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Current issues and development opportunities in damage prevention during the transport of dangerous goods

A közúti veszélyes áru szállítási kárelhárítás aktualitásai és fejlesztési lehetőségei

Csaba Dr. Almási
University of Public Defense
Email: almasi.csaba@uni-nke.hu
ORCID: 0000-0002-3031-0515

Róbert Dr. Révai
Deputy director general
Bajcsy-Zsilinszky Hospital and Clinic
Email: robert.revai@bm.gov.hu
ORCID: 0000-0001-7282-6555

Bevezetés

A veszélyes áruk közúti szállításával kapcsolatos vészhelyzetek megelőzése és kezelése a hivatásos katasztrófavédelmi szerv egyik alapvető feladata. A balesethez vezető okok azonosításán és dokumentálásán túl, elengedhetetlen a következtetéseken alapuló műszaki fejlesztési irányok azonosítása. Veszélyes áruk szállításával kapcsolatos balesetek megelőzése és kezelése rendkívül összetett feladat, ahol a mentési időtényező csökkentése kritikus fontosságú kérdés. Jelen tanulmány a veszélyes áruk tartányos technológiával és közúton történő szállításával kapcsolatos kockázati aktualitásit, valamint a rendkívüli események kezelésének fejlesztési lehetőségeit vizsgálja.

Introduction

Preventing and managing emergencies related to the transport of dangerous goods by road is one of the fundamental tasks of professional disaster management agencies. In addition to identifying and documenting the causes of accidents, it is essential to identify technical development directions based on conclusions. The prevention and management of accidents involving the transport of dangerous goods is an extremely complex task, where reducing rescue time is a critical issue. This presentation examines the current risks associated with the transport of dangerous goods by tank technology and road, as well as the development opportunities for managing extraordinary events.

Kulcsszavak: veszélyes áru, ADR, közút, kockázat, aktualitás, tartányos szállítás

Keywords: dangerous goods, ADR, public roads, risk, current events, tank transport

1. LEGAL BACKGROUND AND TRENDS

The *European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)* was signed in Geneva on 30 September 1957 and entered into force with its Annexes on 29 January 1968. Hungary acceded to the Agreement in 1979. As regards the domestic application of the ADR Agreement, the *Government Decree 165/2025 (VI. 30.) on the promulgation of Annexes A and B to the Agreement on the International Carriage of Dangerous Goods by Road* and on certain aspects of its domestic application, and the *ITM Decree 39/2021 (VII. 30.) on the domestic application of Annexes A and B to the Agreement on the International Carriage of Dangerous Goods by Road (ADR)* are in force in Hungary today.

The requirements of *Regulation (EU) No 70/2012 of the European Parliament and of the Council of 18 January 2012 on statistical returns in respect of the carriage of goods by road (recast)* provide a good picture of trends in the transport of dangerous goods and the production of chemicals in the European Union. In Hungary, we comply with the requirements of Regulation (EU) No 70/2012 in accordance with the provisions of *Annex 13 of Government Decree 388/2017 (XII. 13.) on the mandatory data provision of the National Statistical Data Collection Programme.*

In 2024, EU imports of chemicals and related products declined by 1.1% compared with 2023, while exports grew by 7.0%. This shift boosted the trade surplus by €40 billion. Looking at the longer horizon, between 2014 and 2024 imports rose from €185 billion to €322 billion, reflecting an average annual growth rate of 5.7%. Over the same period, exports expanded from €303 billion to €560 billion, corresponding to an average annual growth rate of 6.3%. As a result, the EU's trade surplus in chemicals steadily increased, climbing from €119 billion in 2014 to €238 billion in 2024. (Figure 1) [1].

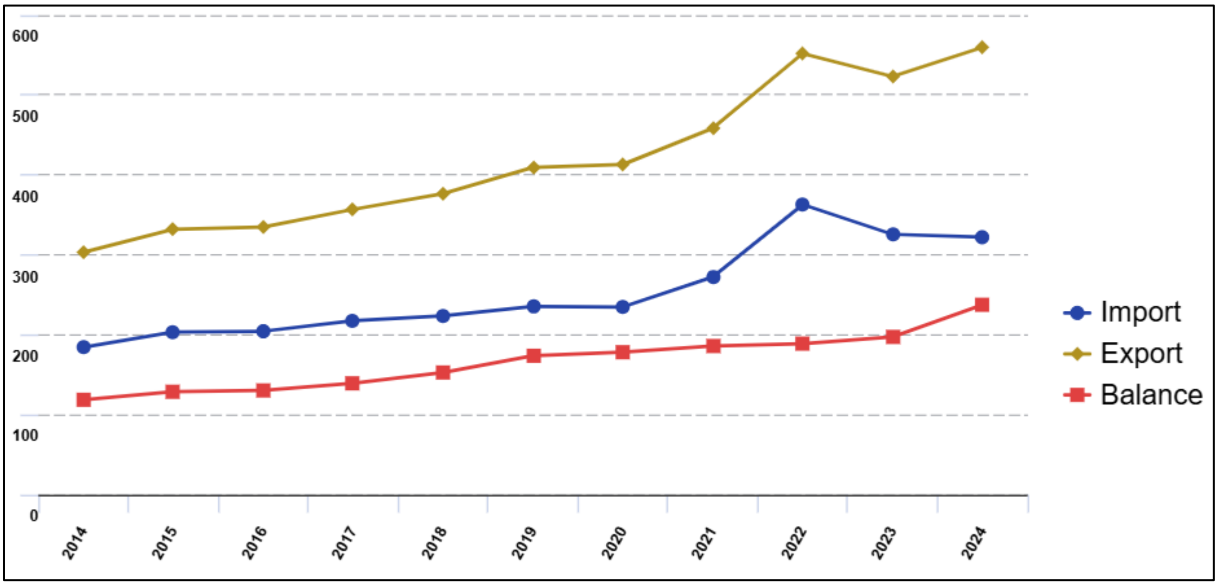

Figure 1: Trade in chemicals and related products in the EU, 2014–2024. Eurostat, 2025 [1].

Over a longer period from 2014 to 2024, both imports and exports grew substantially, but exports consistently outpaced imports. This indicates that the EU chemical industry has strengthened its role as a net exporter, leveraging economies of scale, innovation, and integration into global value chains. The steady increase in the trade surplus, from €119 billion in 2014 to €238 billion in 2024, demonstrates that chemicals and related products are a strategic sector for the EU economy, contributing positively to overall trade balances.

Figure 2 shows the share of dangerous goods in total transport performance (measured in tkm) across EU countries in 2023 and 2024. The highest shares of dangerous goods in road transport were recorded in Finland and Belgium, followed by Denmark. Several countries, including France, Spain and Germany, reported shares between 4.0% and 6.0% in both years. Poland, despite being a major player in road freight transport, had relatively low shares. Slovakia, Portugal and Lithuania each remained below 2.0% in both years. (Figure 2) [2].

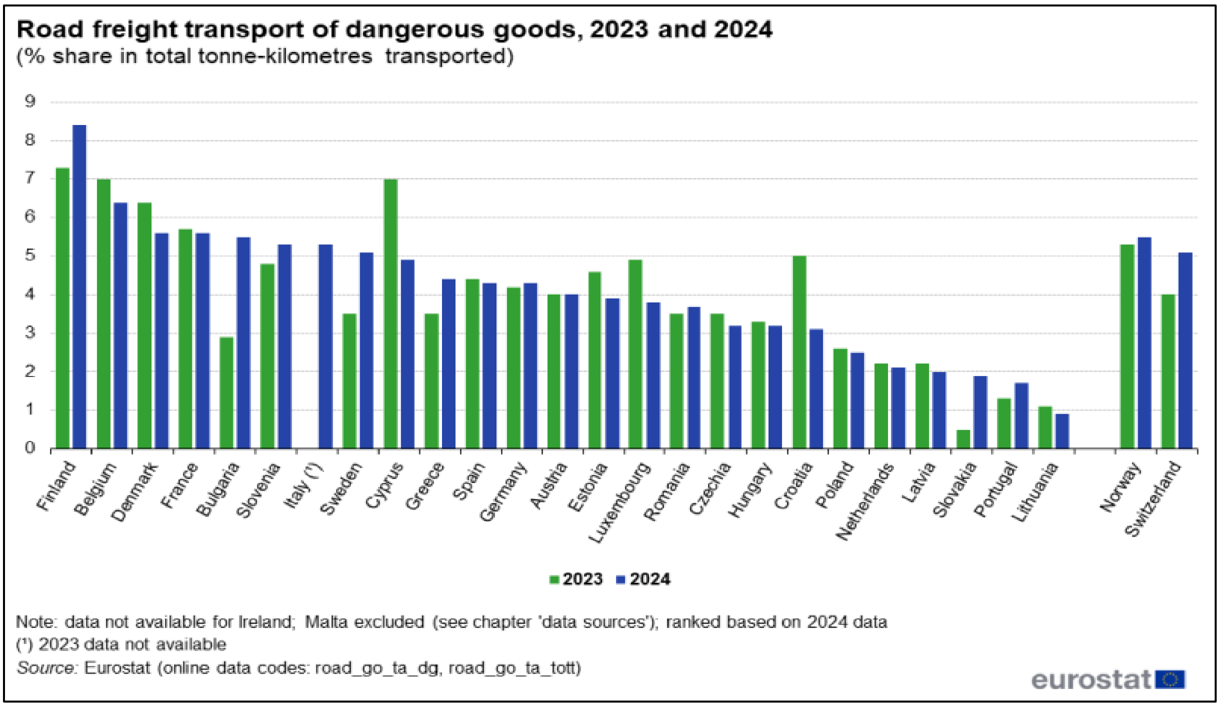

Figure 2: Road transport of dangerous goods, 2023 and 2024 (percentage in tonne-kilometers). Source: Eurostat. [2].

In 2023, the distribution of dangerous goods transported by road was dominated by flammable liquids (ADR Class 3), which accounted for 48.8% of total ton-kilometers. They were followed by gases (ADR Class 2) at 15.8% and corrosives (ADR Class 8) at 12.4%. Together, these three classes represented more than three-quarters (77%) of all dangerous goods transported by road (Figure 3) [3].

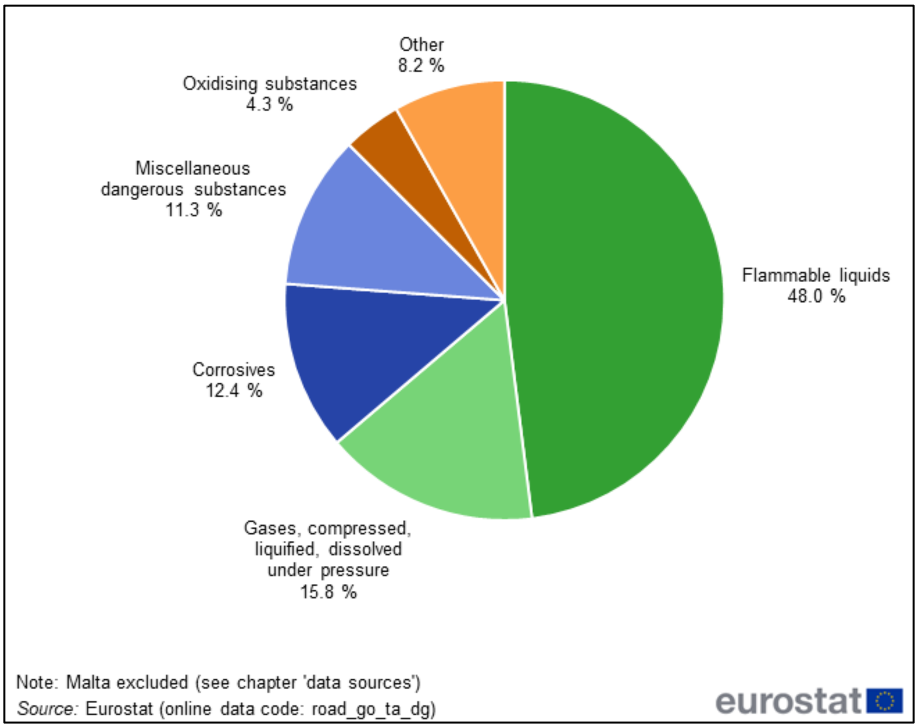

Figure 3: Road transport of dangerous goods, 2023 and 2024 (percentage in tonne-kilometers). Source: Eurostat. [3].

This concentration reflects both technical and economic factors. Flammable liquids, such as fuels and chemical intermediates, are essential for energy supply and industrial production, explaining their overwhelming share. Gases, including LPG and industrial gases, are widely used in heating, energy generation and manufacturing, which drives steady demand for their road transport. Corrosives, though smaller in volume, are critical inputs in chemical processing, metallurgy and other industrial sectors, making their presence significant.

From an economic perspective, the dominance of these three classes highlights the structural dependence of the EU economy on energy carriers and chemical feedstocks. Road transport remains the most flexible and cost-effective mode for distributing these materials across short and medium distances, especially within integrated supply chains. The high share of flammable liquids also mirrors the continued reliance on petroleum-based products, while the growth of gas transport reflects diversification in energy sources. Corrosives, though less visible, represent specialized industrial demand that sustains niche but vital segments of the chemical economy.

The flammability property characterizes not only flammable liquids but several other hazard classes as well. Flammability is present in Class 1 explosives and articles, specifically in Divisions 1.3, 1.4 and 1.5; in Class 2.1 flammable gases; and in Class 4.1 flammable solids, self-reactive substances, polymerizing substances and desensitized solid explosives. Class 4.2 covers substances liable to spontaneous combustion, while Class 4.3 includes substances which, in contact with water, emit flammable gases. Class 5.1 comprises oxidizing substances, and Class 5.2 organic peroxides. In addition, Class 8 corrosive substances may also cause ignition of materials. Class 9 includes, among others, lithium batteries, which are increasingly used and pose specific fire hazards.

2. THE HUNGARIAN DISASTER MANAGEMENT MOBILE LABORATORY UNITS

Accidents involving the road, rail, water, or air transport of dangerous substances, as well as incidents at dangerous establishments, hospitals, landfills, and other hazardous facilities, may result in the release of substances into the environment that can endanger the normal functioning of society and the economy. Fires at waste incineration facilities can pose risks to the public and the environment comparable to those arising from major industrial accidents involving hazardous materials.

In Hungary, hazardous materials response is supported by the Disaster Management Mobile Laboratory (DMML). The DMML is responsible for the identification, monitoring, and forecasting of actual or potential releases of hazardous substances during emergency situations. It formulates recommendations to ensure safe working conditions for first responder emergency services, such as firefighters, ambulance services, and the police, and to implement measures for the protection of the public and the environment. The DMML possesses the necessary technical capabilities and qualified personnel to collect, organise, and process initial data required for emergency assessment, to identify hazardous materials, and to maintain continuous communication and cooperation with partner agencies while contributing to the coordination of emergency response operations.

The industrial-chemical accident safety in Hungary is ensured by 19 county-level DMML units, supplemented by dedicated laboratories serving Budapest and Liszt Ferenc International Airport. The work and operations of DMML Unites are supervised by the National Directorate General for Disaster Management (NDGM) body. In addition to their operational response role, these mobile laboratories also carry out official preventive activities, which are closely integrated with their incident management and intervention functions.

The DMML performs chemical, biological, radiological, and nuclear (CBRN) tasks during incidents involving hazardous materials, fires involving dangerous substances, the transport of hazardous goods, hazardous installations, gas releases, radiation hazards, and biological threats. To fulfil these tasks, the DMML is equipped with radiation detection and contamination measurement systems, Raman spectrometers, detector tubes and electrochemical gas monitors, rapid biological detection devices, and mobile systems for measuring meteorological parameters, gases, and dose rates. Its capabilities are further supported by consequence analysis software and chemical databases, infocommunication systems, independent power supply and lighting, technical support equipment, personal dosimeters, respiratory and skin protection, and decontamination kits.

3. DRAFTING AND SUMMARIZING PROPOSALS

In order to supplement the rescue and the damage reduction (salvage) procedures used in package delivery technology, it is necessary to define the group(s) of dangerous goods for which the development of container rescue technology and procedures is justified, and to identify the necessary technical conditions and possible technical directions for development. The development of technical rescue requirements (salvage) of tankers/containers for the transport of dangerous goods by road in a domestic and international context can be used by professional disaster management agencies, the police, environmental authorities, and transport authorities in developing damage prevention and emergency response strategies, and can be incorporated into any training curriculum that includes a sustainability and safety approach [4].

In the transport of dangerous goods by road, particularly when large quantities are carried in tanks and storage or transport equipment, the technical and procedural conditions required for effective emergency intervention have not yet been fully developed. This is especially evident in the case of tank transport, where rapid and well-defined response measures could significantly reduce the likelihood of a major accident. As a result, there is a clear need to develop a dedicated methodology for damage prevention specifically tailored to tank-based dangerous goods transport technologies. It cannot be assumed that a universally applicable rescue tank or a simplified "package rescue" model can be implemented, as no single tank design is capable of safely accommodating all types of dangerous substances and their diverse physical and chemical properties. However, by analysing the technical characteristics of different tank designs, the types of hazardous materials typically transported, and statistical data on accident frequency, it is possible to identify the most suitable rescue tank solutions for specific scenarios. Past incident patterns related to transport technologies indicate that it is not justified to define remediation solutions solely on the basis of sustainable transport concepts; instead, a risk-based and material-specific approach is required [4].

To support this approach, it is necessary to compare the frequency of incidents involving individual substances with the technical requirements arising from their hazardous properties, in order to determine the most appropriate remediation tools and to develop concrete proposals for their integration into tank systems. Existing mitigation solutions designed for small-scale releases, or situations with a potential risk of release, should be extended and adapted to address scenarios involving the possible discharge of larger quantities. Accordingly, the principle and methodology of mitigation during transport should be elevated to a higher level by examining proportional volume-based compensation procedures. An analysis of past accidents shows that the majority of incidents are associated with bulk transport technologies, which account for nearly two-thirds of the cases examined. Transport involving packaged goods represents approximately one-third of incidents, while other transport technologies occur only to a negligible extent. By identifying the classes of dangerous goods most frequently involved in emergencies, it becomes evident that the risks to rescue personnel, the population, and the environment could be significantly reduced by maintaining appropriate rescue containers in a state of readiness.

At the same time, it must be acknowledged that no single container is suitable for all types of hazardous substances. A comparative assessment of the hazards posed by different materials, the challenges of handling them, and the characteristics of various transport technologies leads to the conclusion that the transport of gases represents the highest level of risk.Mobile containers are considered the most suitable rescue container technology, primarily due to their intermodal capabilities. However, when transporting dangerous goods by combined transport, the possibility of accidents with minor or major consequences during transshipment and temporary storage must also be taken into account. In order to reduce costs, it may be proposed that the mobile container for rescue purposes should have a dual function, which would be achieved by leasing the container to businesses engaged in special tasks and making it available to the professional disaster management service at short notice. [4].

In the "Hubei Dong Runze Special Vehicle Equipment Co., Ltd.", the extremely hazardous tank container IMO 1, T11, T14, T20 and T22 is available in stainless steel with a capacity of between 14,600 and 24,000 liters. These containers are specifically designed for the transport of extremely hazardous and often corrosive substances and fully comply with international standards, including ASME-U Stamp certification for the T20 and T22 models. The range includes rubber-lined, resin-lined or plastic-lined tanks, as well as a number of modifications such as baffles, bolted manholes, valve actuators, coated valves, spill containment boxes, gauges and multiple top discharge connections. Additional safety fittings and flexible connections can also be installed to improve operational performance. In addition to the options listed, numerous other modifications and accessories are available. Share your requirements with us and we will recommend the tank container that best suits your needs, taking into account the product type, operating environment and specific filling or emptying preferences. Our goal is to provide the optimal solution that balances efficiency and cost-effectiveness [5].

Figure 4: T50 mobile tank. Truckchina official website. [5].

In order to supplement the damage control procedures used in parcel delivery technology, the group of dangerous goods for which it is justified to develop tank compensation technology and procedures was determined, and the necessary technical conditions and possible technical directions for development were identified.

The development of technical requirements for the transport of dangerous goods by road in a domestic and international context can be used by professional disaster management agencies, the police, environmental authorities, transport authorities in the development of damage prevention and emergency strategies, and can be incorporated into any training curriculum that includes a sustainability and safety approach.

4. PREVENTION ISSUES AFFECTING THE SAFETY OF DANGEROUS GOODS TRANSPORTATION

One of the important areas of prevention of dangerous goods logistics accidents is the prevention of the release of flammable dangerous substances into the open air, the most important technical basis of which is the installation of signaling systems [6]. In addition to property protection systems, fire protection signaling systems installed for fire prevention purposes [7], which perform their assignments together with widely used fire protection extinguishing systems [8]. In addition to fire protection signaling systems, it is also particularly important the application of monitoring systems for the detection of dangerous substances that are primarily flammable and toxic in industrial environments. These systems can be installed inside buildings, such in the case of commercial and logistics warehouses, or outside the building in the technological and natural environment [9]. In recent years, as a result of technological development, the simplification of these systems and the harmonization of their application with systems serving other purposes have come to the fore. The latter supporting technical system can also be camera systems installed for property and occupational safety purposes [10-11]. The control of dangerous goods road transport activities begins at the border, where customs organizations must exercise special care in handling shipments. Planning and organizing joint cooperation tasks with disaster management could be a further research direction. [12].

5. SUMMARY

The results of the study examining the causes, consequences and frequency of accidents in the transport of dangerous goods by road could be also used in the development of technical requirements promoting the sustainability and safety of transport in domestic and international contexts, they can be used by the professional disaster management body, the police, the environmental protection authority, the transport authority for damage prevention and during the development of emergency management strategies, and can be integrated into the curricula of all training courses that include the sustainability and safety of the approach.

6. BIBLIOGRAPHY

[1] Eurostat (2025a): Growing trade surplus in chemicals and related products in 2024. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Trade_and_production_of_chemicals_and_related_products (13.11.2025.)

[2] Eurostat (2025b): Road freight transport of dangerous goods. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Road_freight_transport_by_type_of_goods&oldid=582170#Road_freight_transport_of_dangerous_goods (13.11.2025.)

[3] Eurostat (2025a): Road freight transport of dangerous goods. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Road_freight_transport_by_type_of_goods#Road_freight_transport_of_dangerous_goods (13.11.2025.)

[4] Almási Cs. (2025). Közúti veszélyes áru szállítási káresemények vizsgálatának műszaki megalapozása. Doktori disszertáció. Védés éve: 2025 Megjelenés/Fokozatszerzés éve: 2025. [Online]. Available: https://tudasportal.uni-nke.hu/xmlui/handle/20.500.12944/101086 (13.11.2025.)

[5] Truckchina (2025): Hubei Dong Runze Special Vehicle Equipment Co., Ltd. [Online]. Available: https://www.truckinchina.com/20-Feet-21cbm-ISO-Standard-Liquid-Chlorine-Storage-Tank-Container-For-UN1017-Cl2-Road-Tansport-pd45886102.html (13.11.2025.)

[6] Cimer Zs. *Módszertani kézikönyv a veszélyes anyagokkal kapcsolatos súlyos balesetek elleni védekezéssel foglalkozó gyakorló szakemberek részére* Budapest: Hungária Veszélyesáru Mérnöki Iroda, 178. p, 2020.

[7] Kátai-Urbán M., Hoffmann I., Bíró, T. "Oltóvíz felfogó és tároló létesítmények tervezése és létesítése német útmutató alapján" *Hadmérnök, 14(2)*, p. 111–122. https://doi.org/10.32567/hm.2019.2.9b (2025.11.23.)

[8] L. Kátai-Urbán, Zs. Cimer: "Summary of Practical Experience in Internal Emergency Planning of Dangerous Chemical Establishments" *Scientific Bulletin of the Nicolae Balcescu Land Forces Academy: 30(1)*, 2024. 29-39. (2025)

[9] L. Kátai-Urbán, G. Horváth, Á. Berger, Zs. Cimer "Анализ изменения стойкости бетонных конструкций в промышленности при химическом воздействии с учетом потенциальных рисков для работников и окружающей среды/ Безопасность труда в промышленности6 - Analysis of Changes in the Durability of Concrete Structures in the Industry under Chemical Exposure, Considering Potential Risks for Workers and the Environment" *Bezopastnost' Truda v Promyshlennosti, 2024(9)*, p. 57–65. (2024) http://doi.org/10.24000/0409-2961-2024-9-57-65 (13.11.2025.)

[10] Cimer Zs. *Ipari biztonsági kockázatkezelési kézikönyv*. Budapest: KJK- Kerszöv Jogi és Üzleti Kiadó, 227 p., 2004.

[11] Á. Berger, Zs. Cimer, L. Kátai-Urbán "The main aspects of the design and maintenance of hazardous material remediation bunds" *Zeszyty Naukowe Wyzsza Szkola Oficerska Wojsk Ladowych 57:3 (217),* pp 5-22., [Online]. Available: https://zeszyty-naukowe.awl.edu.pl/article/552228/en (13.11.2025.)

[12] Bakai K. P., Suba L., Szabó A. "First Year Experience of the Abolition of the €22 Rule and the Introduction of the New e-Commerce Vat Laws" *Pénzügyi Szemle, 4 (4)*. pp. 585-600. Available: https://journals.lib.uni-corvinus.hu/index.php/penzugyiszemle/article/view/1169 (13.11.2025.)