FUND (2011). State of World Population 2011: People and possibilities in a World of 7 billion. New York: United Nations Publication Fund. ISBN 978-08-9714-990-7.
16. Ustawa z dnia 11 września 2019 r. o zmianie ustawy – Prawo Wodne oraz niektórych innych ustaw (Dz.U. 2019 poz. 2170).
17. Ustawa z dnia 20 lipca 2017 r. Prawo wodne (t.j. Dz.U. 2018 poz. 2268 z późn. zm.).
18. WIŚNIEWSKA M.Z. (2022) Environmental Failure Modes and Effects Analysis (FMEA) and its applications. A comprehensive literature review Environmental Engineering and Management Journal 21, 3, 365-379.
19. WOŹNICKA M., LIDZBARSKI M. (2022) Informacje wstępne, cel pracy., Strefy ochronne ujęć wód podziemnych – analiza ryzyka i projektowanie. Część 1 Analiza ryzyka dla ustanowienia stref ochronnych ujęć wód podziemnych. Wyd. Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, Warszawa ISBN 978-83-67567-31-2.

Środowisko i jego wpływ na ekosystemy wodne krajobrazów przemysłowych

Środowisko zmienia się znacząco wraz ze wzrostem populacji ludzkiej. W wielu przypadkach, zwłaszcza w aglomeracjach miejskich i przemysłowych, wartości graniczne dla długoterminowego pozytywnego zrównoważonego rozwoju zostały już osiągnięte. Powietrze i ekosystemy wodne są najbardziej zagrożonymi obszarami środowiska. Biorąc pod uwagę, że woda jest życiem, a jej zanieczyszczenie zagraża zdrowiu i życiu ludzi, fauny i flory, poniższy artykuł koncentruje się na tym, jak zidentyfikować zagrożenia dla bezpieczeństwa, a następnie wyeliminować je do akceptowalnego poziomu przy użyciu metod naukowych i opcji technicznych.

Słowa kluczowe: *aglomeracje przemysłowe, środowisko, zarządzanie krajobrazem, eliminacja ryzyka*