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Analysis of Rescue Measures in Selected Industrial Plants Using Toxic Chemical Compounds in Poznań

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Introduction

The broad development of chemistry has been one of the crucial elements of the socio-economic development in the recent decades. It has contributed to an increased life expectancy and improved health condition of people to a large and unprecedented extent.

However, it has also been realised that economic development poses substantial threats. Both on the global and local level, chemical substances can seriously and often irreversibly damage human health and natural environment. It has been demonstrated very clearly by huge chemical disasters, for example the Flixborough 30-tonne cyclohexan leakage and subsequent explosion in 1974, the Seveso dioxin release in 1976, the Bhopal methyl isocyanate release in 1984, the pollution of Rhine River after a fire in a chemical warehouse in Basilea in 1986 and the Chernobyl nuclear reactor disaster [1,3].

In Poznań the source of chemical threats to the inhabitants and environment are the plants using dangerous substances and road or rail transportation of dangerous commodities. A serious failure at a high- or increased-risk plant and during road or rail transportation of dangerous commodities may pose a threat to a very large group of people and to the environment (Table 1).

In the recent years, there have been instances of mass chemical human poisoning in the city and municipal district of Poznań, for example: chlorine poisoning of 25 people in an office building in Poznań, carbon monoxide poisoning of 29 women at a nursery centre in Puszczykowo Zaborze,

inhalational poisoning with an unknown substance of 21 people in Adam Wodziczko School Complex in Mosina in 2004 (200 pupils and teachers were evacuated altogether), lethal poisoning (probably with hydrogen sulphide and methane) of 2 men and hospitalization of another 4 in Piotrkówek near Szamotuły. These accidents have made the authorities and medical and rescue services aware of the threat to the people and environment posed by any release of dangerous chemical substances.

Table 1. Plants of a high and increased risk of a serious industrial failure in Wielkopolska [9]

Tabela 1. Zakłady o dużym i zwiększonym ryzyku wystąpienia poważnej awarii przemysłowej w Wielkopolsce [9]

No.	Name of the plant	Address of the plant	Type of dangerous substance	Amount of dangerous substance (in tonnes)	County	Type of plant
1.	Progas Eurogaz Kłodawa Sp. z o.o.	ul. Solna 1 Kłodawa	liquified gas propane butane	286.4	Koło County	PHR
2.	Dynea sp. z o.o.	ul. Fabryczna 4 Trzemeszno	phenol formaldehyde	116 162	Gniezno County	PHR
3.	Gaspol S.A. Warszawa, Pleszew Western Region	ul. Komunalnych 1 Pleszew	liquified gas propane butane	990	Pleszew County	PHR
4.	Naftobazy Sp. z o.o. Fuel Base No. 4 in Rejowiec Poznański	Rejowiec Poznański	products of petroleum distillation	93,000	Wągrowiec County	PHR
5.	Naftobazy Sp. z o.o. Fuel Base No. 8 in Jastrowie	ul. Polna 1 Jastrowie	products of petroleum distillation	46,000	Złotów County	PHR
6.	Zakłady Chemiczne "Luboń" S.A.	ul. R. Maya 1 Luboń	hydrofluorid acid	40	Poznań County	PHR
7.	Statoil Gaz Sp. z o.o.	ul. Północna 52 Kościan	liquified gas propane butane	290	Kościan County	PHR
8.	Polski Gaz Sp. z o.o. Chojęcin-Szum Branch	Chojęcin Szum 8d Kępno	liquified gas propane butane	280	Kępno County	PHR
9.	PKN Orlen S.A. Warehouse Base No. 74	ul. Węglowa 1 Ostrów Wielkopolski	products of petroleum distillation	42,700	Ostrów County	PHR
10.	British Petroleum Gas Poland Sp. z o.o.	ul. Rabowicka 4/5 Swarzędz	liquified gas propane butane	2,917	Poznań County	PHR
11.	Krotgaz Liquified Gas Distribution Plant in Krotoszyn (Plant No. 2)	ul. Sadowa 2 Krotoszyn	liquified gas propane butane	188.6	Krotoszyn County	PIR
12.	Centrum Paliw i Rozpuszczalników Sp. z o.o.	Słomowo 1 Września	products of petroleum distillation	2,820	Września County	PIR

Table 1. cont.
Tabela 1. cd.

No.	Name of the plant	Address of the plant	Type of dangerous substance	Amount of dangerous substance (in tonnes)	County	Type of plant
13.	Gospodarstwo Hodowlano – Produkcyjne Dublet Plus	Smolina 9 Brudzew	propane	89	Turek County	PIR
14.	Polish Oil and Gas Company PGNiG S.A. in Warsaw Nitrogen Removal Plant in Odolanów	ul. Krotoszyńska Odolanów	natural gas	64	Ostrów County	PIR
15.	Kompania Piwowarska S.A.	ul. Szwajcarska 11 Poznań	ammonia	50	Poznań County	PIR
16.	Wyborowa S.A.	ul. Komandoria 5 Poznań	ethanol	16,590	Poznań County	PIR
17.	Linde Gaz Polska Sp. z o.o.	ul. Przemysłowa 17 Kościan	acetylene	20	Kościan County	PIR
18.	PKN Orlen S.A. Warehouse Base No. 71	ul. Przemysłowa Międzychód	products of petroleum distillation	3,700	Międzychód County	PIR
19.	Zespół Elektrociepłowni Pątnów, Adamów, Konin S.A. Pątnów Plant	ul. Kazimierska 45 Konin	fuel oil	7,588	Konin County	PIR
20.	Huta Aluminium Konin S.A.	ul. Hutnicza 1 Konin	toxic substances	173	Konin County	PIR
21.	Zespół Elektrociepłowni Poznańskich S.A.	ul. Gdyńska 54 Poznań	fuel and diesel oil	10,800	Poznań County	PIR
22.	PKN Orlen S.A. Warehouse Base No. 72	ul. Nowy Dwór Konin	fuel oil	3,050	Konin County	PIR
23.	Holding Metalplast sp. z o.o.	ul. Łukowska 7/9 Oborniki	pentane	17	Oborniki County	PIR
24.	Przedsiębiorstwo Przemysłu Fermentacyjnego „Akwawit" S.A.	ul. Święciechowska 2, 64-100 Leszno	ethanol	13,600	Leszno County	PIR
25.	Zespół Elektrociepłowni Pątnów, Adamów, Konin S.A. Adamów Plant	ul. Przemysłowa 1 62-700 Turek	sulphuric acid	74.4	Turek County	PIR

PHR – plant of a high risk of a serious industrial failure,
PIR – plant of an increased risk of a serious industrial failure.

Aim of the study

The aim of the study was to analyse rescue measures in case of a chemical failure in selected industrial plants using toxic chemical compounds in the city and municipal district of Poznań. The following research tasks were carried out within the study:

- analysis of current legal solutions in providing medical assistance in case of chemical accidents and disasters,
- assessment of chemical threats in Poznań,
- analysis of the potential for providing medical assistance within the medical rescue system in Poznań,
- presentation of the concept of chemical security within the rescue medicine system.

Materials and method

The study was based on an analysis of three chemical failure simulations in the city and municipal district of Poznań in selected industrial plants that use toxic industrial agents. The following plants were selected for the study: Kompania Piwowarska S.A. (use of ammonia), Aquanet S.A. (use of chlorine) and Zakłady Chemiczne "Luboń" S.A. (use of hydrogen fluoride).

The study was conducted in the above-mentioned industrial plants, health care and National Fire Service units in Wielkopolska and Poznań.

The basic research method was a diagnostic survey using the following research tools [4]:

- examination of documentation,
- observation of medical rescue actions,
- questionnaires (a study of the functioning of the Internal Disease and Toxicology Ward of Franciszek Raszeja Hospital in Poznań),
- simulation drills (using PHAST MICRO and ALOHA computer programs),
- application drills (model organizational solutions to medical rescue actions),
- practical drills (verification of the proposed concept).

Discussion of the results

On the basis of available data analysis on Zakłady Chemiczne "Luboń" S.A. it was concluded that the plant's localization, surrounding buildings and access roads would create a threat in case of a failure. As a result, the plant Zakłady Chemiczne "Luboń" S.A. was assigned to a category of high-risk chemical facilities.

A PHAST MICRO computer simulation of a failure scenario was run to assess the potential effects of a 50-kg hydrogen fluoride release in the plant in Luboń. The program calculated the size of the danger zones for such a release and with a westerly wind of 3m/s to be the following:

- mortal danger zone (concentration of hydrogen fluoride 50 ppm) – 1.62 km,
- health danger zone (concentration of hydrogen fluoride 30 ppm) – 2.7 km.

Once a month there are regular theoretical and practical chemical emergency trainings for the plant's internal rescue teams. Additionally, on-site trainings with external rescue teams are also organized, with the most recent one held with the National Fire Service, emergency ambulance service and police in 2005. After the analysis of the internal contingency (operational-rescue) plan for Zakłady Chemiczne "Luboń" S.A. it was stated that the document in question is n accordance with the Environmental Protection Law of April 27, 2001 and the Ministry of Economy order of August 16, 2001.

The ALOHA computer program was used to predict the size of mortal and health danger zones in case of a 100-kg chlorine release in Aquanet S.A. at the Water Treatment Plant Station in ul. Wiśniowa 13 in Poznań. The program calculated the size of the danger zones for such a chlorine release and with a westerly wind of 3m/s to be the following:

- mortal danger zone (concentration of chlorine 20 ppm) – 0.165 km,
- health danger zone (concentration of chlorine 10 ppm) – 0.235 km,
- minor and reversible health effect zone (concentration of chlorine 1 ppm) – 0.779 km.

On the basis of the analysis of available data and conclusions from plant's internal rescue team trainings it was stated that first-aid procedures and basic rescue regulations had been established for chemical rescue team members in Aquanet S.A., ul. Wiśniowa 13 in Poznań. Additional procedures were established for alerting the staff, management and proper rescue teams, evacuation and alerting the population about potential contamination in case of a chlorine release.

In order to evaluate the established solutions and further improve the staff's preparedness in case of a chemical emergency, there are regular trainings conducted by masters from Water Production Department. Additionally, every 2 years there are simulation trainings with external rescue services to drill particular emergency scenarios. The trainings provide an opportunity to evaluate the preparedness of the staff, management and chemical rescue team.

Based on the analysis of the available data, a conclusion can be drawn that Aquanet S.A., ul. Wiśniowa 13 in Poznań does not create any serious threat in the event of a chemical failure.

On the basis of the available data on Kompania Piwowarska Lech Browary Wielkopolski S.A., ul. Szwajcarska 11 in Poznań, it was concluded that the plant's localization, surrounding buildings and access roads would not create a serious threat in the event of a failure. As a result, Kompania Piwowarska Lech Browary Wielkopolski S.A. was assigned to a category of increased-risk chemical facilities.

The ALOHA computer program was used to predict the size of mortal and health danger zones in case of a 5-tonne ammonia release from the plant. The program calculated the size of the danger zones for such an ammonia release and with a westerly wind of 5m/s to be the following:

- mortal danger zone (concentration of ammonia 5034 ppm) – 0.36 km,
- health danger zone (concentration of ammonia 300 ppm) – 1.3 km,
- minor and reversible health effect zone (concentration of ammonia 25 ppm) – 3.3 km.

Twice a year there are regular theoretical and practical chemical emergency trainings for the plant's internal rescue teams. Additionally, on-site trainings with external rescue teams are also organized, with the most recent one held with the National Fire Service, emergency ambulance service and police in 2004. It is our conviction that the internal rescue team trainings held with external rescue teams should be organized regularly every 3 years. There is a sufficient number of hospital beds where patients in need of medical assistance can be transproted. We are of the opinion that the organization of the ZOZ Nowe Miasto Hospital Emergency Ward should be accomplished soon due to its location in the vicinity of Kompania Piwowarska Lech Browary Wielkopolski S.A. After the analysis of the internal contingency (operational-rescue) plan for Kompania Piwowarska Lech Browary Wielkopolski S.A. it was stated that the document in question is n accordance with the Environmental Protection Law of April 27, 2001 and the Ministry of Economy order of August 16, 2001.

On the basis of the data analysis it was concluded that the number of regular staff and rescue team trainings at plants using toxic industrial substances was insufficient to reduce any significant effects of a serious chemical failure. It is our suggestion that such trainings should be organized at least once a month internally, and twice a year with participation of external rescue services [4].

During medical rescue operation the disaster area should be divided into three zones: A, B and C. Zone A is the contaminated, unconditionally dangerous (hot) area, where rescuers have to wear chemical resistant gasproof clothing for full skin, eyes and respiratory tract protection. Zone B is the dirty, relatively dangerous (warm) area, where rescuers have to use only respiratory tract protection equipment. Zone C is the clean, safe (cold) area where no protection is needed [3,6].

On the basis of the analysis of the chemical failure simulations, universal standards of medical assistance in the event of chemical contamination have been presented. First medical aid should be based on three major measures:

- evacuation of the victims out of the contaminated zone,
- removal of the toxic substance from skin and clothing to prevent further local injuries and absorption,
- symptomatic treatment, sustaining the vital functions of the organism.

Only then do specialized measures, specific to a given poisoning, follow:

- causal treatment (appropriate antidotes),
- measures to enhance the elimination of the poison from the organism [4,6].

The medical staff participating in the decontamination of the injured should be equipped with personal protection clothing. In this way the staff will be able to give aid in the B zone if there is a need to save human lives or if there is a sudden change in situation at the disaster site which poses a threat to the rescuers' lives.

An immediate evacuation from the danger zone and the removal of the contaminated clothing can be one of the crucial elements of a life-saving operation. The decision to decontaminate those injured in a chemical disaster should be based on the type of the chemical substance in question and on the evaluation of how severe the condition of the injured is.

In chemical disasters the injured should be divided into groups according to the general principles in disaster medicine. It is important for the segregation to be a continuous process carried out at regular intervals. This is because both the condition of the injured and means of treatment and transportation may change [4].

According to the type of injury and the presence of symptoms caused by a chemical factor, the injured can be divided into the following groups and evacuated in the following order [2,6]:

1. Those in need of immediate transportation and treatment (red colour);
2. Those in need of less immediate transportation (yellow colour);
3. Those in need of the least immediate transportation (green colour);
4. Those in need of palliative treatment – transportation according to the recommendation (black colour).

Special consideration is due to the division of those exposed to irritant gases. A principle should be adopted for those with mechanical injuries and exposed to irritant gases not be assigned the green evacuation colour.

Special consideration is also due to assign injured children to a particular group, as they are more sensitive to toxic substances and should have priority in receiving medical assistance [2].

The speed of the evacuation from the contaminated zone and appropriate measures taken in the very first minutes can be crucial to the victim toll. That being so, rescue procedures should be limited to the most basic actions:

- intubation and cricothyrotomy,
- staunching the bleeding (ligation),
- gaining access to the vein and liquid transfusion,
- cleansing the wounds,
- analgesia if needed,
- ensuring normothermia.

Oxygen or assisted breath use is advisable as early as during first aid.

In some cases of poisoning (for example, with cyanides or organophosphorus compounds) and when immediate transportation of the injured to a hospital is impossible, it may be advisable to apply specific antidote treatment and specialist medical equipment [2,6].

The treatment and course of action in a multiprofile hospital are supervised by a clinical toxicologist who has extensive specialist assistance at his/her disposal. The most important task of the local authorities in the event of a sudden threat of mass chemical contamination is to notify the rescue teams about the potential number of people working or living in the contaminated area, distribution of public institutions, available plans of buildings and access roads, which will facilitate the organization of a rescue operation [5].

Decontamination, or the removal of the toxic substance from people and equipment, takes place in the zone adjacent to the red one. Both the victims and rescuers leaving the chemical disaster area undergo decontamination. In this zone a preliminary division of patients into groups can take place, especially if there are many seriously injured and resuscitation procedures are necessary.

A medical point is organized in the support area to further divide patients into groups. Injury severity is estimated and the order of assistance and transportation to specialized units is established [3,4,6].

Those who do not directly participate in the rescue operation, but who influence its course, for example local authority representatives, stay in close vicinity of the support zone without interfering with the evacuation of the victims. There should be a communication point in the vicinity to notify nearby hospitals to prepare for the admission of the injured and to contact with the nearest toxicological centre. The clinical toxicologist decides about the need to administer specific antidotes and apply a decontamination type depending on the toxic substance involved [5,7].

The concept of organizing rescue and providing medical assistance within medical and chemical rescue service in Poznań in case of chemical contamination coincides in many respects with the one proposed by the National Fire Service [4].

The following conclusions can be formulated on the basis of the results:

1. The legal solutions in the current National Medical Rescue Law do not specify chemical rescue objectives within the rescue medicine system and should be amended.
   These issues are specified in the Environment Protection Law of 27 April 2001, which however does not clearly specify medical rescue team procedures in case of chemical failures and disasters at on the district, voivodship and national level.
2. The analysis of data on chemical threats to the people and environment in Poznań has demonstrated that the plants using dangerous substances and road or rail transportation of dangerous commodities, lacking any monitoring system of dangerous commodity transport in both transit and local traffic, are the sources of potential threat.
3. The examination of medical assistance potential in the medical rescue system in Poznań so far contributes to the positive evaluation of the emergency notification centre and hospital emergency wards.
4. In order to improve medical assistance within medical and chemical rescue service in case of chemical contamination, the following five chemical-medical areas in Wielkopolska should be outlined: Poznań, Piła, Leszno, Kalisz and Konin area.
5. A Regional Clinical Toxicology Centre should be organized in Poznań. The centre should comprise:
   - Poisoning Treatment Centre,
   - Toxicological Information Centre,
   - Chemical-Toxicological Analytical Laboratory.

   There should be an antidote bank in the Regional Clinical Toxicology Centre, which would enable an immediate intervention in case of any mass chemical threat. A toxicological information line should be opened in the Regional Toxicological Centre in Poznań to improve medical assistance. This would ensure an immediate access to a database containing information on dangerous chemical substances. Computer programs would first analyse the clinical symptoms introduced and then they would present possible chemical poisoning causes and propose further procedural options.
6. In compliance with the new National Medical Rescue Law, dispatchers in the Emergency Notification Centre in Poznań should be trained to identify and react to chemical threats.

7. One of the most important chemical safety aspects is the preparation of measures and preventive programmes to minimize the risk of mass poisoning and to improve the efficiency of any rescue operation.

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Analiza postępowania ratowniczego w wybranych zakładach stosujących toksyczne związki chemiczne w Poznaniu

Streszczenie

Szeroki rozwój chemii stanowi jeden z kluczowych elementów rozwoju gospodarczego-społecznego, przyczynił się do zwiększenia długości życia ludzi i polepszenia stanu ich zdrowia, ale jednocześnie niesie ze sobą także poważne zagrożenia wystąpienia awarii. Celem przeprowadzonej pracy była analiza postępowania ratowniczego na wypadek awarii chemicznej w wybranych zakładach stosujących toksyczne związki chemiczne w Poznaniu i powiecie poznańskim. Podstawą przeprowadzenia badania była analiza trzech symulacji awarii chemicznych w wytypowanych zakładach przemysłowych: Kompania Piwowarska S.A., posiadającą na swoim terenie amoniak, Aquanet S.A., stosujący chlor oraz Zakłady Chemiczne „Luboń" S.A., gdzie zmagazynowano fluorowodór. W pracy przedstawiono: analizę aktualnych rozwiązań prawnych w zakresie świadczenia pomocy medycznej w wypadkach i katastrofach chemicznych, ocenę zagrożeń chemicznych w Poznaniu, analizę możliwości świadczenia pomocy medycznej w systemie ratownictwa medycznego w Poznaniu, koncepcję bezpieczeństwa chemicznego w systemie medycyny ratunkowej.

Przeprowadzona analiza materiału dotyczącego zagrożeń chemicznych dla ludzi i środowiska w Poznaniu wykazała, że takimi zagrożeniami są zakłady stosujące substancje niebezpieczne oraz transport drogowy i kolejowy towarów niebezpiecznych pozbawiony systemu pełnego monitoringu przewozu towarów niebezpiecznych (zarówno w ruchu tranzytowym jak i lokalnym).

Na podstawie przeprowadzonych badań dotyczących możliwości świadczenia pomocy medycznej w systemie ratownictwa medycznego w Poznaniu, pozytywnie należy ocenić dotychczasowe funkcjonowanie centrum powiadamiania ratunkowego oraz szpitalnych oddziałów ratunkowych.

Dla usprawnienia świadczenia pomocy medycznej w przypadku skażenia chemicznego w ramach ratownictwa medycznego i chemicznego należy w Wielkopolsce wyznaczyć pięć obszarów chemiczno-medycznych: poznański, pilski, leszczyński, kaliski, koniński.

Zgodnie z nową Ustawą o Państwowym Ratownictwie Medycznym w zorganizowanym Centrum Powiadamiania Ratunkowego w Poznaniu należy przygotować dyspozytorów w zakresie rozpoznawania i reagowania na zagrożenia chemiczne.

Jednym z najważniejszych elementów bezpieczeństwa chemicznego jest opracowanie działań i programów profilaktycznych minimalizujących ryzyko wystąpienia masowych zatruć, a także umożliwiających przeprowadzenie sprawnej i szybkiej akcji ratunkowej.