ONE APPLICATION OF ANALYTICAL HIERARCHICAL PROCESS IN FORENSICS AS A METHOD FOR RISK ASSESSMENT

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Introduction

Forensic engineering, as an application of a wide range of scientific disciplines, skills, and methods, allows for obtaining answers related to establishing facts that may have legal consequences. The advancement of science and technology has contributed to the fact that certain criminal matters and undesirable events cannot be successfully illuminated and resolved without the application of specialized expertise. The use of new technical and technological systems by perpetrators of criminal acts necessitates the need to counteract even higher technical and technological systems and expert knowledge in order to achieve successful crime fighting. The utilization of advanced technological systems needs to be considered both in terms of responding to occurrences of undesirable events and the implementation of repressive measures, as well as from the perspective of preventive actions.

A forensic engineer, as a knowledgeable individual possessing specific skills and expertise, conducts the process of establishing facts and investigating physical causes of accidents and other undesirable events, aiming to prepare engineering reports, expert opinions, testimony in legal proceedings, as well as providing advisory opinions to assist in resolving disputes affecting life or property (Kenneth et al., 2001). Investigations and reconstructions of events, in this case fires, leading to loss of life and/or property damage, do not always have to be tied to legal processes; rather, they can be undertaken to determine causes in order to prevent the recurrence of such events.

Incorporating multidisciplinary knowledge and technical solutions is the foundation of forensic engineering, with the goal of uncovering causes and examining consequences of the events that materialize through elements necessary for law enforcement. Risk is present in all human activities and systems, as probability of expose (someone or something valued) to danger, harm or loss (Brown, 2014; Delić &

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Softić, 2014). Risk is an inevitable part of business, and in many fields, it is essential to confirm the implementation of appropriate systemic analysis processes, especially considering the extent of data that are collected and processed in business processes. The Analytic Hierarchy Process (AHP) method, as a multi-criteria decision analysis method might be used in group or individual decision-making support in cases where risk assessment has to be done. Different applications of AHP might be classified as applications based on a theme, specific applications, and applications combined with some other methodology (Vaidya & Kumar, 2006; Petrillo, Salomon & Tramarico, 2023).

Forensic risk assessment refers to the ability to calculate the probability of the occurrence of undesirable events, with the aim of timely identification of the need for preventive action or assessment of responses taken in the event of undesirable occurrences. Results can be directed towards preventive action, identifying individuals or circumstances that could lead to undesirable events such as fires (and pollution as their consequence), or discovering the causes of undesirable events and activities taken to mitigate the consequences. It can also contribute to planning and providing the necessary minimal resources for efficient and effective protection of the working and living environment. Forensic risk assessment is one of the fundamental elements of modern forensic practice in various fields, attracting the attention of the contemporary scientific community and ongoing research. Identifying static and dynamic risk factors and corresponding responses for their prevention is included in the risk assessment process (Brown et al., 2014; Vaidya & Kumar, 2006) that can be done by AHP method.

Methods of Risk Identification, Analysis, and Assessment

Risk identification is a process of identifying and documenting potential risks, i.e., potential hazards or threats that may result in undesirable events. Such identification involves the application of appropriate methods to identify risks and prepare information about all identified risks, forming the basis for problem/risk evaluation. Based on risk identification, all sources of hazards should be discovered and accurately described. The results of risk identification include: recognizing undesirable events; describing sources of hazards, risk factors, conditions of occurrence, and ways of development and consequences of undesirable events; preliminary hazard and risk assessments (Vaidya & Kumar, 2006; Mlađan et al., 2013; Petrillo, Salomon & Tramarico, 2023; Geng, et al., 2021).

Systematic risk analysis involves obtaining quantitative hazard assessments. It is a general methodology for researching systems with the goal of defining system problems and determining ways and paths of their resolution; defining system goals, constraints, available resources, functional interactions, and interactions between the system and the environment; indicating the information and data that need to be collected, processed, and used for understanding system characteristics or improving its functioning; pointing out methods for evaluating and verifying chosen solutions or decisions. Risk analysis includes considering all possible scenarios of occurrence, ways of development, and consequences of undesirable events; assessing the frequency and realization of each scenario of occurrence and way of development and consequences of undesirable events; examining fields of harmful factors arising from different scenarios of undesirable event development; assessing the impact consequences of harmful factors of the unwanted event on humans or other material objects, as well as the environment; calculating risk indicators (Mlađan et al., 2013; Islam & Gazder, 2023; Geng et el., 2021).

Methods used in risk assessment relate to the assessment goals, acceptable risk criteria, stages of object functioning, available resources for conducting the assessment, object type, information availability, experience and qualification of the assessor, etc.

Analytic Hierarchy Process (AHP)

The analytic hierarchy process method, developed by Thomas Saaty (Saaty, 1980), is a multi-criteria decision analysis method used in group or individual decision-making as well as researchers (Vaidya & Kumar, 2006; Petrillo, Salomon & Tramarico, 2023). The central part of AHP involves pairwise comparisons of hierarchy elements and forming corresponding local reciprocal numerical matrices from which weights of compared elements are determined using mathematical procedures. The matrices and calculated element weights carry information about decision-maker consistency, which can be measured in various ways, directly and indirectly. In the standard AHP, consistency ratio (CR) is used. If there are N decision-makers addressing the same problem, then at each level of the hierarchy, instead of one local matrix, there are N such matrices and the same number of sets of element weights. The AHP method is based on defining the hierarchy of a complex problem and Saaty's methods for determining the weights of all alternatives in relation to the set goal. The analytic part of this method represents hierarchical problem decomposition. The problem is broken down into multiple levels of decision factors among which a hierarchy is established. The method starts with defining the goal, determining criteria related to the goal, and if necessary, sub criteria. After defining the hierarchy, the decision-maker compares elements-criteria in pairs at the same level to establish their mutual priorities or rank criteria. Comparison is carried out based on the relative importance of compared elements, in relation to an element of a higher level of the hierarchy. Comparison is done using Saaty's scale (Table 1).

Table 1 *Saaty's Scale*

Definition	**Numeric value**
Equal importance	1
Weak importance of one over the other	3
Essential or strong importance	5
Demonstrated importance	7
Absolute importance	9
Intermediate values between the two adjacent judgements	2, 4, 6, 8

Comparisons in pairs are made based on Saaty's scale of importance (Table 1), by assigning values from the set {1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 3, 4, 5, 6, 7, 8, 9}. In this scale, 1 means that both factors (being compared) are equally important, while 9 indicates that the first factor in the pair is more important than the second factor. Pairs are compared relatively to each other, not in relation to a defined or imagined quality or quantity.

After the pairwise comparisons, the decision-maker calculates their relative weights with respect to the goal. They compare alternatives (in pairs) for each criterion and assign relative weights, thus creating a database of compared pairs.

The computational part of the AHP method is based on a reciprocal matrix, in which the elements of the upper triangle of the matrix are reciprocals of the corresponding elements in the lower triangle with respect to the diagonal, which is always 1. The general matrix for comparing n decision elements at a specific level of the hierarchy is expressed as ($a_{ij}=1/a_{ji}$, for each i and j; $a_{ii}=1$ for each i, $\det A\neq 0$).

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}$$

AHP compares pairs, taking into account the goal, criteria, and alternatives. The analysis of individual decision-maker consistency can be performed based on the calculated values for CR and ED (Eigenvector Discordance) for each comparison matrix. The vector weight of each criterion is derived from this comparison. The CR is calculated during the standard AHP procedure. First, the Consistency Index (CI) is calculated:

$$CI = \frac{(\lambda max - n)}{(n-1)} \tag{1}$$

where λmax is the maximum eigenvalue of the comparison matrix. Using this index and the Random Index (RI), which depends on the order of the matrix, the Consistency Ratio (CR) is obtained.

$$CR = \frac{CI}{RI} \tag{2}$$

The RI is determined from Table 2, where n is the rank of the matrix:

Table 2 *Values of Random Indexes*

n	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4

If the CR for the comparison matrix is found to be CR < 0.10, the decision-maker is considered to be satisfactorily consistent. In some cases, this statement may also hold if CR > 0.10 (Saaty, 1980).

Using the AHP method, it is possible to decompose any complex problem into multiple sub problems, and each level represents a set of criteria elements relevant to that sub problem. In this way, forensic engineering can define the causes of undesirable events using engineering knowledge as a series of criteria of the same or varying importance, or a sequence of influences that led to the unwanted state.

System Analysis and Risk Management

Due to the presence of risks in all activities and domains of life, as well as the high potential in terms of material, energy, and economic aspects of production systems, it is necessary to pay special attention to the areas of system analysis and risk management. Risk management is primarily oriented towards maximizing system stability and achieving gains while minimizing losses and the consequences of undesirable events. System analysis, as a general methodology for researching systems with the goal of defining system problems and determining ways and paths of their resolution, is focused on making decisions to analyze and thereby prevent undesirable events. Undesirable events can be viewed from different perspectives, through the analysis of events that have occurred, the analysis of current uncertain conditions, or the analysis of potential occurrences of uncertain conditions.

Engineering uncertain conditions can be seen as the combined application of forensic procedures for past events and system analysis and risk management for events that may occur in the present or future.

Undesirable events, malfunctions in the functioning of technical systems, or the occurrence of accidents, fires, and explosions most often arise due to design errors, mistakes in implementation and/or construction of systems, inadequate materials, and of course, failure to adhere to procedures and operational processes of technical systems (Figure 1).

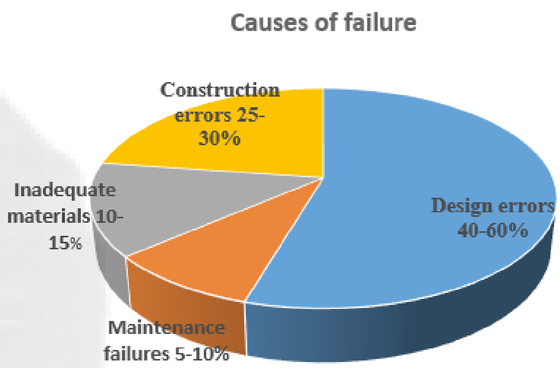

Figure 1 *Most Common Causes of Technical System Failures*
(Delić et al., 2014)

The mechanism of failure occurrence can involve a series of physical, chemical, and other processes that may lead to failures, endangering human lives and health, as well as causing material damage. In technical systems, design solutions, construction, material selection, proper usage conditions, regular and extraordinary maintenance, and the implementation of a series of other measures aim to reduce the probability of undesirable events, thereby minimizing or accepting them to an acceptable level. In the case of fires, this probability should ideally approximate zero. It is particularly important to consider that the fundamental processes that represent the causes at the lowest level, and the basis for initiating the mechanism of failure, include corrosion, wear, oxidation, hardening, and the like (Imamović et al., 2017).

The Interaction of System Analysis and Risk Management with Forensic Engineering

System analysis and risk management are the antithesis of accident investigation. Risk management aims to prevent accidents, while forensic engineering focuses on analyzing the causes and consequences of accidents. Both aspects are related to legal norms and standards. However, we can use both synergistically, as support and a prerequisite for strengthening both aspects, to conduct an analysis of the causes of undesirable events from the perspective of risk management, in order to enhance existing practices and establish preventive measures for the occurrence of undesired events. This is achieved by conducting system analysis and risk assessment before project initiation and by monitoring the implementation and control of risk occurrence.

The implementation plan for project activities or system construction can be based on previous experience to prevent future accidents through system analysis, risk assessment, and control, determining immediate and root causes of undesired events, and ensuring timely identification of the same. The plan can also be developed by assessing the framework and frequency of undesired event occurrences to estimate the probability of occurrence, ensuring that the estimated impacts align with the severity of the undesired event.

The usefulness of forensic engineering for risk management is evident, established, and widely applied. It wouldn't be an exaggeration to say that without forensic engineering, risk assessment would be nearly impossible (Singh et al., 2012; Chhetri & Kayastha, 2015). Conducting investigations into undesired events, documenting details of their severity and frequency, identifying main causes and contributing factors, builds a knowledge base and statistics that underlie the assessment and determination of the probability and seriousness of risk occurrence. Importantly, findings with any degree of certainty can be of interest for future analyses, planning, and risk management.

Forensic engineering involves an understanding of legal foundations related to the investigated undesired events, particularly regarding risk identification and the responses undertaken within the scope of system analysis and risk management. Forensic engineering is absolutely essential for risk management. A solid analysis and risk management not only reduce accidents but also serve as tools in forensic engineering. A professional comprehension of the differences between system analysis and risk management and forensic engineers holds practical benefits. Ultimately, these two fields share similar professional focuses, functions, purposes, and areas of action. System analysis and risk management are indispensable components of forensic engineering, whether it's analyzing an accident or preventing one, especially when legal implications may influence outcomes. Additionally, various methods and tools, such as the risk matrix (using the AHP method), can be applied in forensic engineering.

Legal aspects, particularly in cases of violation or non-compliance, have an impact on determining and implementing penal provisions in specific fields of action because risk assessment and risk management control are significant in the processing of cases requiring handling in the field of forensic engineering. One of the fundamental questions during case processing by a forensic engineer is whether there is a risk assessment for a specific activity and whether appropriate preventive and corrective measures have been implemented as part of the risk analysis during decision-making and rules establishment, concerning potential influences that could lead to the occurrence of an undesired event (Krishnamurthy, 2016).

Analysis and Risk Assessment of Explosions and Fires

Risk assessments of events involving fires and explosions are continuously analyzed from the perspective of systemic risk analysis, addressing potential issues and ensuring safety in a general sense. Starting from the premise that risk represents the degree of probability that a specific event will occur, coupled with knowledge of materials and conditions that could lead to hazards, the necessary elements for risk analysis and assessment are identified (Wu, 2016). Risk assessment is performed for fires, while risk analysis can be conducted in a broader context using methods for risk analysis, which encompass events to identify problems and prioritize strategic risk assessments and decision-making (Figure 2). Risk assessment forms the foundation for establishing fire and explosion protection systems, events discussed in this work. Systemic analysis and risk assessments contribute to generating recommendations that, when implemented, enhance the safety of individuals, structures, and other material assets.

Figure 2 *Risk Management Model*[2]

2 http://iso18001-delhi-ncr.blogspot.com/2008/10/iso-180012007-ohsas.html

A specific aspect in risk analysis and management is the environment, which with its conditions and factors can significantly impact the entire safety system. Therefore, risk analysis encompasses all elements and factors present in the environment of the space or object being analyzed. Depending on the degree of variability of environmental elements, it is necessary to continuously implement a cycle of processes that lead to the improvement of the risk management system (Figure 3).

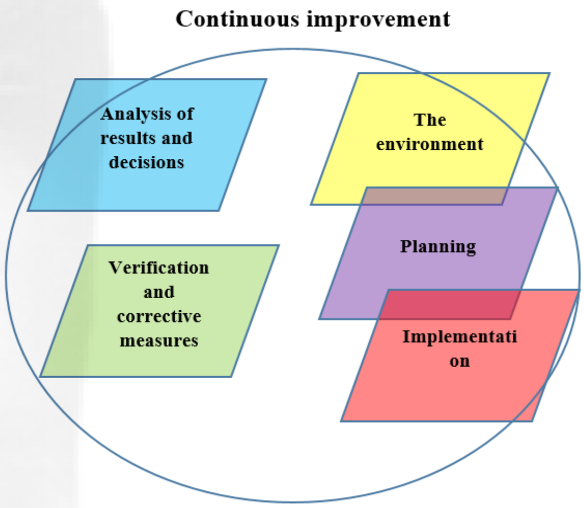

Figure 3 *The Process of Improving the Risk Analysis System*

The threat assessment models, data, and assumptions used for quantifying the risk of fire need to be specifically developed and considered. Models related to the systematic analysis of fire risk should be aligned with their purpose and utilized with particular attention due to the complexity of processes and the influence of environmental factors. Users of these fire-related models must be aware of limitations in terms of their application scope and employ them within those constraints.

During analysis, the range of fire types that can occur in the observed context should definitely be considered. Effects influencing the occurrence and spread of fire, especially flame propagation which can create additional hazards to people, equipment, and the environment, need to be adequately examined. It is also crucial to incorporate appropriate assessments of flame development, propagation, and smoke dispersion to evaluate the impact on action directions, particularly concerning critical locations along the fire's path. Assessment of Fire Consequences Appropriate considerations should be undertaken to analyze the effects of fire on humans, material goods, and the environment. Considerations can relate to various injury and damage mechanisms arising from heat (thermal radiation, inhalation of hot gases), reduced visibility, decreased oxygen, and inhalation of toxic gases and combustion products.

Table 3 *Number of Fires in the Last 5 Years. Forensic Analysis*

Year	Number of fires
2018	2521
2019	2659
2020	2292
2021	2272
2022	2181

Criteria for assessing damage in relation to people, material goods, and the environment must be carefully considered in relation to relevant factors and used judiciously when drawing conclusions related to the occurrence and effects of fire processes (Chhetri, & Kayastha, 2015; Ketsakorn & Phangchandha, 2023). These criteria are also used for defining safety measures and designing evacuation routes, as the harmful effects of fire processes can lead to the disruption of primary and even vital system functionalities, endanger human health and lives, cause damage and destruction of material goods, and harm the environment. It should also be taken into account that fire processes can occur as a primary cause or as a consequence of unwanted events, as well as the spatial and temporal distribution and significance of elements and factors in the environment that influence the occurrence and development of fire processes.

Assessment of the Consequences of the Fire (Air Pollution) at the Chinese Market Centre on August 12, 2021 Using the AHP Method

To demonstrate the interconnectedness of forensics and systemic risk analysis, let us consider the example of the consequences of the fire at the Chinese Market Centre in New Belgrade on August 12, 2021, which directly impacted air pollution with sulfur dioxide (SO_2), PM10 (particles with a diameter of 10 micrometers or less), ozone (O_3), nitrogen dioxide (NO_2), and nitrogen oxides (NO_X). Through the AHP method, we will illustrate at which locations the polluting particles have the greatest impact on the living and working environment. The measurement locations for pollution were Belgrade Omladinskih brigada, Belgrade Vračar, Belgrade Zeleno brdo, and Belgrade Vinča (data retrieved from http://www.amskv.sepa.gov.rs/mob/). The established hierarchy is shown in Figure 4.

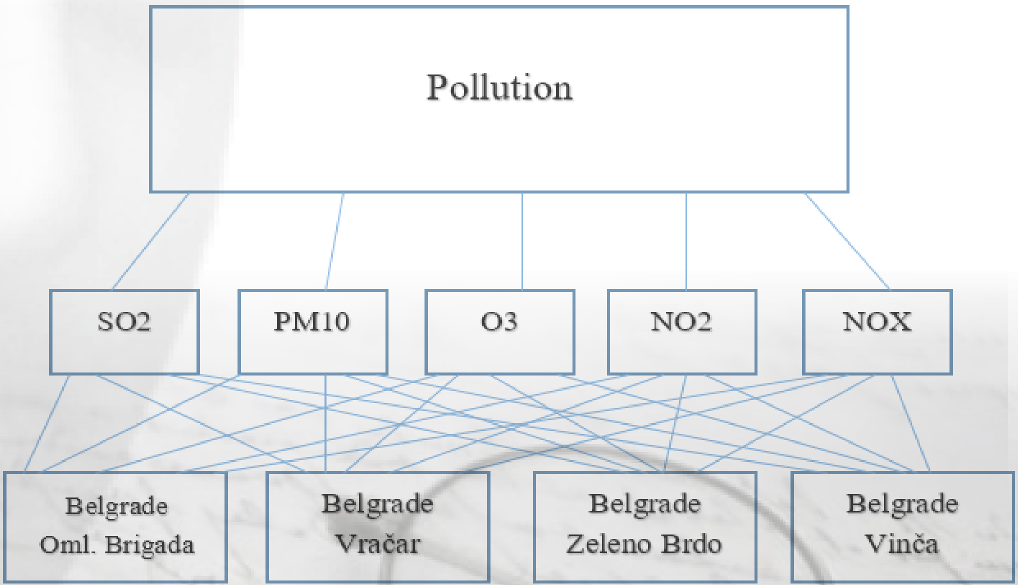

Figure 4 *Hierarchical Representation of the Pollution Problem*

Table 4 *Values of Pollutant Particles at the Location Belgrade, Omladinskih Brigada Street*

Time	SO_2 [μg·m^{-3}]	PM10 [g·m^{-3}]	O_3 [g·m^{-3}]	NO_2 [g·m^{-3}]	NO_X [g·m^{-3}]
Place	Belgrade Oml. brigada				
12.8.2021 21:00	16,79	17,19	21,56	62,77	64,49
12.8.2021 22:00	16,95	26,38	9,85	97,08	140,38
12.8.2021 23:00	17,36	38,72	9,99	95,53	145,5
13.8.2021 00:00	17,92	34,99	4,68	79,4	117,54

Table 5 *Values of Pollutant Particles at the Location Belgrade, Vračar*

Time	SO_2 [μg·m^{-3}]	PM10 [g·m^{-3}]	O_3 [μg·m^{-3}]	NO_2 [g·m^{-3}]	NO_X [g·m^{-3}]
Place	**Belgrade Vračar**				
12.8.2021 21:00	19,12	20,6	46,01	25,8	28,8
12.8.2021 22:00	28,69	19,35	62,84	17,97	20,25
12.8.2021 23:00	20,92	18,91	48,37	21,22	31,92
13.8.2021 00:00	24,72	31,61	3,78	40,75	65,2

Table 6 *Values of Pollutant Particles at the Location Belgrade, Zeleno Brdo*

Time	SO_2 [μg·m^{-3}]	PM10 [μg·m^{-3}]	NO_2 [μg·m^{-3}]	NO_X [μg·m^{-3}]
Place	**Belgrade Zeleno brdo**			
12.8.2021 21:00	12,22	14,73	28,75	58,45
12.8.2021 22:00	12,19	16,26	31,32	66,72
12.8.2021 23:00	12,2	16,27	29,93	69,71
13.8.2021 00:00	12,66	17,24	32,62	78,03

Table 7 *Values of Pollutant Particles at the Location Belgrade, Vinča*

Time	SO_2 [ug.m-3]	PM10 [ug.m-3]	O_3 [ug.m-3]	NO_2 [ug.m-3]	NO_X [ug.m-3]
Place	**Belgrade Vinča**				
12.8.2021 21:00	7,5	26,65	101,04	7,48	9,75
12.8.2021 22:00	7,73	83	47,17	31,11	34,19
12.8.2021 23:00	7,5	66,1	37,39	36,65	39,36
13.8.2021 00:00	7,78	49,61	51,76	23,33	25,59

The period immediately after the outbreak of the fire was chosen for conducting the analysis, and Figure 5 shows as the situation was at 10 p.m.

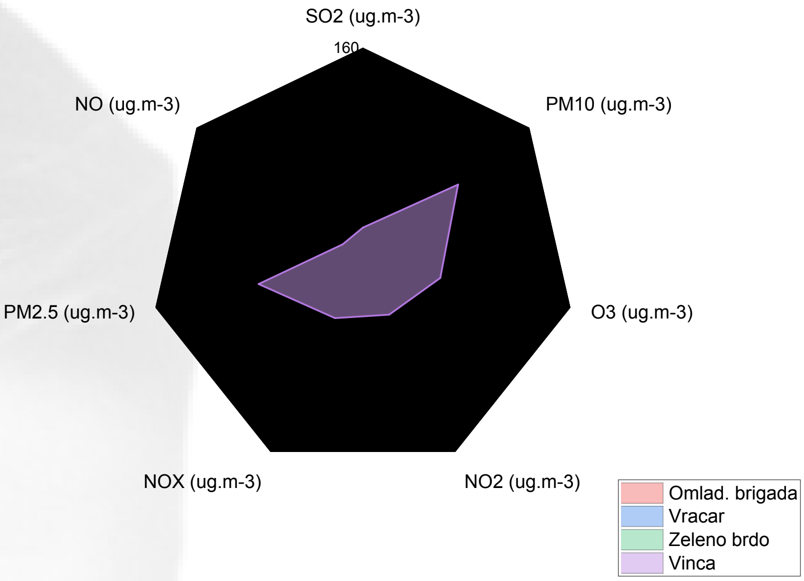

Figure 5 *Situation at 10 p.m. Approximately Two Hours After Fire Start*

According values shown in the tables 4 – 7 further steps in applying AHP method conducted.

Table 8 *Comparing the Significance of Pollutant Particles on the "Nine-Point" Scale*

	SO_2	**PM10**	**O_3**	**NO_2**	**NO_X**
SO_2	1	5	(5)	2	3
PM10		1	(3)	(5)	(5)
O_3			1	3	4
NO_2				1	2
NO_X					1

Table 9 *Assessments and Priorities in Relation to SO_2*

	Belgrade Oml. brigada	**Belgrade Vračar**	**Belgrade Zeleno brdo**	**Belgrade Vinča**
Belgrade Oml. brigada	1	2	2	5
Belgrade Vračar		1	(2)	(6)
Belgrade Zeleno brdo			1	(3)
Belgrade Vinča				1

Table 10 *Assessments and Priorities in Relation to PM10*

	Belgrade Oml. brigada	**Belgrade Vračar**	**Belgrade Zeleno brdo**	**Belgrade Vinča**
Belgrade Oml. brigada	1	7	4	5
Belgrade Vračar		1	(3)	3
Belgrade Zeleno brdo			1	(3)
Belgrade Vinča				1

Table 11 *Assessments and Priorities in Relation to O_3*

	Belgrade Oml. brigada	Belgrade Vračar	Belgrade Zeleno brdo	Belgrade Vinča
Belgrade Oml. brigada	1	3	(2)	5
Belgrade Vračar		1	5	3
Belgrade Zeleno brdo			1	(3)
Belgrade Vinča				1

Table 12 *Assessments and Priorities in Relation to NO_2*

	Belgrade Oml. brigada	Belgrade Vračar	Belgrade Zeleno brdo	Belgrade Vinča
Belgrade Oml. brigada	1	5	(3)	4
Belgrade Vračar		1	4	2
Belgrade Zeleno brdo			1	(2)
Belgrade Vinča				1

Table 13 *Assessments and Priorities in Relation to NO_X*

	Belgrade Oml. brigada	Belgrade Vračar	Belgrade Zeleno brdo	Belgrade Vinča
Belgrade Oml. brigada	1	3	3	4
Belgrade Vračar		1	(5)	(7)
Belgrade Zeleno brdo			1	(8)
Belgrade Vinča				1

Table 14 *Determining the Normalized Attribute Vector (Pollutant Particles)*

	SO_2	PM10	O_3	NO_2	NO_X
SO_2	1	5	(5)	2	3
PM10		1	(3)	(5)	(5)
O_3			1	3	4
NO_2				1	2
NO_X					1

Table 15 *Determining the Normalized Attribute Vector (Pollutant Particles)*

	SO_2	PM10	O_3	NO_2	NO_X
SO_2	1	5	0,2	2	3
PM10	0,2	1	0,33	0,2	0,2
O_3	5	3	1	3	4
NO_2	0,5	5	0,33	1	2
NO_X	0,33	5	0,25	0,5	1
Σ	7,03	19	2,11	6,7	10,2

Table 16 *Determining the Normalized Attribute Vector (Pollutant Particles) - Each Element in the Table is Divided by the Sum of the Elements in the Corresponding Column*

	SO_2	PM10	O_3	NO_2	NO_X	$\sum atribute /5$
SO_2	0,14	0,26	0,09	0,30	0,29	0,22
PM10	0,03	0,05	0,16	0,03	0,02	0,06
O_3	0,71	0,16	0,47	0,45	0,39	0,44
NO_2	0,07	0,26	0,16	0,15	0,20	0,17
NO_X	0,05	0,26	0,12	0,07	0,10	0,12

Table 17 *Normalization of a Vector With Respect to SO_2 - Triangular Matrix of Pairs*

	Belgrade Oml. brigada	Belgrade Vračar	Belgrade Zeleno brdo	Belgrade Vinča
Belgrade Oml. brigada	1	2	2	5
Belgrade Vračar		1	(2)	(6)
Belgrade Zeleno brdo			1	(3)
Belgrade Vinča				1

Table 18 *Determining the Normalized Vector in Relation to SO_2*

	Belgrade Oml. brigada	Belgrade Vračar	Belgrade Zeleno brdo	Belgrade Vinča
Belgrade Oml. brigada	1	2	2	5
Belgrade Vračar	0,5	1	0,5	0,17
Belgrade Zeleno brdo	0,5	2	1	0,33
Belgrade Vinča	0,2	6	3	1
Σ	2,2	11	6,5	6,5

Table 19 *Normalization of a Vector in Relation to SO_2 - Each Element in the Table is Divided by the Sum of Elements in the Corresponding Column*

	Belgrade Oml. briga-da	Belgrade Vračar	Belgrade Zeleno brdo	Belgrade Vinča	$\sum atribute /4$
Belgrade Oml. brigada	0,45	0,45	0,18	0,31	0,77
Belgrade Vračar	0,23	0,23	0,09	0,08	0,03
Belgrade Zeleno brdo	0,23	0,23	0,18	0,15	0,05
Belgrade Vinča	0,09	0,09	0,55	0,46	0,15

We repeat the same procedure for other pollutants.

Table 20 *Normalized Pollutant Vector*

SO_2	PM10	O_3	NO_2	NO_X
0,22	0,06	0,44	0,17	0,12

Table 21 *Normalized Pollutant Vector by Location*

	SO_2	PM10	O_3	NO_2	NO_X
Belgrade Oml. brigada	0,77	0,57	0,38	0,39	0,43
Belgrade Vračar	0,03	0,13	0,29	0,25	0,07
Belgrade Zeleno brdo	0,05	0,14	0,19	0,23	0,15
Belgrade Vinča	0,15	0,16	0,14	0,13	0,35

Table 22 *Determination of Composite Normalized Vector*

	SO_2	PM10	O_3	NO_2	NO_X	Σ atribute
Belgrade Oml. brigada	0,17	0,03	0,17	0,07	0,05	0,49
Belgrade Vračar	0,01	0,01	0,13	0,04	0,01	0,19
Belgrade Zeleno brdo	0,01	0,01	0,08	0,04	0,02	0,16
Belgrade Vinča	0,03	0,01	0,06	0,02	0,04	0,17

Based on the weights of the composite normalized vector, the exposure order of pollutants is as shown on Figure 5.

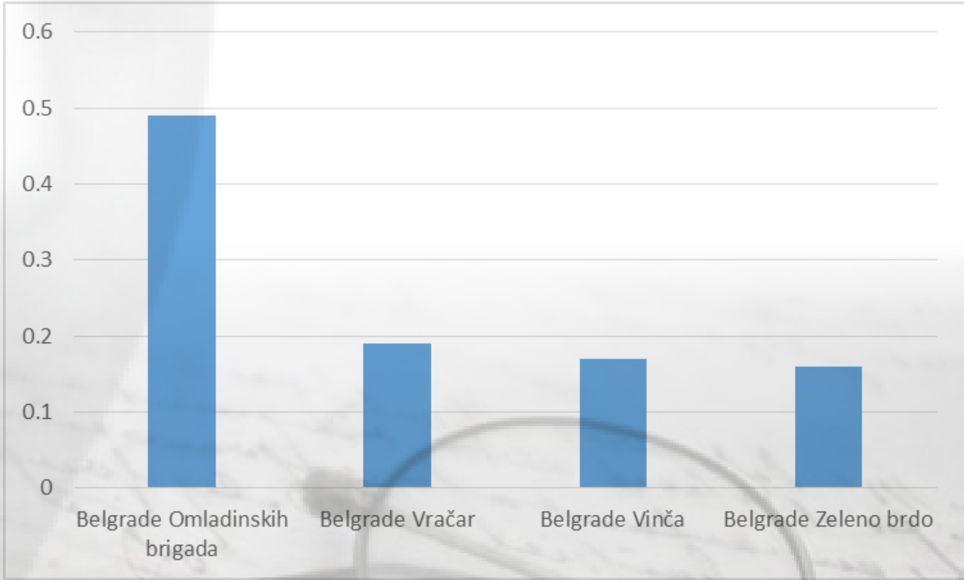

Figure 6 *Results of AHP Method – Exposure Order by Location*

The pollution results in the examined areas are expected, given that the center of the fire was the Chinese Market Centre near the measuring station in Omladinskih brigada (Figure 6-7). Vračar and Vinča, in addition to the additional pollution, also have their "usual" pollution, and Zeleno brdo is the least polluted due to its altitude.

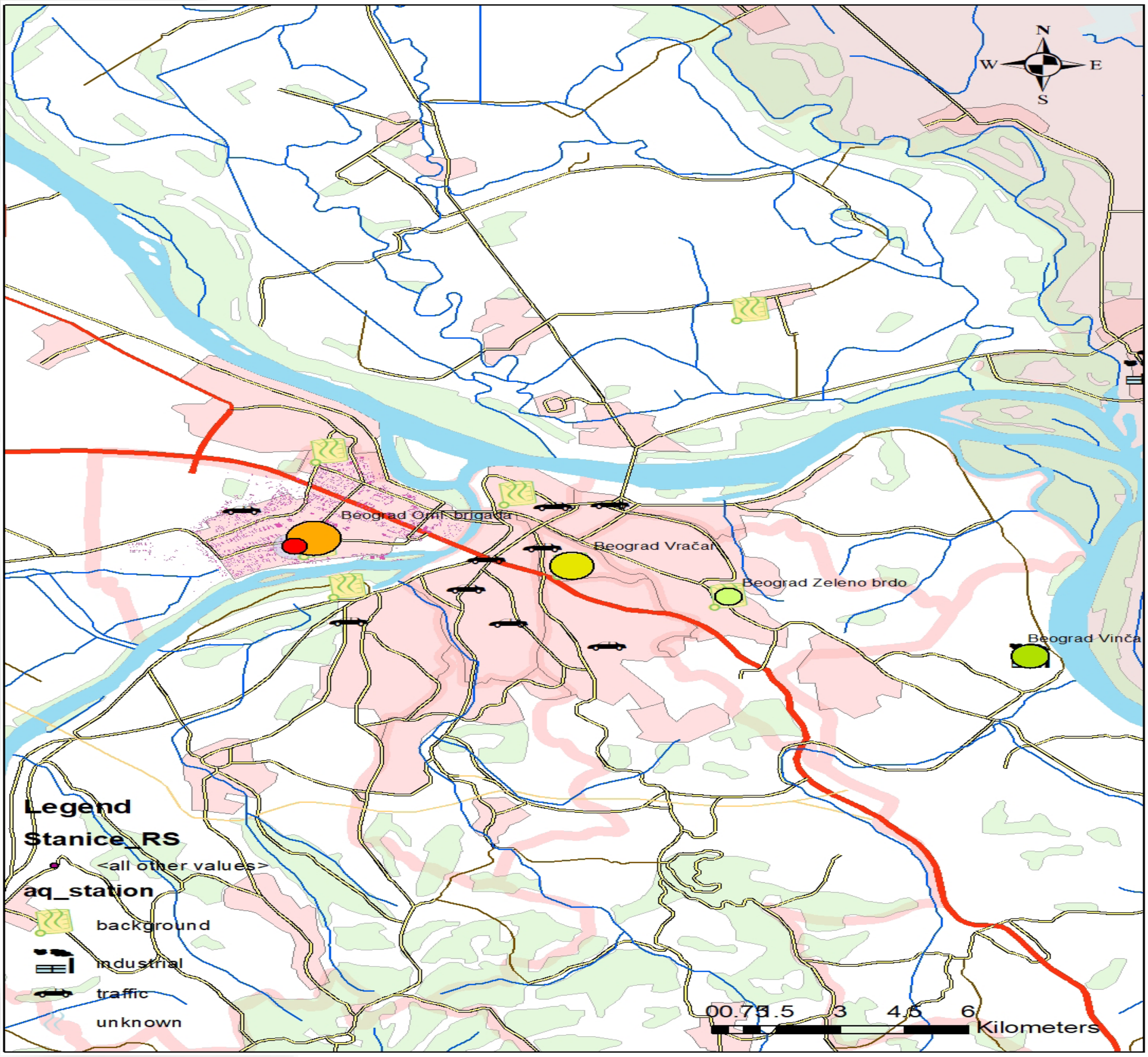

Figure 7 *Location of the Incident and Results of Applied AHP Method*

Conclusion

To demonstrate the interconnectedness of forensics and systemic risk analysis, scope of study was the consequences of the fire at the Chinese Market Centre in New Belgrade on August 12, 2021. Through the AHP method, we got at which locations the polluting particles have the greatest impact on the living and working environment. As the AHP method is one of widely used multi-criteria decision analysis approaches, in this study is shown approach based on exact data and the expert-judgment method with the facility to check the consistency of the rating provided by the expert, confirming the relative priority of each used data relevant to the criteria. It is shown that distance from evet, environment condition and measures air pollutant on stations, are relevant for prioritizing and taking actions. In the examined area the pollution effect was as expected, as the center of the fire was the Chinese Market Centre near the measuring station in Omladinskih brigada. Values measured of observed air pollutants (SO_2, PM10, O_3, NO_2, and NO_X) on the stations for automatic air quality monitoring Vračar and Vinča, didn't differ from normal level, and Zeleno brdo is the least polluted due to its altitude.

The selection of factors is based on the availability of data for the study area and the relevance with respect to fire incidents. However, more factors can be considered for further study if data are available.

Risk assessment with involvement further factors of interest might contribute to resolve problems using fuzzy mathematics and the analytic hierarchy process together to evaluate risk which is proved useful to solve uncertainty and imprecision problems (Peng et al., 2021).

Solving problems due to fire and explosion, systematic studies are necessary, and mapping and risk assessment might contribute, however conducted study is in line with that. Also, the study of Chhetri and Kayastha (Chhetri & Kayastha, 2015) consider application of an AHP method for fire potential zone mapping generation for city area. Furthermore, AHP has been applied in many and diverse areas of decision-support in environmental management such as wildfire risk map (Mahdavi, et al., 2012), forest fire risk map (Kanga, et al., 2013), urban fire risk map (Srivanit, 2011), land use pattern selection (Malczewski, et al., 1997) and similar.

According to presented results it was confirmed correlation between location of fire and concentration of the air pollutants in the examined area as well as contribution to event analyse from the forensic point of view. Furthermore, it can be applied for further development and adaptation of standard operating procedures related to responding to the occurrence of undesirable events are elements of preventive actions related to occurrence and reducing negative effects.

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