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POSSIBLE EFFECTS OF DISASTERS INVOLVING DANGEROUS SUBSTANSES HARMFUL TO THE ENVIRONMENT, THE HUMAN LIFE AND HEALTH

A VESZÉLYES ANYAGOKKAL KAPCSOLATOS KATASZTRÓFÁK LEHETSÉGES KÖRNYEZETET, EMBERI ÉLETET ÉS EGÉSZSÉGET KÁROSÍTÓ HATÁSAI

The 20th century is referred to by the many as the century of 'Technical improvement' in terms of development of the various sciences. At the same time the twentieth century can be referred to as the century of 'technological catastrophes'. This article tries to shortly summarise the possible effects of these catastrophes involving dangerous substances harmful to the environment, the human life and health. Kulcsszavak: katasztrófa, káros hatások, veszélyes anyagok, súlyos baleset

A 20. századot a különböző tudományágak fejlődése következtében sokan a „műszaki haladás" századának is nevezik. Ugyanakkor a 20. századot a „műszaki katasztrófák" századának is nevezhetjük. Jelen cikk rövid összefoglalót kíván nyújtani e veszélyes anyagokkal és technológiával kapcsolatos katasztrófák lehetséges környezetet, emberi életet és egészséget károsító hatásairól. Key words: disaster, harmful effects, dangerous substances, major accident

Introduction

Technological catastrophe demanded the most victims occurred in 1984 in course of an accident at the chemical plant of company Union Carbide in Bhopal (India). In consequence of a malfunction and failure, 40 tons of toxic methyl isocyanate cloud was released from the plant, resulting in 2500 deaths and additional 200 000 injuries. Table 1, showing the rank of industrial accidents which demanded at least 5 casualties and occurred in the period of 1945-'91, justifies the importance of industrial safety as well.

Country	Number of accidents	Ranking by number of accidents	Number of death	Ranking by number of deaths	Number of deaths per accident	Ranking by severity
USA	144	1	2241	2	15,5	8
Japan	30	2	526	5	17,5	6
India	18	3	4430	1	246,1	1
German Federal Republic	18	3	158	10	8,8	10
Mexico	17	4	848	3	49,9	3
France	15	5	236	8	15,7	7
Italy	14	6	260	7	18,6	5
Brazil	13	7	815	4	62,7	2
China	13	7	454	6	34,9	4
United Kingdom	13	7	170	9	13,1	9

Table 1: Severity rank of fatal accidents (at least 5 deaths) by countries, 1945-1991 [1]

The situation in the field of industrial safety has not changed even to our days: in consequence of the industrial accident occurred in 1998 in Spain almost the entire fauna and flora of Coto Donana National Park died out. On 30 January 2000 a pollutant with cyanide content 800 times higher than the permitted one, spilled to the river “Lápos”, then to the river “Szamos” and “Tisza”, from the water clarifying plant of the Romanian-Australian company Aurul in Zazar (Romania). In consequence of the accident fauna and flora of the river “Tisza” got near to extinction.

On 13 May 2000 an explosion occurred in the firework factory near to Enschede (the Netherlands). The accident resulted in 21 deaths and more than 1000 injuries. The accident was the result of an organisational shortcoming, as it was established in the course of inspection. 21 persons died and 700 persons injured in the course of an explosion occurred in a fertilizer plant 3 kilometres far from Toulouse (France) on 21 September 2001. A crater with diameter of 50 meter developed in the plant. The accident is supposed to be retraceable to human failure.

Causes of Major-accidents

Hazardous industrial establishments, arising from their activities, always mean some kind of risks to the environment and people living there. Statistical analysis of the major-accidents occurred last decade indicates that the most frequent reasons for the industrial accidents are ‘human errors’ which are retraceable mainly to managerial shortcomings. Failures of technical and technological facilities, which can be retraced to human failures finally, as defects could be prevented with sufficient control, inspection and maintenance, contributed measurably to the occurrence of major-accidents. Primary causes of industrial major-accidents are human error (50%), technical failure (24%), uncontrolled chemical reaction (10%), external factors (16%) [1]. The following conclusions can be drawn from the statistical analysis of the industrial major-accidents:

— even if the most qualified experts operate the most advanced equipments made by the best producers, incident failures may develop;
— though safety systems were designed and tested (under operative circumstances) on the basis of experiences of the past, they proved not to be efficient enough in case of certain accidents.

Aim of the operators and the various administrative bodies is to minimize the risks originating from the activities of hazardous industrial establishments, through application of various means. A really wide-range of means can be applied: the operator can for example substitute a dangerous substance for a less dangerous substance as means of risk minimization, or adopt various measures for prevention of major-accidents; or the authorities can specify various stipulations in its resolutions, or the drawing up of various emergency plans.

Major Industrial Accidents

Risks originating from the activities of the hazardous establishments can be retraced to several initiating events. There is need to analyse the consequences of potential accidents (incident failures) in terms of emergency planning and disaster management. Consequences of release of dangerous substances can be derived from the models presented below.

A dangerous substance can be released from a tank in the ways below:

— release of liquid from an atmospheric tanks;

— release of gas and/or liquid from a pressurized tank and technological equipment;

— release of gas and/or liquid from a pressurized pipeline [2].

Release of any dangerous gas or liquid (liquefied gas) for any reason may lead to development of a direct or indirect gas (vapour) cloud. The direct gas (vapour) cloud develops generally in consequence of release of gases. An indirect vapour cloud may develop, if the out-flowing liquid forms a pool. In case of direct or indirect release the substance shall gets into the air in its vicinity, and shall move depending on the weather conditions.

If a flammable gas or vapour gets into the air and there is an ignition source present in its direct vicinity, then it has to be considered that fire shall start, resulting in heat-load of the environment.

If ignition of the vapour of a flammable substance released is:

— immediate, and release occurs through a narrow hole, a jet fire develops;

— delayed, and the rate of combustion in the gas cloud is extremely high, it results in a gas cloud explosion;

— is caused by a distant ignition source, a deflagration occurs, which reversing may get to the outflow point and a fire ball may develop.

In case of release of dangerous liquids:

– if the liquid released spreads on the surface (forms a pool) in the vicinity of the tank (pipeline) and then ignite, a pool fire shall develop. When outflow of a liquid results in pool fire, it may take place in an area compassed with fire-barrier or without the presence thereof.

— if release of a dangerous liquid is consequence of heat-effect, then the liquid is supposed to be boiling in the tank and ignite immediately. In this case we talk about “boiling liquid expanding vapour explosion" (BLEVE), resulting in development of fireball.

— in course of the combustion of dangerous liquids, toxic combustion products may develop which – lifting for the effect of heat of combustion, and travelling for the effect of wind – may have a toxic effect far as well.

— in case of instantaneous release of a dangerous liquid, due to adiabatic expansion the temperature drops sharply. The

temperature, in case of certain substances, can reach either -100°C at the initial point of release. In a situation like that, effect of the high cooling should be taken into account besides other dangerous effects.

— if the liquid released, does not form an explosive mixture with the air, or does not ignite, then the cloud shall disperse slowly in the surrounding air. In case of a cloud involving toxic substances – in a certain concentration – living beings are exposed to danger in the area contaminated by the cloud.

— In case of explosive substances (hereby release of the explosive substance is not a necessary condition), if the conditions of explosion are developed in the course of storage, transportation or processing, then an explosion occurs, the blast of which shall have a dangerous effect on man or may lead to another major-accident (domino effect).

The table below shows the possible ways and consequences of release of dangerous substances.

ACCIDENT SEQUENCE	CAUSE	CONSEQUENCE
Jet fire	Immediate ignition of flammable vapours/gases releasing under pressure.	Heat load of the environment.
Unobstructed vapour cloud explosion (UVCE)	Delayed ignition of flammable vapours/gases releasing under pressure.	Air blast.
Vapour cloud deflagration	Ignition of a flammable vapour/gas caused by distant ignition source.	Heat load of the environment, reverse burning to the source of release.
Pool fire (obstructed and unobstructed)	Dispersion of a flammable liquid on the surface.	Heat load of the environment.

ACCIDENT SEQUENCE	CAUSE	CONSEQUENCE
Boiling Liquid Expansive Vapour Explosion (BLEVE)	Vapour /gas explosion is caused by a boiling liquid.	Heat load of the environment, air blast, (fireball).
Dispersion of toxic cloud (primary, secondary)	Release of a vapour/gas from the tank, or evaporation of a liquid pool.	Intoxication of man (animals), and environment.
Explosion of the entire explosive substance	Development of conditions of an explosion (initiation).	Air blast.

Table 2:
Potential consequences [2]

Effects of Major-accidents

Accidents involving dangerous substances can lead to various hazards to human life and health. In most cases various kinds of dangerousness emerge at the same time. The following examples provide a general summary on consequences of the potential hazards.

HAZARDS	CONSEQUENCES
Explosion	Blast from explosion and projectiles, as well as high temperature.
Intoxication	Toxic substances can be inhaled or get into the body through skin.
Fire	Heat effect that may cause burn injuries.
Oxidation	Accelerates burning and may cause burn injuries.
Burning, irritation	Skin, eyes and mycoderm may be hurt due to contact with weak acids and bases.

HAZARDS	CONSEQUENCES
Frost-bite	Release of deep-frozen liquids and pressurized gases may cause frost-bites.
Infection	Organism infection.
Anhelation	Inhalation of fumes and other gases may lead to state of anoxia.
Dangers to the environment	Risk of water, soil and air contamination.

Table 3:
Consequences of the potential hazards [2]

Analysis of the major accidents occurred in the past justified that the population is basically exposed to four effects listed below:

Physical effect: Fires and uncontrolled chemical reactions can lead to explosion, the blast of which can damage buildings (broken windows, collapsed apparatuses, etc.), and may cause human injuries (rupture of the drum). In case of especially heavy explosions the projectiles may spread to hundreds of metres.

Heat effect: Accidents involving dangerous substances often lead to severe fires not only at the initial scene of the accident, but also far away from the initial scene of the accident, in consequence of the dispersion of flammable liquids and gases/ vapours. In case of severe fires, objects in the vicinity of the fire may ignite due to the heat-effect.

Potential effect on human health: burn injuries.

Intoxication: A toxic dangerous substance can get into human body in three ways: by inhalation, through the skin and by ingestion, generally with consuming contaminated foods.

Toxic substances released in accidents may travel several kilometres in the atmosphere. Danger zone may extend to several square kilometres, which in this way can be much larger than the area affected by physical effects, fire or heat-effects. The actual risk shall continue to exist till the gas cloud passes over the area (it takes usually a few hours). Sensation of various smells and gases, or burning of the mycoderms (eye, throat), or difficulties in breathing can be the first signs of release of pollutants. Not

all the substances can be perceived by human sense organs. Consumption of plants contaminated by toxic substances may have serious effects on health. Potential effect to human body: intoxication. Contamination of the environment: Release of dangerous substances may lead to the contamination of soil, surface and underground waters. The dangerous vapour cloud may contaminate large areas through rain-out, and in consequence of bioaccumulation a dangerous substance may accumulate in the food chain. Time of decay for harmful effects can be very extended, until the contaminants are removed and clearing is carried out [3] [4].

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