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WOMEN IN THE SHADOW OF INDUSTRIAL RISKS

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Abstract

Hazardous substances plants are increasingly exposed to the potential effects of natural and civilisational disasters. Industrial accidents result in numerous problems for operators and the surrounding population. Accident prevention and population preparation has been getting a lot of attention nowadays, both scientifically and socially.

The tragedy in Seveso, Lombardy, resulted in long-term health problems for the plant's workers and the surrounding population. This disaster has exponentially highlighted the potential dangers of chemical plants and their long-term effects, and has accelerated the development of appropriate industrial protection regulations.

Following the disaster, several studies have been carried out, of which the Seveso Women's Health Study has focused exclusively on women. The research team clearly concluded that the health of the women and their descendants affected by the disaster was negatively affected by the airborne chemicals.

Our hypothesis is that with proper preparation and adequate protection measures, chemical accidents occurring on the premises of plants dealing with hazardous substances can be reduced, and public preparation for industrial accidents can increase protection against adverse effects. In addition to properly preparing the public, a key step in preventing and effectively dealing with industrial accidents is the development of monitoring and public alarm systems, which will increase the chances of timely detection, intervention, alert and public information, thereby minimizing the risks of chemical accidents.

Keywords: industrial disasters, women, health impacts, Seveso event, research

NŐK AZ IPARI KOCKÁZATOK ÁRNYÉKÁBAN

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Absztrakt

A veszélyes anyagokkal foglalkozó üzemek fokozottan ki vannak téve a természeti és civilizációs katasztrófák lehetséges hatásainak. Az ipari balesetek következtében számos káros hatással és következménnyel kell számolniuk az üzemeltetőknek és a környező lakosságnak. A baleset megelőzés és lakosságfelkészítés egyre nagyon figyelmet kap napjainkban mind tudományos, mind pedig társadalmi viszonylatban.

A lombardiai Seveso-i tragédia az üzem dolgozói és a környező lakosság számára hosszú távú egészségügyi problémát eredményezett. Ez a katasztrófa hatványozottan rámutatott a vegyi anyagokkal foglalkozó üzemek potenciális veszélyeire és azok hosszú távú hatásaira, valamint felgyorsította a megfelelő ipar védelmi szabályozás kidolgozását.

A katasztrófát követően több kutatás is készült, amelyek közül a „Seveso Women's Health Study" kutatócsoport kizárólag nőket vizsgált. A kutatócsoport egyértelműen megállapította, hogy a katasztrófában érintett nők és leszármazottiak egészségére negatív hatással volt a vegyi anyagok levegőbe kerülése.

A hipotézisünk, hogy kellő felkészítés és megfelelő védelmi intézkedés mellett, csökkenthető a veszélyes anyagokkal foglalkozó üzemek területén bekövetkező vegyi balesetek száma, illetve az ipari balesetekre történő lakossági felkészítés növelheti a káros hatások elleni védelmet. A lakosság megfelelő felkészítése mellett az ipari balesetek megelőzésének és hatékony kezelésének kulcsfontosságú lépése a monitoring és lakossági riasztó rendszerek fejlesztése, amellyel nagyobb eséllyel lehetővé válik az időben történő észlelés, a beavatkozás, a lakosság tájékoztatása és riasztása, ezzel minimalizálva a vegyi balesetek kockázatait.

Kucsszavak: ipari katasztrófák, nők, egészségügyi hatások, Seveso-i esemény, kutatás

Introduction

Serious accidents involving dangerous substances in plants are becoming more and more common these days. The Seveso incident in Lombardy in 1976 was the first major industrial disaster to have a long-term impact on the region and the health of generations. It led to the Seveso I and then Seveso II Directives in the European Union,

which tightened the standards for hazardous establishments (Nerín et al., 2014). Currently, the Seveso III Directive is in force to protect the public.

Chemical accidents near densely populated areas can cause significant damage. Increased human exposure was identified as a major concern in 43% of accidents investigated by the US Chemical Safety Board (CSB), which underlines the importance of social factors in risk assessment and in the design of measures to minimise exposure during accidents (Tahmid et al., 2020)

In Hungary, the Monitoring and Public Alert (MoLaRi) System is applied in several counties to ensure the safety of the population living near hazardous plants, which contributes significantly to the protection of the population. However, international experience shows that unmanned public aircrafts can also be used in such situations. These aircrafts are capable of radiation detection and identification of chemical agents, as well as search, logistical support and liaison for people trapped in the hazardous plant area.

Industrial accidents and other chemical disasters can have dramatic consequences for the populations affected, and the consequences are often unpredictable. Our research looks at the Seveso accident in Italy, which has influenced perceptions of industrial safety and the need to tighten restrictions. The explosion at the chemical plant released huge quantities of dioxin into the air, which is highly toxic and causes acute and chronic effects in the human body.

The women affected by the disaster were particularly vulnerable as they were mostly staying at home and caring for family members, which meant prolonged exposure to the contaminated environment. In addition, women were more often the primary caregivers during rescue and care tasks, which exacerbated their situation. Women appear to be particularly vulnerable to the health risks and impacts of industrial accidents.

The general lessons learned from industrial disasters have highlighted the importance of strict compliance with environmental and safety standards (Seveso I, II, III) in industrial installations in order to minimise the risk and consequences of this type of accident. The Seveso tragedy has drawn widespread attention to the importance of industrial safety and has underlined the importance of measures to protect the health and safety of women in this type of emergency.

Chemical disaster

On 10 July 1976, a major industrial accident occurred in Seveso (Lombardy) at the ICMESA chemical plant, which was primarily involved in the production of TCDD via the TCP reactor for the synthesis of trichlorophenol (hereafter TCP) (Abate et al, 1982; Ames et al., 2018). TCDD is the most toxic element of the group of polychlorinated dibenzodioxins, which are formed as a by-product of certain chemical reactions (Consonni et al, 2008; Kerger et al, 2019). In the years following the incident,

high levels of TCDD were recorded in the bodies of the affected population (Landi et al, 1998). Unfortunately, the release of hazardous substances into the air can pose a hazard over long distances.

At the time, the health of people living in the area and their offspring was monitored annually by government-funded researchers, and the results were summarised. In this research, we summarise the short- and long-term consequences of the event based on a review of several scientific publications, Phase I of the monitoring, which covers the period 1976-1996, a 20-year period, is presented below. Phase II will cover the period 1997-2001, while Phase III will provide a brief overview of the results for the period 1976-2018.

During Phase I of the monitoring, contaminated area was divided in three zones „A" (very high contamination where people were displaces), „B" (high) and „R" (low) see Fig. 1 (Consonni et al., 2008; Kerger et al., 2019).

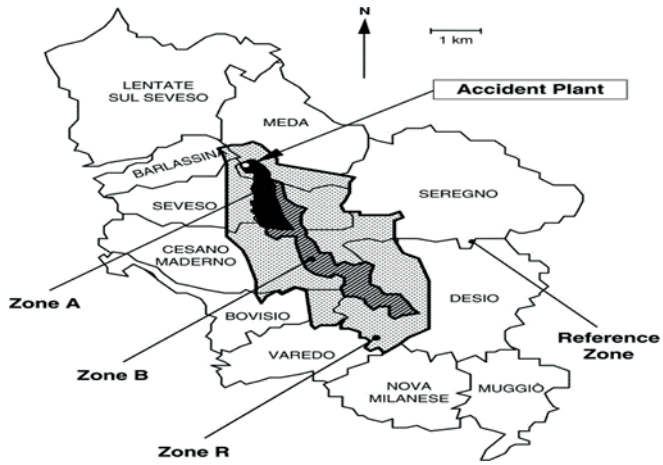

Figure 1.
The area of Seveso, Italy, and 11 surrounding towns
(Source: Consonni et al., 2008; Kerger et al., 2019)

The researchers divided the population in the study area into two groups, with data for the period 1976-2001 in Table 1:

– „Present": of the more than 37,000 people, those who lived in any of the three contamination zones on the day of the accident, who were directly exposed to the toxic cloud and who consumed food from local crops and livestock.

– „Not present": of the nearly 8,000 people who moved to any of the contaminated zones in the 10-year period following the accident, this includes newborns (Consonni et al., 2008).

In the study, zones A, B and R covered part of the territory of six municipalities. In the reference group, the inhabitants of these six unaffected areas and of five surrounding towns not affected by pollution were tested and the following results were obtained:

The total number of people present was 181 574 and 51 166 were not in the vicinity of the event.

The total study population, exposed and unexposed, comprised 278 108 inhabitants of 11 municipalities (Consonni et al., 2008).

Table 1 summarises the population concerned.

Zone	Present (resident of the area on July 10, 1967)			Nonpresent (entered the area after the accident)			Total
	Females	Males	Total	Females	Males	Total	
A	371	352	723	43	38	81	804
B	2 350	2 471	4 821	574	546	1 120	5 941
R	15 928	15 715	31 643	3 496	3 484	6 980	38 623
Reference	93 224	88 350	181 574	25 547	25 619	51 166	232 740
Total	111 873	106 888	218 761	29 660	29 687	59 347	278 108

Table No. 1.
Number of affected population in Seveso, Italy, 1976-2001
(Source: Consonni et al., 2008; based on Bertazzi et al., 2001).

Follow-up was virtually complete for those living in the 11 settlements surveyed, and approximately 99% of those who had moved out of the area. Over 40 years of follow-up, it was observed that there was an increase in lymphatic and haematological cancers in zones A and B. In addition, a number of other types of cancer and circulatory diseases were also associated with increased mortality rates (Bertazzi et al., 2001¸ Eskenazi et al., 2001). The research team is now only studying the follow-up of zone A, but a multigenerational study of the affected population in this zone is underway. The researchers are currently investigating the health and developmental processes of the second generation of Seveso, but follow-up of the third generation of Seveso has already started (Consonni et al., 2008; (Eskenazi et al., 2018). This event was the largest industrial disaster in the region (Bertazzi et al., 2001), leading to the tightening of industrial safety standards. In retrospect, the tightening of industrial safety standards was justified as a matter of fact, as more than 40 years later, the toxic effects of the explosion affected future generations.

Effects of chemical exposure on women

TCDD, or 2,3,7,8-tetrachloro-dibenzo-p-dioxin, is an extremely potent chemical compound associated with a number of biochemical, physiological and toxicological processes, including modulating the function of growth factors and receptors, and influencing immunotoxicity, developmental toxicity and carcinogenic effects. (Emond et al., 2016)

haracteristic	SWHS	Follow-up	Follow-up
	1996–1998	2008–2009	2014–2016
	n (%)	n (%)	n (%)
Total	981 (100)	833 (84.9)a, b	705 (71.9)a, c
Characteristics at explosion			
Zone of residence			
A	167 (17.0)	142 (17.0)	123 (17.4)
B	814 (83.0)	691 (83.0)	582 (82.6)
Age (years)			
0–10	232 (23.7)	200 (24.0)	181 (25.7)
11–20	279 (28.4)	252 (30.3)	226 (32.1)
21–30	241 (24.6)	206 (24.7)	175 (24.8)
31–40	229 (23.3)	175 (21.0)	123 (17.4)
Menarche status			
Premenarche	284 (29.0)	247 (29.7)	221 (31.3)
Postmenarche	697 (71.0)	586 (70.3)	484 (68.7)
Characteristics at interview			
Age (years)			
mean (SD)	40.8 (11.7)	52.2 (11.1)	57.7 (11.0)
Range	21–63	32–73	38–80
Marital status			
Never	76 (7.7)	47 (5.6)	40 (5.7)
Ever	905 (92.3)	786 (94.4)	665 (94.3)
Maternal education			
≤Required	651 (66.4)	550 (66.0)	382 (55.4)
Secondary school	288 (29.4)	249 (29.9)	277 (40.2)
>Secondary school	42 (4.3)	34 (4.1)	30 (5.4)
Menopause status			
Premenopause	703 (71.7)	394 (47.3)	223 (31.6)
Postmenopause	278 (28.3)	439 (52.7)	482 (68.4)
Primary wage earner educated			
≤Required	627 (63.9)	529 (32.3)	376 (54.7)
≥Secondary school	354 (36.1)	252 (32.1)	311 (45.3)

a

Percent of initial cohort (n = 981).

b

16 (1.6%) deceased, 36 (3.7%) could not be located or contacted, 96 (9.8%) refused.

c

33 (3.3%) deceased, 64 (6.5%) could not be located or contacted, 179 (18.3%) refused.

d

Required (8 years of school), Secondary School (9–13 years), >Secondary School (>13 years).

During pregnancy and l actation, the exact functioning of these processes is not yet fully understood, since several factors - exposure level, duration of lactation, age, parity and diet, as well as individual chemical pharmacokinetics - can influence the elimination of compounds.

The Seveso Women's Health Study research group conducted a study between 1996 and 2008 (Wesselink et al., 2014), which specifically looked at the consequences of chemical explosion on women's health. First, women newborn in 1967 and women aged of 40 and over. This study examined whether TCDD exposure was associated with physical functioning and working memory 20 years after the disaster. (Ames et al., 2018). Table 2 shows the participants in the research.

The group investigated its differentiation, influencing pubertal development, behaviour, cortical dominance and cognition (Ames et al., 2019). The research team repeatedly collected blood from women participating in the study, which aimed to modify the human PBPK model for TCDD, and examined pregnancy and lactation for this. They examined blood concentrations of TCDD at different life stages, as well as pregnancy (Emond et al., 2016). They examined women's reproductive history, pregnancy history, miscarriage, some of them had pelvic examinations, ultrasound, menstrual diaries (Eskenazi et al., 2000)

Exposure to endocrine-disrupting chemicals (EDCs) during sensitive developmental periods can influence disease later in life. Although direct measurement of fetal hormones is not possible, other biomarkers such as the ratio of second finger to fourth finger length (2D:4D) may serve as indicators. These biomarkers have sexually dimorphic properties and may be biomarkers of androgen/estrogen balance in utero. However, it is unclear whether intrauterine EDC exposure may affect the 2D:4D ratio. (Slama et al., 2019) Table 3 summarizes health data for Seveso residents.

Table No. 2.
Participants Seveso Women's Health Study, Seveso, Italy, 1976-2016.(Source: Eskenazi et al., 2018)

Outcome	Author, year	Study population	Sample	Exposure measure	Key findings
Child health					
Chloracne	Caramaschi, 1981	Surveillance	146 cases, zones A, B, R	Zone	↑ % chloracne in Zone A
		of children	182 controls, zone nonABR		
		<14 years			
	Baccarelli, 2005	Case-control study	101 cases	Plasma TCDD (1993–98)	↑ >10 ppt vs ≤ 10 ppt
			211 controls		
Liver function	Mocarelli, 1986	Surveillance 1976–1982	1500 children 6–10 years, from zones A, B, R	Zone	↑ GGT (76–77) in Zone A boys
					↑ ALT (76–77) in Zone A boys
					↑ AST (80–82) in Zone A girls
	Ideo, 1982	Surveillance	31 children, from Zone A 6–8 years	Chloracne status	↑ d-glucaric acid levels in children with chloracne
		08/76–12/76			
	Ideo, 1985	Surveillance of children 05/1981	34 zone A	Zone	↔ d-glucaric acid levels
			61 zone B		
			121 zone R		
			61 zone nonABR		
Immune function	Mocarelli, 1991a	Surveillance 1976–1982	692 zone A	Zone	↑ lymphocytes (76–77) in Zone A children 0–14 y
			3703 zone B		↔ lymphocyte response to PHA in Zone A children 0–14 y
			6974 zone R		
			5743 nonABR		

Tooth development	Alaluusua, 2004	Dental exam 2001	48 zone A, B, R	1976 serum TCDD	↑ developmental defects of enamel in children <5 years in 1976
			65 nonABR		
Reproductive health					
Male fertility	Mocarelli, 2008	Sperm quality study (1997–1998)	135 men, zone A, B, R and 1–26 y in 1976	1976 serum TCDD	1–9 y in 1976
			184 men nonABR		↓ sperm concentration
					↓ motile sperm
					↓ estradiol
					↑ FSH
					10–17 y in 1976
					↑ sperm concentration
					↑ motile sperm
					↓ estradiol
					↑ FSH
					↔ 17–26 years in 1976
Female fertility	Eskenazi, 2010	SWHS	463 women	1976 serum TCDD,	↑ time to pregnancy
		(1996–1998)		TCDD estimated to pregnancy	↑ infertility
Menstrual cycle	Baccarelli, 2005	Chloracne case-control study	45 cases	Chloracne	↔ irregular cycle in cases vs controls
			103 controls		

Menstrual cycle	Eskenazi, 2002b	SWHS (1996–1998)	301 women	1976 serum TCDD	↑ cycle length only in women who were premenarche in 1976
Ovarian function	Warner, 2007	SWHS (1996–1998)	363 women	1976 serum TCDD	↔ number or size of follicles ↔ ovulation ↔ progesterone, estradiol
Endometriosis	Eskenazi, 2002b	SWHS (1996–1998)	601 women	1976 serum TCDD	↑ endometriosis
Fibromas	Eskenazi, 2007	SWHS (1996–1998)	956 women	1976 serum TCDD	↓ fibroids
Menopause	Eskenazi, 2005	SWHS (1996–1998)	616 women	1976 serum TCDD	Nonmonotonic ↑ early menopause 20.1–100 ppt ↔ early menopause >100 ppt
Chronic health					
Cancer	Consonni, 2008	Cancer Mortality Study (1976–2001)	804 zone A 5941 zone B 38,623 zone R	Zone	↔ All cancer mortality (76–01) ↑ All cancer morality after 20 years in Zone A (96–01) ↑ Lymphatic-hematopoietic cancer mortality in Zone A

			232,740 nonABR		↑ Lymphatic-hematopoietic cancer mortality in Zone B
			Total person-years: 6,192,864		↔ Lymphatic-hematopoietic cancer mortality in Zone R
	Pesatori, 2009	Cancer Incidence Study	723 zone A	Zone	↔ All cancer incidence (76–96)
		(1976–1996)	4821 zone B		↑Breast cancer in Zone A (ns)
			31,643 zone R		↑ Lymphatic-hematopoietic cancer in Zone A (ns)
			181,574 nonABR		↑ Lymphatic-hematopoietic cancer in Zone B
	Warner, 2002	SWHS (1976–1996)	981 women	1976 serum TCDD	↑ Breast cancer incidence
	Warner, 2011	SWHS (1976–2008)	833 women	1976 serum TCDD	↑ All cancer incidence
Cardiovascular disease	Consonni, 2008	Mortality Study	804 zone A	Zone	↔ All cause mortality
		(1976–2001)	5941 zone B		↑ IHD mortality in Zone A males
			38,623 zone R		↑ Hypertension mortality in Zone A females
			232,740 nonABR		

	Warner, 2014	SWHS	965 women	1976 serum TCDD	↑ All CVD incidence (ns)
		(1976–2008)			↑ IHD incidence (ns)
Diabetes	Consonni, 2008	Mortality Study	804 zone A	Zone	↑ Diabetes mortality in females in Zones A, B, R
		(1976–2001)	5941 zone B		
			38,623 zone R		
			232,740 nonABR		
	Warner, 2013	SWHS	981 women	1976 serum TCDD	↔ Diabetes
		(1976–2008)			↔ BMI, Obesity
					↑ Metabolic syndrome in <12y in 1976
Bone health	Eskenazi, 2014	SWHS (2008–2009)	340 women <20y in 1976	1976 serum TCDD	↔ BMD (spine, total hip, femoral neck)
					↑ Bone structure in women exposed before peak bone mass
Thyroid health	Chevrier, 2014	SWHS	909 women	1976 serum TCDD	↓ TT4 in 1996
		(2008–2009)		1996 serum TCDD	↔ TSH, FT3, FT4 in 1996
					↓ TT4 in 2008
					↔ TSH, FT3, FT4 in 2008
Immune function	Baccarelli, 2002	Immunology study	62 zone A, B	1992 plasma TCDD	↓ IgG w TCDD

		(1992–1994)	58 zone nonABR		↔ IgM, IgA, C3, C4 w TCDD
Neurologic function	Pocchiari, 1979	Surveillance	446 zone A,	Zone	↑ idiopathic clinical neurologic damage in Zone A
		1977–1978	255 zone B, R		
	Assenato, 1989	Surveillance	193 chloracne cases		↔ Abnormal electrophysiologic or nerve conduction velocity measures
		1985			
	Ames, 2017a	SWHS		1976 serum TCDD	↔ Physical function
		(1996–1998)	154 women		↔ Working memory
		(2008–2009)	459 women		
Second generation health					
Sex ratio	Mocarelli, 1996	Municipality birth registry	74 births	Zone A	↓ Sex ratio (1977–84)
			(04/77–12/84)		↔ Sex ratio (1985–94)
	Mocarelli, 2000	Municipality birth registry	674 births	1976 serum	↓ Sex ratio in fathers <19 years in 1976 and TCDD >15 ppt
			(04/77–12/96)	TCDD	↔ Sex ratio in fathers ≥19 years in 1976 and TCDD >15 ppt
Neonatal thyroid	Baccarelli, 2008	Neonatal Screening Registry (1994–2005)	56 zone A	Zone	↑ b-TSH in Zone A
		Chloracne Study	425 zone B	TCDD extrapolated to pregnancy	↑ b-TSH in Zone B

			533 nonABR		↑ b-TSH > 5μU/mL in Zone A
			51 mother-child pairs		↑ b-TSH w TCDD and TEQ extrapolated to pregnancy
Male fertility	Mocarelli, 2011	Sperm quality study (2002–2003)	39 Seveso sons born 1977–1984	Lactational exposure	↓ sperm concentration
			58 unexposed male blood donors		↓ progressive motility
					↑ FSH

Table No. 3.
Summary of health studies of Seveso residents.(Source: Eskenazi et al., 2018)

The Seveso Second Generation Study aimed to investigate the relationship between prenatal exposure to TCDD and thyroid hormone concentrations. Complete follow-up data from 570 children, including fasting blood sampling, were used. Total and free thyroxine (T4), free triiodothyronine (T3) and thyroid stimulating hormone (TSH) levels were measured by immunoassays. Prenatal TCDD exposure was determined by the mother's initial TCDD concentration in serum collected after the blast and the estimated maternal TCDD level at gestational age (Warner, Rauch, Brambilla, et al., 2020)

RESULTS: „Compared to the lowest quartile (Q1), maternal initial serum TCDD is lower with free T3 (Q2: adj-β = -0.13, 95% CI -0.26, 0.00; Q3: adj-β = -0.22, 95% CI -0.35, -0.09; Q4: adj-β = -0.14, 95% CI -0.28, 0.00; p-trend = 0.02). In participants with high thyroid antibody status, the inverse association between maternal initial serum TCDD and free T3 was significantly stronger than in participants with normal antibody status (p-interaction = 0.02). A positive correlation was observed between maternal initial serum TCDD and TSH concentrations in participants with high thyroid antibody status (Q2: adj-β = 11.4%, 95% CI -25.2, 66.1; Q3: adj-β = 49.0%, 95% CI 3.0, 115.5; Q4: adj-β = 105.5, 95% CI 36.6, 209.2; p-trend < 0.01), but not in participants with normal antibody status (p-interaction < 0.01). Similar results were found for TCDD estimated during pregnancy." (Warner, Rauch, Brambilla, et al., 2020)

During the Seveso tragedy, the length of time spent in the contaminated environment and the isolation of the residence affected the subsequent short- and long-term health of women.

These findings suggest that prenatal exposure to TCDD may affect thyroid function in later life (Warner, Rauch, Brambilla, et al., 2020).

In addition, studies by researchers have shown an increase in the incidence of cardiovascular and respiratory diseases, diabetes, and an increase in the incidence and mortality from cancers, particularly gastrointestinal and lymphatic and haematological cancers (Bertazzi et al., 1998).

Women are also at risk of being among those who will bear the brunt of industrial accidents in decades to come, with serious long-term implications for both health and society. In addition to physical pain caused by respiratory diseases, skin lesions, and genetic problems the quality of life was affected. Respiratory issues can impact women's everyday functioning rights from their ability to exercise and work, and skin related conditions do not only mean physical pain as well but also affect an enormous part of the personal perception about oneself. Furthermore, the risk of genetic problems for future offspring as well as infertility or reproductive disorders have longer-term implications on women's family planning and health outcomes making their situation even more vulnerable.

Women hit by industrial accidents are the only women who have social functions: they restore life and sustainable development of a community. They are the ones who take care of patients, with their families and help reconstruct a new society these provided. It contributes to the psychological burden women already face and their health concerns.

Proposal for the effective prevention of chemical accidents

Preventing and mitigating the impact of chemical accidents is a demaning in many respects of problem, which needs to be tackled with co-operation between industry, government agencies or lawmakers but also scientific community as well civil society. Industrial accidents can have disastrous and wide-ranging effects on human health, the environment and society which is why it's crucial that they are prevented or managed appropriately.

The application of a more stringent regulatory framework in industry and environment is one of the central measures. Public authority for hazardous substances stored, handled and transported in industrial installations with the aim of highest standard of safety shall be regulated by law; Laws on this matter must always comply leadership movements regular or new technologies provide too updated. Also, it must be ensured that the noncompliance receives a punishment as there will not have been no use to comply with safety standards if industry chooses not to.

Risk assessment and management are parts of prevention strategies. Chemical plants should always conduct hazard identification and risk assessment to ascertain potential sources of hazards, including all risk factors faced by the workers involved in chemical processes so that appropriate measures can be taken into consideration for minimizing risks.

Advances in Technology — New Innovations That Help Prevent Chemical Accidents It is important to encourage the development of technologies and processes that reduce or replace hazardous substances in production through less dangerous activities. Through innovation in the chemical industry, it introduces new and improved technologies with safer chemicals.

All chemical plant workers need to be trained how workplace safety training and preparation needed for each employee in the factory. Workers should be properly trained to comply with and apply preventive safety measures to effectively prevent accidents. Theoretical and practical training should be carried out frequently so that they are aware of how to act correctly and appropriately in the event of a hazard.

Therefore it is important to use communication and information correctly to prevent chemical accidents. To alert the public to potential risks and educate them on how they may be able to protect themselves, it is crucial that we build communication strategies. Along with that, it can help in the dissemination of knowledge on steps to be followed during emergencies.

Community engagement and dialogue is key since the measures can only be as effective or useful based on how residents of a particular area perceive them. Community affected participation in decision making and the implementation of protection mechanisms is quite relevant to enable strategies for prevention that meet real demands, with respect to environmental situations.

It is crucial that stakeholders work closely together to prevent and respond better these both chemical accidents and associated risks. This is the only way to effectively safeguard human health and environment, ensuring that chemical accidents have less of a negative impact.

Conclusion

Chemical accidents are a cause of concern not just due to the loss of life and destruction but also because controlling them is central for social security measures. These incidents can lead to severe health, environmental and socioeconomic implications for certain groups in the society (the vulnerable like women, children; elderly members of households living with disabilities etc). Strict regulation of industrial processes, sufficient safety measures and workforce training in place to prevent disasters as much as humanly possible; plus continuous risk assessment and management should be exercised.

Community involvement and dialogue with affected local residents about environmental accidents is essential for successful hazard prevention, as they need to helped to identify risks in the district. Public information and alerting and widespread innovation in technology can also help improve the safe use of chemicals, including alternatives to cultivation.

To lay the foundation for preventing chemical accidents, collaborative work among industry, government and non-governmental organizations (NGOs), as well as experts from different scientific communities is essential. A common approach and a clear communication can contribute to risk reduction of chemical accidents as well as limiting their effects, which in turn will help protecting people and the environment.

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