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Major Chemical Accidents in the 21st Century Europe and its Lessons Learned in Higher Education[1]

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This article provides an example of how to use case studies in the case of disaster management education subjects. The development of the subject's program and content are a continuous activity, actually a consequence of the changing world. Companies carrying out chemical processes while maintaining their competitiveness, cannot be considered constant in parallel with the constantly evolving technical conditions. Therefore, industrial processes, chemical processes, accident prevention, recovery techniques, presentations in the lectures need to be updated.

New methods can be used for computing devices, applications, or their results. In the case of hazard analysis, the software and the presentation of their computational results are, in my experience, effective in the line of teaching methods. Namely, depicting and propagating the propagation of a gaseous material with a dangerous property, the direction and speed of the wind (and other physical chemical parameters) is an effective frontal technique for the students.

The chemical processes are based on numerous chemical processes, which are able to operate under constant control of the control parameters. There is a strong professional justification for describing these processes, which is the subject of the Dangerous Technology section of the subject in the field of industrial security.

Keywords*: hazardous chemicals, case study, chemical industry, chemical accident, higher education, disaster management*

Introduction

Mankind was helped by numerous accidental discoveries and inventions to achieve today's development level. Here are a few seldom heard special discoveries:

Thanks to the development of Sir Humphry Davy in 1815, by replacing the lamp used for lighting in mines with a safety alternative, much fewer accidents occurred in coal mines. Methane was an undesirable by-product in many coal mines, resulting in frequent firedamp explosions. Davy's lamp saved many lives and proved to be a huge opportunity for mining. [1]

In 1839, Charles Goodyear invented a process that made it possible to use rubber extracted from the rubber tree on an industrial scale, thus making rubber one of today's most useful materials. The vulcanization process was accidentally invented. This process is a chemical process which increases the strength and durability of rubber tires. The tire retains

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its elasticity in a much wider range of temperature, therefore vulcanised rubber can be used for more purposes. [1]

In 1846 nitroglycerin was produced by an Italian scientist, Ascanio Sobero, the first to do so according to the publications. Nitro-glycerine is a very explosive liquid, so it was very risky to use.

In 1866, Alfred Nobel, a Swedish inventor, mixed silicon dioxide with liquid nitro-glycerine, thus obtaining an extremely explosive paste and patented the process in 1867. Nobel's aim was to place dynamite on the market and use it for larger construction work, such as building roads and tunnels. Unfortunately, however, dynamite has been used by the military as a weapon in numerous battles. [1]

The contradictory story of dichloro-diphenyl-trichloroethane (DDT) is also worth recounting to the readers. DDT was first produced in 1874 by the German chemist Othmar Zeidler. Its usefulness was proved by Swiss biochemist Paul Hermann Muller in 1939, discovering its effectiveness as a general insecticide. Muller received a Nobel Prize in 1948. The introduction of DDT reduced the occurrence of malaria, typhoid, yellow fever and bubonic plague which had killed millions of people. However, it was found that DDT is not selective, its effects are not limited to insects and it is very dangerous to the human body, because it is able to cause many changes in the body. Decays very slowly and accumulates in different living organisms.

The first artificially created element was technetium (Tc), created in 1937 by Emilio Segre and Carlo Perrier. Alloys containing technetium oxide reduce corrosion. [1]

Justification for the Choice of the Subject

To maintain today's standard of living, it is inevitable to have contact with dangerous substances on a daily basis. Production, transportation, use and storage are all activities involving continuous risk factors throughout the world. Work accidents, malfunctions, damage incidents, transport accidents in the country; the release of dangerous materials whether they are gaseous, liquid or solid are practically everyday occurrences. It is important for disaster management specialists to have a professional routine in activities involving chemicals, so that they can provide effective professional advice to students they are in charge of, the would be future professionals. Naturally, primary interveners and professionals from authorities may also encounter this problem.

A Brief Introduction to Present Europe's Chemical Industry

The chemical industry supports virtually all segments of the economy and is closely entwined with its customers downstream. Rubber and plastics, pulp and paper, and the automotive industry are all huge users. Closely two-thirds of EU chemicals are supplied to EU manufacturers or construction. The EU chemical industry distributes technology throughout the region's economy. The EU chemical industry's share of world markets has declined in the past two decades. Trading chemicals all over the place prompts competition, provides an incentive to develop different markets through innovation, inspires production efficiency and helps develop the quality of human life.

Characteristics of the EU28 chemical industry structure:[3] [2] [3]
- number of companies: 28,221;
- turnover: 520.2 billion €;
- direct employees: 1,155,000.

The chemical industry demands energy and competes globally. Anything that increases energy costs in Europe in relation to our participants has a major impact on competitiveness. EU legislation adds several costs for the European chemical industry, hampering its worldwide competitiveness. [2] [3]

Among others REACH prices will likely decrease after 2018; on the other hand complying with biocidal product and plant protection regulations will become costlier. The aim is to guarantee regulation by achieving its objectives in the most well-organized way, and correct any shortcomings without negotiating health, safety and environmental protection. Europe's chemical industry needs a regulatory framework that is fit for the purpose, consistent, cost-effective and which does not negatively impact its competitiveness vs other regions.

Over the last two decades, the European chemical industry, together with pharmaceuticals has made a huge effort to minimise the environmental impact of its production. The European chemical industry is still a world leader, and a highly inventive sector. Germany and France are the two largest chemicals producers in Europe, followed by Italy and the United Kingdom. [2] [3]

Characteristics of Hungary's Chemical Industry Structure

The chemical industry plays a significant role in Hungary's economy. The chemical and pharmaceutical businesses have a long history in Hungary, as they do investigation, improvement and novelty that are mainly essential now to the competitiveness and sustainable development of the country's chemical companies. [4] [5] [6] [7] [8]

Manufacturers operate laboratories and research centres. The Chemical Research Centre of the Hungarian National Academy and the technical universities of Budapest, Veszprém, Debrecen and Miskolc participate in both basic and applied research projects in cooperation with companies and/or under EU programmes and projects.

Characteristics of Hungary's chemical industry structure:[4] [4] [5] [6] [7] [8]
- turnover: > 16 billion €;
- direct employees: 80,305.

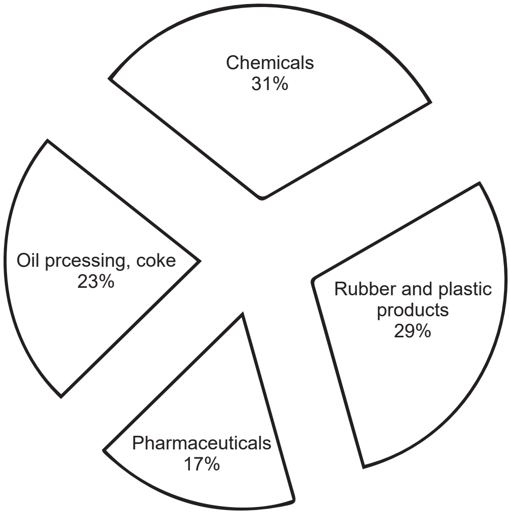
Strengths of the Hungarian chemical industry:
- a robust petrochemical base,
- rule economies of scale, up-to-date technologies and sound environment practices,
- powerful presence on the stock exchange,
- volume improved by investment to meet demands from electronics and agriculture.

[3] Based on data of the year 2015.
[4] Based on data of the year 2015.

Development targets of the Hungarian chemical industry (weaknesses):

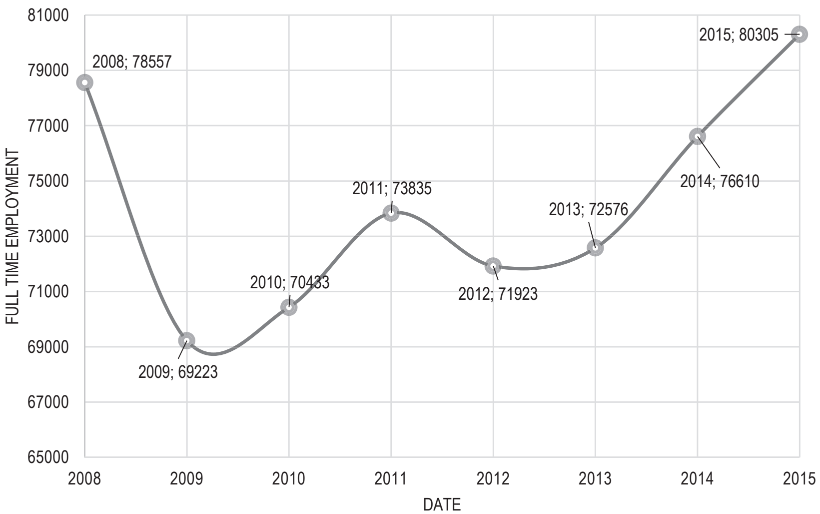
- depends heavily on imported raw materials and energy,
- high and volatile energy prices weaken competitiveness.

The chemical enterprises are trying hard to maintain and develop close relations with vocational training schools, dedicated high-schools and technical universities to attract young, well-trained and highly educated people to replace the aging employees. This aims to avoid skill shortages and losing professionals to other developed economies. Chemical industry structure in Hungary (2015), source: Hungarian Chemical Industry Association as shown in Graph 1. [4] [5] [6] [7] [8]



Graph 1. *Chemical industry structure in Hungary (2015), source: Hungarian Chemical Industry Association.*
(Compilation of data by the author based on source [4–8].)

The business is a giant employer, with more than 80,000 workers, including 14,000 in chemicals and 17,000 pharmaceuticals. With gross wages above the national average, the chemical segment is a valued employer. Full time employment in the Hungarian chemical industry (2008–2015) source: Hungarian Chemical Industry Association as shown in Graph 2. [4] [5] [6] [7] [8]



Graph 2. *Full time employment in the Hungarian chemical industry (2008–2015) source: Hungarian Chemical Industry Association.*
(Compilation of data by the author based on source [4–8].)

In the following part of my paper some characteristic major chemical accidents will be discussed and lessons learned and accepted in higher education will be summarized.

Toxic Leakage in a Frozen Food Storehouse in France

On the premises of a company operating hundreds of frozen food storehouses located in the village of Nemours, near the A6 motorway in Seine-et-Marne, France, packaging, distribution and storage of food products take place. The company employed 236 employees in 2005 and consisted of two buildings separated by a passageway. The logistics warehouse contains a laboratory and a refrigerated storage room with the refrigerator containing ammonia. This technology line is capable of storing up to 2 tonnes of ammonia. [9]

As regards the pressure vessel containing ammonia, it is important to note that it was only equipped with filling and fluid drainage valves, but it did not have various pressure accessories, such as pressure gauges or safety valves.

Between 20th and 26th April 2005, safety improvements were planned for the refrigeration equipment used by the company to replace the condenser and other accessories (including, for example, the valves) of the cooling system circulating ammonia under pressure. Prior to the development work, part of the ammonia had to be removed from the system. As noted in subsequent studies, during this process, it escaped the attention of the maintenance workers that 500 kg of the 2 tonnes of liquid ammonia in the cooling circuit remained in the evaporator. 1500 kg of ammonia was transferred into four 450 kg tanks rented by a subcontractor specializing in the maintenance of refrigeration equipment, which were placed outside the storehouse and stored under guard. On April 23, 2005, one 450 kg ammonia tank began to leak.

The toxic cloud affected a total of 100 people on the plant site, including 21 warehouse workers and people who were parking 200 meters from the tank at the rest area on the A6 motorway.

Following this incident, the authorities required the operators to prepare and fully comply with a so-called internal emergency plan.

During the response, significant protection resources were used with substantial efforts and professional supervision. About 100 firefighters, 40 vehicles, and 2 helicopters were needed to manage the incident.

Local ambulance units reported approximately 50 people injured, 28 of them were examined and five injured were hospitalized for a severe asthma attack. Due to the internal emergency plan, a 150-meter radius security perimeter was set up by local professionals.

At the site of the incident, the primary interveners diluted the ammonia gas leaking from the ruptured tank with the help of a water curtain, thus preventing the ammonia cloud from spreading to the nearby rest area. [9]

The waste water generated during the intervention was collected in a 300-m^3 basin and after a laboratory inspection, it was released into the communal drainage system.

The major problem identified as the reason of the accident was the rupture of the pressure vessel, caused by the overpressure in the tank, which can be traced back to overfilling during the transfer. Vessels used for the transfer were originally designed to store liquefied gases and liquids with a filling rate of 85–100%. As a further problem, post-accident analyses revealed that the tanks in which the ammonia was transferred were not suitable for filling above 430 kg, which was very close to the container's storage capacity.

A further complication that also contributed to the damage incident was that the transfer method applied was not suitable for the tank model used by the operator and the company did not have documents or instruction manuals which could have explained the markings used on the tank. [9]

After the investigation of the accident, the following measures were required from the company by the competent French authority: [9]

- preparation of a training material for the employees, which included the events that had happened before, simulations, presentation of consequences and analysis of the event;
- the company was to take measures that are capable of preventing or minimizing leakage of a similar dangerous material;
- clarifying, continuous updating and practicing the internal emergency plan;
- the instructions of the tank filling processes need to be revised;
- installation of devices for the measurement of the concentration of ammonia and their mobile use if the dangerous material is transferred in an open space;
- defining the responsibility of the actors involved in the event in legal proceedings.

Measures taken by the dangerous establishment following the accident: [9]

1. replacement of some of the equipment in the technological line with more suitable ones that fit the parameters more accurately, e.g. tubular heat exchangers were replaced with plate heat exchangers;
2. the maximum amount of ammonia present at the site was reduced to 600 kg;

3. building well-designed loading stations which greatly facilitates the process and in the event of a possible ammonia leak, the toxic gas clouds automatically flow to the chimney due to a ventilation system, thereby reducing the harmful effects on workers.

As regards the equipment used by the operators, concerns were raised about the use of simple, multi-function tanks that did not have safety valves, pressure and overcharge accessories, avoiding incomplete ammonia removal.

Road Accident of a Tanker Truck Transporting Ammonia

On 19th September 2006, on the outskirts of Balatonberény, Somogy County, a tanker truck with UN marking 1005 crashed into a ditch and leaked dangerous material. The police officer arriving at the scene of the incident found that the accident was caused by a truck driver unlawfully overtaking the truck transporting ammonia. [10]

The disaster management units observed the following points during the reconnaissance:

- the ambulance arriving at the scene began treating the injured;
- the accessories protecting the valves at the top of the trailer of the lorry were damaged in the accident and ammonia leaked through the damaged valves.

Measures taken during the response: [10]

- the road section affected by the accident was closed by police officers in a radius of 60 metres;
- disaster management specialists equipped with type "A" personal protection (gas-tight protective suit) closed the deformed valves on the top of the damaged tank and temporarily stopped ammonia leakage with an emergency patch;
- the dangerous material was transferred from the damaged tank into a suitable container vehicle;
- the local unit of Disaster Management, the Emergency Reconnaissance Team (the predecessor of the Disaster Management Mobile Laboratory) carried out reconnaissance and took measurements (inside the danger zone) which revealed the presence of the dangerous substance in the immediate vicinity of the damaged tank;
- the presence of ammonia was not detected after closing the valves.

Ammonia Leakage in a Facility in Nagykanizsa, Hungary

On 3rd January 2003, the service staff of a facility in Nagykanizsa performed the scheduled replacement of one of the pumps responsible for cooling the plant. According to the maintenance workers' narrative, prior to performing the operation, they were planning to separate the sections of the pipelines as prescribed in the operational instructions. Meanwhile, in order to remove the small amount of gaseous ammonia remaining in the pump, they opened the air valves and the gas was released (into the hall) at full pressure through an opening of approximately 16 mm diameter. The maintenance workers immediately alerted the employees in the factory who then left the danger zone and gathered in a safe place. [11]

Following the incident, the relevant units of disaster management were immediately alerted and squads from the Nagykanizsa Fire Department arrived at the scene, who reported the incident to the Zala County Disaster Management Directorate, the Nagykanizsa Civil Protection Branch Office and the Nagykanizsa Police Department. Soon the Emergency Reconnaissance Team was also alerted and the West-Transdanubian Inspectorate for Environmental Protection was informed about the events in addition to other establishments in the vicinity of the establishment. [11]

Primary interveners dressed in fully protective clothing, equipped with breathing apparatus disconnected the power in the plant. Then during the reconnaissance, it was revealed that the air in the room containing the pump became saturated with ammonia and thus it was leaking through the doors into the plant.

For the sake of the operations, they designated the intervention zones according to hazard. The primary zone was a circle of 10-meter radius around the leakage and it was the one with the strictest personal protection requirements (full respiratory and chemical protection equipment) were put in place to protect the primary interveners. The second zone was a circle of 50-meter radius, in which the incident commander required interveners to wear firefighting protective clothing together with the accompanying respiratory protection equipment. [11]

Subsequently, under the professional guidance of the specialists of the plant arriving on site in the meantime, valves were closed in the pump room and with further operations, ammonia leakage was completely stopped. The ammonia accumulated in the pump rooms of the facility was removed with vaporised water. During the described operations, the chemical reconnaissance units continuously monitored the concentration of ammonia in the air (with the help of detection tubes and measuring instruments).

Subsequently, the plant gradually channelled the ammonia contaminated water into the communal wastewater system, bearing in mind the sustainable capacity of the residential network. In the coming days, all the facilities in the factory were ventilated and inspected.

Reconnaissance findings and the accident analysis later revealed that approximately 300 litres (about 200 kg) was leaked out of 3 tonnes of ammonia and due to the effective intervention, there was no injury or permanent damage to the environment. Based on the continuous reconnaissance, it was stated that the concentration of ammonia did not reach the life-threatening value, but its level was repeatedly found in the range of “harmful to health”. The loss of working hours resulted in a significant economic damage in the operation of the plant. [11]

Accident of a Fuel Tank in Hungary

On 25th March 2010, at the Csepel Base Depot of MOL[5] Group, an explosion occurred during the cleaning of a tank of 5,000 cubic metre, originally used for storing petrol; the hydrocarbon compound residues caught fire in the empty uncleaned tank. As a result, the top of the tank collapsed and the subcontractor worker performing maintenance inside the tank lost his life. The dead body of the man burned beyond recognition. It could only be pulled out through a crack at the bottom of the tank formed as a result of the explosion. At the site, the cleaning work was carried out by a subcontractor company which claimed to have provided the workers with appropriate personal protective equipment, namely respiratory protection (breathing apparatus), protective clothing and the necessary external professional supervisors

5 Magyar Olaj- és Gázipari Nyrt. – Hungarian Oil and Gas Plc.

were also present. The rather robust tank of 5,000 cubic meters cracked open as a result of the physical consequences of the explosion and the roof structure of the tank collapsed. It is assumed that the industrial incident occurred when the hydrocarbon residues were removed and an explosive mixture of petrol vapour and water was formed and an adverse event resulted in a spark. The cleaning worker probably had taken a non-explosion proof hand-held radio with himself, while other case studies claim that his clothing was not entirely suitable and became charged with static electricity due to friction. The author of this article, as a member of the primary mission unit on the day indicated was on the site and conducted a chemical investigation. [12] [13]

Explosions in a Pharmaceutical Plant: Linz, Austria

The case happened in Linz, Austria, in an industrial park where thirty chemical companies are located. The plant involved in the event produces chemical and intermediate products for the pharmaceutical industry, the highest tier according to Seveso. In the unit affected, glyoxylic acid was produced, using ozone, oxygen, methanol dimethyl maleate with the help of a catalyst in several steps. The chemical process was performed with ozone at –20 °C and 1.7 bar. After a lengthy experiment, a technological process was developed and the product became more valuable for the company. [14]

On 13th August 2003, after 10 o'clock in the morning, the technological unit exploded as a result of a harmful side process. The material released during the event, which was largely methanol, caused fire. According to the witnesses, a special phenomenon occurred, called "fireball", with a diameter of at least 80 m, causing considerable damage to the structure. Several units arrived on the spot, both the company's own industrial firefighters and local firefighters as well, and thanks to the effective primary intervention, the fire did not spread to other facilities. [14]

Many of the workers on the site suffered burns, broken bones and bruises that were made even more serious by the broken glasses. According to the available literature, twenty people had to be treated. The unit was completely destroyed in the explosion. This accounted for about one quarter of the total area of the facility, so the damage was enormous.

A further fact is that closed offices were also destroyed or suffered significant damage due to the explosion. In the entire industrial park, chemical activities were shut down until the event was settled. Fortunately, environmental damage was not detected beyond the boundaries of the facility. Specialists attributed this to the fact that a significant part of the chemical material was burned in the explosion process.

The analysis revealed that one of the columns had an irregular chemical leak, probably methanol and peroxide. It resulted in a spontaneous combustion and decomposition which then spread to the first and then to the second column. This is referred to as the so-called domino effect which means that the dangerous effect spreads further to other chemical processes. [14]

Based on the information available, it is interesting to note that, after the event, the pharmaceutical company did not change its procedures and introduced only minimal technological improvements. Among others, the columns used in the ozonolysis process were installed in the refrigeration units, in a separate, closed and guarded building unit. Naturally, the ozonator units of the facility were equipped with ozone sensors.

The reactors were equipped with pressure relief valves to withstand explosions in case of overpressure and additional safety measures were introduced, for example regular control parameter measurements (temperature, pressure) were scheduled.

Despite the increased security level of the technology, two more explosions occurred on the same site one year after the complete restart. These events resulted in a significantly lower material damage. The analysis of the damage incident showed that the new security measure was carried out properly from a professional point of view. These measures made it possible to avoid injuries but are not yet sufficient to prevent the occurrence of a second accident in the future. [14]

The company relied on more than 50 experts and spent about 400,000 Euros on expertise and analysis. Consequently, the technology underwent a significant change, the reaction is carried out with air and inert gas in the future instead of ozone.

A Chemical Incident During the Cleaning of a Tanker Truck in Budapest, Hungary

On 8th July 2014, in a truck washer in the 13th district of Budapest, a trailer truck with tank lined up for cleaning the inside of its tank. Previously, a flammable hydrocarbon, pentane, was carried inside. Prior to the cleaning, the material previously transported was identified with the help of the consignment note and the visual elements displayed on the tank such as dangerous goods labels and orange warning plates with numbers. The tank cleaning started in line with the instructions manual, although it was not detailed enough. The truck parked in that part of the truck washer where chemicals are cleaned. The driver of the vehicle unlocked the dome covers but they were not opened. The attendant opened all the four dome covers of the tank and attached the cleaning device to three of them. The attendant grounded the tank with the cleaning heads, since there was no separate grounding point on the tank. The discharge valves on the right side of the tank were turned open and the cleaning device was started. Pressurisation began in the system until normal working pressure was reached, which was maintained during the whole cleaning process. Once normal working pressure was reached, the attendant launched the washing process. The washing process involved high pressure water of approximately 80 °C. The washing water going through the tank flowed into the drainage system built at the bottom of the washing area. At the end of the cleaning process, the attendant stopped the washing and switched on the ventilation system of the washing area. After the ventilation system was switched on, the attendant left the area and an explosion occurred. No personal injury occurred during the damage incident; however, the material damage caused was significant. In addition to the vehicle and the cleaning device, the roof structure of the facility got damaged as well as the wall structure separating the washing areas and another vehicle. The damage did not render the vehicle immobile. The truck and its trailer managed to leave the spot without outside help. The case analysis identified pentane residues as the cause of the explosion. Most probably, air-pentane mixture was formed, in which a static spark triggered an explosion. [15] [16]

Explosion and Fire in an Oil Storage Depot—Hertfordshire, England

On 11th December 2005, at around 6 a.m., several consecutive explosions occurred at the Buncefield Oil Storage Depot, located in Hertfordshire, England. Following these explosions, there was a huge fire that burned for several days and caused enormous damage to the surroundings of the facility in South-England. The blasts in the storage depot in Buncefield started with the detonation of hydrocarbon-air mixture coming out of an overfilled tank. Overfilling was due to the failure of the signalling system measuring the tank parameters. However, the strength of the explosion could not be explained with this circumstance. [17] [18] [19] [20]

Despite the extraordinary damage, the number of serious injuries was relatively low. To be more precise, 43 people suffered minor injuries and there were no fatalities. The nearby commercial and residential properties suffered minimal damage. It was a major disaster management task that approximately 2,000 people had to be evacuated on short notice from the damaged commercial and residential buildings. Residents in the properties in the vicinity of the industrial park that had not suffered damage were warned to stay indoors. [17] [18] [19] [20]

On12th December 2005, the fire escalated at around lunch time. At this time, 26 fire engines, 180 firefighters and 20 support vehicles took part in the rescue.

The primary interveners acted in accordance with the instructions for the management of chemical incidents, while partner organisations, such as the Environment Agency worked in close co-operation with each other. Experts from the Environment Agency provided professional advice to interveners in order to minimize contamination, paying close attention to nearby surface- and groundwater (and water bases). At the beginning of the incident, the Health Protection Agency experts were ready to participate in the analysis of the situation. [17] [18] [19] [20]

The Buncefield incident has clearly pointed out the need for a suitable, well-functioning (properly updated) emergency management plan, an ideal solution for a potential chemical accident in order to provide a proper professional basis for primary interveners. In addition, a publicly available document is easily accessible for the interested population. Furthermore, the event also highlighted the problem of commercial and residential areas being in the vicinity of a dangerous establishment, for which there are plenty of examples around the world. Moreover, it also serves as a typical example for the physical, chemical and biological impacts of a damage incident.The plant's land use plan ignored and failed to simulate, calculate and analyse the potential for the formation of gaseous hydrocarbons. The main lesson to be drawn is that greater attention should be paid to the risks affecting the population in emergency planning. [17] [18] [19] [20]

An effective emergency planning addresses the following issues: various communication channels between the primary interveners, the specific tasks and the probable consequences of the event. The plan must include concrete actions to be taken in the event of an emergency, specifying precisely the responsibilities of the plant employees in the document.

Over the past 12 years, the case has been covered in countless studies to provide valuable lessons to the readers. Since the case is extremely well-documented (including a lot of photos and videos), it has a relatively large publicity and reputation, hence the popularity of this topic. The professional reason why this topic is addressed to students in the disaster management specialization is that a typical series of events and its consequences can be modelled through this case: in a carbohydrate depot, filling a tank of several thousand cubic metres led to a serious industrial disaster caused by a series of human errors. When analysing the case, it was found that on the whole, the response of primary interveners was efficient and highly professional.

Educational Methods and Their Development Opportunities in Education in Disaster Management

The causes of industrial and chemical hazards and their disasters are failures, unanticipated side effects of technical systems. However, this is a misleading over-simplification and many other factors are involved. The calculus of industrial hazard is a blend of industrial structures, people and environments that contain atmospheric, ecological, psychological and social components.

The object of the disaster management's main specialisation is to update the knowledge and skills of the college students on multi-dimensional aspects of chemical catastrophe risk management and emergency incident-response, effective planning, integration and organization. [21] [22] [23] [24] [25]

The objectives of the disaster management specialization planned for the present is to enable the students to assess and deliver their respective aspects and roles in relation to chemical disasters management and delineate strategies for risks mitigation and implementation of effective response in case of emergencies.

The educational aims of the subject program (elective course-unit, joint training, credit-based education) purpose to allow the students: [21] [22] [23] [24] [25]

- identify the scenario and challenges associated with chemical disaster risks and consequences;
- explain described observations about chemical disaster risks, mitigation methods and response mechanism;
- define preparedness for chemical emergencies and response of various services in chemical disasters;
- integrate environmental planning with disaster management in siting of Industries and Industrial estates;
- understand hazard and risk in materials, processes, others;
- understand how to avoid, how to treat events and how to minimize the number of victims, the economical and environment damages.

Educational methods shall be chosen for teaching a particular aspect of chemical disaster, from a range of the following:

- presentation (slides) and discussion,
- group work / project/ dialogue-exercise,
- film, simulation show followed by question-answer, discussion,
- lecture followed by query-answers,
- demonstration/hands on exposure (computer based).

At the end of this educational unit, the participants will be able to : [21] [22] [23] [24] [25]
- define and separate between chemical and industrial hazards,
- label their causes and impacts,
- comment the global, national and regional scenario.

To conclude, case studies of chemical disasters give the opportunity to:
- define the on-site hazards and risks of accidents that can lead to disaster within premises and outside,
- state the industrial siting aspects of off-site emergencies in case of a chemical disaster,
- analyse the vulnerability of the off-site population, property and environment to the risk of a chemical disaster,
- calculate the risk perception level, mitigation and preparedness including response measures, planning, coordination and command system on-site and off-site for handling emergencies.

A nation's legislative and institutional systems provide the basis for plans and administration in all areas of disaster risk reduction and emergency response. Then strong engagement exits between environmental degradation and disaster risks, environmental legislations and their implementation is a central criterion for disaster risk management. Conversely, the role of legal provisions on environment and natural resources can play significant role in addressing hazards and reducing vulnerability of natural disasters, and in handling after a disaster relief and recovery challenges, are seldom recognized. [21] [22] [23] [24] [25]

Conclusion

In the recent past, there has been a large number of industrial accidents in Hungary and European countries as well as in distant countries, some of which occurred during activities involving dangerous substances. For our daily activities, it is inevitable to come into contact with large quantities of dangerous chemicals. The life cycle of chemicals is so closely related to our everyday lives that it can be definitely stated that each and every person performs some kind of activity involving chemicals on a daily basis.

Using detergents, heating or cooking with gas-fired appliances, fuelling a car, a car engine running inside a garage, a poorly functioning combustion equipment, improperly installed and operated ventilation equipment, spraying in a kitchen garden or in a huge agricultural area are all just a few examples that can happen in a household in our everyday lives. The activities mentioned above are carried out on a thousand or even on hundreds of thousand-fold scale in industry, agriculture, and of course with many different chemicals in the lead.

Statistics reveal that for most of the damage incidents people are to blame, mostly because of the following reasons: non-observance of operation rules, inattention and professional incompetence can all lead to accidents with serious consequences. It is of utmost importance for students studying in any of the three specialties of the disaster management course to master the basics and application of physics and chemistry. During their studies, students take part in both theoretical and practical training, through which they get into contact with the subfield of natural sciences connected to industry. After obtaining a degree, they should possess professional skills in incidents involving dangerous substances that allow them to make high quality decisions. For a disaster management specialist, in addition to legislation, the knowledge and the sensible, conscious use of natural sciences is crucial for decision-making.

Chemicals and related activities can create increased emergencies and pose a risk of malfunctioning or accident. The main purpose of my paper was to present the importance of education through case studies. Ultimately, disaster management students are familiarised with various dangers that may occur during industrial activities, their occurrence characteristics and the methods of identifying the hazards.

In a dangerous establishment with an advanced safety management system, the main guidelines relevant to the employees are discussed at least on a monthly basis in the form of further training and professional discussions.

Conclusions from the case studies are compatible with the curriculum of the disaster management course, and in addition, there are numerous other professional points for continuous improvement of the course syllabuses.

Closing remarks

In Hungary, natural sciences education is world-renowned, with over 120 years of tradition. Thanks to the high-quality, internationally acknowledged national higher education in natural sciences, there are many innovative processes in the domestic chemical industry. The undesirable effects of an industrial accident can be significantly influenced by the fact that disaster management higher education equips those in charge of managing interventions and training interveners with technical-natural sciences qualifications. A lecturer with empirical experience can familiarise students with technical and natural subjects with considerable efficiency. The teaching of natural sciences is not complete with the teaching of only theoretical knowledge. The desired outcome is that a prospective expert is able to make effective decisions. Our rapidly changing world is also reflected in the chemical processes.

References

[1] AMMU, M., HARISANKER, A. V. (eds.): 100 Milestones in Chemistry. *Manorama Tell Me Why*, 8 1 (2014), 1-51

[2] *Landscape of the European Chemical Industry.* 2017. *The European Chemical Industry Council (Cefic).* www.chemlandscape.cefic.org/country/eu/ and www.chemlandscape.cefic.org/wp-content/uploads/combined/fullDoc.pdf (Downloaded: 30.09.2017)

[3] *European Commission website about chemicals.* https://ec.europa.eu/growth/sectors/chemicals_hu (Downloaded: 30.09.2017)

[4] *The Hungarian Chemical Industry Association, based on Mavesz's data.* www.chemlandscape.cefic.org/country/hungary/ (Downloaded: 30.09.2017)

[5] *The Situation of the Hungarian Chemical Industry. Made on behalf of the Hungarian Chemical Industry Association.* Budapest, November 2016. http://mavesz.hu/wp-content/uploads/2016/02/Kopint-tanulma%CC%81ny-A4-2016nov_full-page.pdf (Downloaded: 30.09.2017)

[6] *Report on Industry Performance in 2015*. A Brief Introduction to Hungary's Chemical Industry. Budapest: Központi Statisztikai Hivatal, 2016. www.ksh.hu/docs/hun/xftp/idoszaki/jelipar/jelipar15.pdf (Downloaded: 30.09.2017)

[7] *Chemical Industry in Hungary, the 25th Anniversary Publication of the Hungarian Chemical Industry Association.* http://mavesz.hu/file/MAVESZ_25_kiadvany_v8b_EN_72dpi.pdf (Downloaded: 30.09.2017)

[8] KLEMENT T.: *Vegyipari helyzetkép. MAVESZ prioritások.* Eger: Magyar Vegyipari Szövetség, 2016. http://mavesz.hu/wp-content/uploads/2016/02/Klement-T_Eln%C3%B6ki-megnyit%C3%B3-EGER-2016-1.pdf (Downloaded: 30.09.2017)

[9] *French Ministry of Environment—DPPR/SEI/BARPI—IMPEL.* No. 29687. http://aria.developpement-durable.gouv.fr/accident/29687_en/?lang=en (Downloaded: 30.09.2017)

[10] GREFFER J.: Ammóniát szállító pótkocsis tartálykocsi balesete. *Védelem, katasztrófa- és tűzvédelmi szemle,* XIV 2 (2007), 37. www.vedelem.hu/letoltes/ujsag/v200702.pdf (Downloaded: 30.09.2017)

[11] WÉBER A.: Ammóniaömlés a Zalahúsnál. *Védelem, katasztrófa- és tűzvédelmi szemle,* 10 1 (2003), 37–39. www.vedelem.hu/letoltes/ujsag/v200301.pdf (Downloaded: 30.09.2017)

[12] Robbanás és tűz a MOL bázistelepén a XXI. kerületben. *Lánglovagok* (online), s.d. www.langlovagok.hu/kepek/4269_robbanas-es-tuz-a-mol-bazistelepen-a-xxi-keruletben (Downloaded: 30.09.2017)

[13] Robbanás a MOL Csepeli Bázistelepén. *Lánglovagok* (online), 2010. 03. 25. www.langlovagok.hu/html/hirek/9423.shtml (Downloaded: 30.09.2017)

[14] *IMPEL—French Ministry for Sustainable Development—DGPR / SRT / BARPI—Magistrat der Landeshauptstadt Linz.* No. 25337/35822. www.aria.developpement-durable.gouv.fr/wp-content/files_mf/FD_2533735822_linz_20032004_ang.pdf (Downloaded: 30.09.2017)

[15] *Tartálytisztítás Magyarországon.* Magyar Vegyipari Szövetség, s.d. http://mavesz.hu/file/tartalytisztitok_2015.pdf (Downloaded: 30.09.2017)

[16] *META-CLEAN Tartálymosó Kft.* www.metaclean.hu/ (Downloaded: 30.09.2017)

[17] *PSLG Safety and Environmental Standards for Fuel Storage Sites: Process Safety Leadership Group, Final Report HSE Books.* 2009. www.hse.gov.uk/comah/buncefield/response.htm (Downloaded: 30.09.2017)

[18] *WHO Library Cataloguing-in-Publication Data Manual for the Public Health Management of Chemical Incidents.* 2009. www.who.int/environmental_health_emergencies/publications/FINAL-PHM-Chemical-Incidents_web.pdf (Downloaded: 30.09.2017)

[19] *Buncefield Major Incident Investigation. Initial Report to the Health and Safety Commission and the Environment Agency of the Investigation into the Explosions and Fires at the Buncefield Oil Storage and Transfer Depot, Hemel Hempstead, on 11 December 2005.* www.endsreport.com/docs/20060713d.pdf (Downloaded: 30.09.2017)

[20] *Buncefield Major Incident Investigation Board. The Buncefield Incident 11 December 2005: The Final Report of the Major Incident Investigation Board.* HSE Books 2008. Vol. 1. www.buncefieldinvestigation.gov.uk (Downloaded: 30.09.2017)

[21] ANIL, K. G., SREEJA, S. N.: *Training Module Chemical (Industrial) Disaster Management, National Institute of Disaster Management (Government of India, Ministry of Home Affairs), National Institute of Disaster Management.* New Delhi: IIPA Campus, s.d.

[22] ANIL, K. G., SREEJA, S. N.: *Environmental Legislation for Disaster Risk Management, National Institute of Disaster Management Ministry of Home Affairs.* New Delhi: IIPA Campus, & Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, 2012.
[23] *Emergency Planning Guidelines for Hazardous Industry.* Queensland: Chemical Hazards and Emergency Management Unit, 1998.
[24] MANLEY, A. D.: *Security Manager's Guide to Disasters Managing Through Emergencies, Violence, and Other Workplace Threats.* Boca Raton: CRC Press, 2009.
[25] DOBOR J.: The Importance of the Teaching of Case Studies of Industrial Accidents in the Disaster Management Education. *Ecoterra—Journal of Environmental Research and Protection*, 14 1 (2017), 26–32. www.ecoterra-online.ro. http://www.ecoterra-online.ro/files/1496321269.pdf (Downloaded: 30.09.2017)