Chemical Risk Assessment and Prevention Action Plan Related to Petroleum Production. Case Study of Laboratory and Storage Units in an Algerian Oil and Gas Company

Samia Chettouh [1, 2*], Saleh Arif [2]
1 Laboratory of Research in Industrial Prevention (LRPI),
2 Institute of Health and Industrial Safety, University of Batna 2, Algeria

ABSTRACT: Chemical risk is considered one of the most frequent risks in the workplace, affecting the safety of workers continuously exposed to chemical substances. In addition, it can have an environmental impact and cause an explosion when unacceptable conditions are met. To know the effects of chemical risks and how to prevent them, this study is proposed, the main objective of which is the evaluation of chemical hazards and the proposal of an action plan to avoid this kind of risk in industrial companies. Our case study focused on the crude oil production company " PERTAMINA" using the SEIRICH software. The results indicate that most chemicals are hazardous and can cause serious harm to workers exposed to them periodically. Therefore, the proposed preventive action plan for safety improvement aims to ensure continuous development in oil and gas field production, processing, and distribution, taking into account the health and safety of workers.

الملخص: تُعْتَبَرُ المَخاطِرُ الكِيمْيائِيَّةُ واحِدَةً مِن المَخاطِرِ الأَكْثَرِ شُيُوعاً فِي مَكانِ العَمَلِ ، حَيْثُ تُؤَثِّرُ فِي سَلامَةِ العُمّالِ الَّذِينَ يَتَعَرَّضُونَ بِشَكْلٍ مُسْتَمِرٍّ لِلمَوادِّ الكِيمْيائِيَّةِ. فضلا عن ذلك، يُمْكِنُ أَنْ يَكُونَ لَها تَأْثِيرٌ بِيئِيٌّ وَتُسَبِّبُ اِنْفِجاراً عِنْدَ اِسْتِيفاءِ الظُرُوفِ المُلائِمَةِ. لِمَعْرِفَةِ آثارِ المَخاطِرِ الكِيمْيائِيَّةِ وَكَيْفِيَّةِ الوِقايَةِ مِنها تَمَّ اِقْتِراحُ هٰذِهِ الدِراسَةِ الَّتِي هَدَفُها الرَئِيسِيُّ هُوَ تَقْيِيمُ المَخاطِرِ الكِيمْيائِيَّةِ وَاِقْتِراحُ خُطَّةِ عَمَلٍ لِتَجَنُّبِ هٰذا النَوْعِ مِن المَخاطِرِ فِي الشَرِكاتِ الصِناعِيَّةِ. رَكَّزَت دِراسَةُ الحالَةِ الخاصَّةِ بِنا عَلَى شَرِكَةِ إِنْتاج النَفْطِ الخامِ "PERTAMINA" بِاِسْتِخْدامِ بَرْنامَج SEIRICH وَأَظْهَرَت النَتائِجُ أَنَّ مُعْظَمَ المَوادِّ الكِيمْيائِيَّةِ خَطِرَةٌ وَقَدْ تَسَبَّبَ أَضْراراً جَسِيمَةً لِلعُمّالِ الَّذِينَ يَتَعَرَّضُونَ لَها بِشَكْلٍ دَوْرِيٍّ. وَبِناءً عَلَى ذٰلِكَ، تَقْتَرِحُ خُطَّةُ العَمَلِ الوِقائِيَّةُ تَحْسِينَ الأَمْنِ مِن خِلالِ ضَمانِ اِسْتِمْرارِ تَطْوِيرِ إِنْتاجِ النَفْطِ وَالغازِ وَتَوْزِيعِهِما آخِذَةً بِعَيْنِ الاعتبار صِحَّةَ وَسَلامَةِ العُمّالِ.

Keywords: Chemical risk; Environmental impact; Prevention; Risk assessment; Workplace safety.

الكلمات المفتاحية: المخاطر الكيميائية;تأثير بيئي ;وقاية ;تقييم المخاطر ;السلامة في مكان العمل.

Corresponding author's e-mail: s.chettouh@univ-batna2.dz

DOI:10.53540/tjer.vol.20iss1pp73-84

NOMENCLATURE

CLP:	Classification, Labelling and Packaging
CMR:	Carcinogenic, Mutagenic and Reprotoxic chemicals
CNAMTS:	Caisse Nationale d'Assurance Maladie des Travailleurs Salariés
DGT:	Direction Générale du Travail
EU:	European Union
FFP3:	Filtering Face Pieces 3
INRS:	Institut national de la recherche scientifique
MSDS:	Material Safety Data Sheets
OEL:	Occupational Exposure Limits
PPE:	Personal Protective Equipment
QHSE:	Quality, Health, Safety, Environment
SEIRICH:	Système d'Evaluation et d'Information sur les RIsques Chimiques
US-NAS:	United States National Academy of Sciences

1. INTRODUCTION

The chemical industry has significantly contributed to the development of the social economy, but it also poses dangers and concerns about its safety have received considerable attention (Shao et al., 2022, Song et al., 2020). This is why Occupational Risk Assessment is one of the mandatory requirements for every company to effectively monitor potential hazards requiring attention (immediate intoxication, asphyxiation, fires, explosions, pollution, etc.), to carry out more detailed reviews or to prioritise preventive actions (Bendib et al., 2021, Bouasla, et al., 2021, Birrer &Delva, 2021). The prevention of these chemical risks is one of the bases of the Occupational Risk Assessment. The Occupational Risk Assessment is based on identifying dangerous products in the company, whatever its activity, and on an exhaustive and rigorous risk assessment process (Hanekamp &Calabrese, 2021). In addition, the regulations include specific provisions for hazardous chemical agents, carcinogens and mutagens. Thus, the more a chemical substance is dangerous, the stricter the prevention rules must be respected to protect workers. This is why a prevention action plan for chemical risks is essential to protect the workers' and public's health and safety and also to reduce the environmental impacts and accelerate the resumption of normal operations.

Efficient and easy-to-use screening tools are essential in chemical risk assessment systems; therefore, this study aims to assess the chemical risk and to set up a preventive action plan for the laboratory and storage units of the company PERTAMINA (Algeria). We will use the SEIRICH software, a simulator that allows companies to learn about and assess their chemical risks to achieve these objectives.

This study is structured into four main sections: the second section gives the basic ideas of Chemical Risk Assessment and SEIRICH software. In the third section, an industrial case study is presented and analysed. The study is completed with a proposal for preventive and protective actions against chemical risks in the laboratory and storage units and, finally, the study's conclusions.

2. MATERIALS AND METHODS

Chemical risk assessment

Unfortunately, the chemical industry is a high-risk industry with frequent accidents such as fires and explosions. Recently, numerous catastrophic accidents have occurred in Algeria's chemical and petrochemical production process. In 2004, an explosion in the Skikda oil refinery caused 27 deaths and 74 injuries and the loss of more than 800 million USD. In 2005, a fire followed by an explosion in the same refinery caused three deaths, seven injuries, and more than 7 million dollars of material damage. More frequent and fewer severe accidents occurred in 2013, 2017 and 2021. statistical studies conducted by (Chettouh et al., 2016, and Chettouh et al., 2018) showed that 18% of accidents in the petrochemical production sector are due to chemicals.

To ensure that a chemical will not cause unacceptable environmental risks and to perform an environmental quality assessment, Chemical Risk Assessments should be performed prospectively and retrospectively (Gustavsson et al., 2023, Phneah et al., 2017, Morash et al., 2023). Therefore, Chemical Risk Assessment has become an essential tool for preventing and managing various occupational diseases or accidents caused by increased amounts of hazardous substances in the workplace to ensure safety improvement and reduce the incidence of industrial accidents (Moon et al., 2021). The Chemical Risk Assessment Process, as proposed by the United States National Academy of Sciences (US-NAS) (Council, 1983), consists of the following four steps; Fig. 1 summarises the complete procedure of chemical risk assessment.

Hazard Identification: is a determination of the exposure to a chemical substance can lead to an increase in the occurrence of specific harmful effects on the health of operators, equipment and the environment;

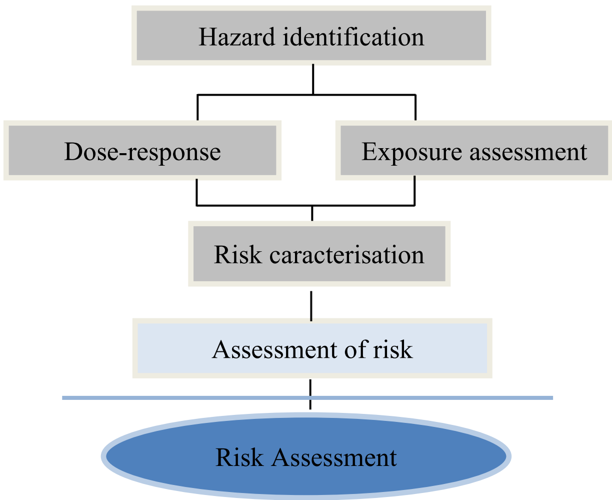

Figure 1. The four steps of the risk assessment process.

A dose-response assessment: determining the relationship between the magnitude of exposure to a hazard and the probability and severity of adverse effects;

Exposure assessment: is the process of measuring or estimating the magnitude, frequency, and duration of human exposure to an agent in the environment or estimating future exposures for an agent that has not yet been released;

Risk characterisation: combining the information from the hazard characterisation and the exposure assessment to form a conclusion about the nature and magnitude of risk and, if indicated, implement additional risk management measures.

Several well-known international bodies recognise the Chemical Risk Assessment Process as an essential tool to prevent accidents. It is also recognised as a constantly evolving process that has changed significantly in the past few decades (El-Harbawi et al., 2020, Commission, 1994).

Numerous tools and sources of information are available to carry out a chemical risk assessment and build their prevention action plan; several tools have been proposed, such as guidance documents, handbooks, checklists, questionnaires, brochures, and software tools (El-Harbawi et al., 2020). This paper will use SEIRICH, a free chemical risk assessment tool.

3. SEIRICH SOFTWARE

Several tools and methods are available to support chemical risk assessment; some are for occupational risks, such as SEIRICH (Stepa &Haiducu, 2022). SEIRICH is a free software tool developed by INRS and its partners (DGT, CNAMTS and several professional organisations). SEIRICH allows Chemical Risk Assessment at workstations based on analysing actual work and operating conditions (Aachimi &Clerc, 2020, Aachimi, 2022). It has been online for more than six years. With more than 15,000 user companies since June 2015, SEIRICH has become a reference tool for Chemical Risk Assessment. It uses algorithms to assign a risk score that allows the prevention specialist to prioritise the situations to be treated. Designed to be used by company directors, QHSE managers, doctors, occupational health departments, chemists, toxicologists and chemical risk specialists, it allows them to find out about the most hazardous chemical products and to carry out their chemical risk assessment (Aachimi &Clerc, 2020, Miraval, 2018, Omrane, et al., 2018).

Previous works have used SEIRICH software for chemical risk assessment, such as the study conducted by Blandin et al. (Blandin et al., 2018) Using SEIRICH software to assess chemical risk from welding fumes. Espinoza and Vonarx (Espinoza &Vonarx, 2018) employed the SEIRICH software when conducting a study to identify endocrine disruptors in an industrial mechanics company. Omrane et al. (Omrane et al., 2018) have opted to use the SEIRCH software to assess chemical risks and to implement a preventive action plan in the endoscopy units and the interventional radiology unit of a Tunisian university hospital. Lanotte et al. (Lanotte et al., 2018) conducted a study to assess and prevent occupational risks in a sweeping chimney company in Haute Savoie; the inventory of chemical products was performed using the Seirich software. Villanti and Bousquet (Villanti &Bousquet, 2020) have used the SEIRICH software in the aerospace subcontracting sector to assess the effects on the health and safety of employees associated with the use of carcinogenic, mutagenic and reprotoxic products. Harrathi et al. (Harrathi et al., 2022) assessed the chemical risk from cleaning and disinfection products in a public hospital during the COVID-19 pandemic and compared the levels of this exposure with those of the years preceding this pandemic. Rousset et al. (Rousset et al., 2022) conducted a study on disinfectants from hatcheries to the slaughterhouse, and they assessed the Residual chemical risk using SEIRICH.

The SEIRICH software assessment process consists of 5 steps (Miraval, 2018):

- Definition of zones and tasks
- Inventory of labelled products and emitted chemical substances
- Prioritisation of potential risks
- Residual risk assessment
- Development of a prevention action plan

4. RESULTS AND DISCUSSIONS

In this section, we will conduct a Chemical Risk Assessment for the PERTAMINA company using the SEIRICH software.

Industrial case study

The petroleum industry includes the global processes of exploration, extraction, refining, transporting (often by oil tankers and pipelines), and marketing of petroleum products. The Hassi Messaoud oil and gas field, one of the largest deposits in the world, is located 650 km South East of the capital (Algiers) (Kechiched et al., 2013). This deposit contains several oil and gas companies, including "PERTAMINA», a partnership between Algeria and Indonesia. In this part, we will define the areas in which we will assess chemical risks by SEIRICH software.

Performing the chemical risk assessment by SEIRICH software

The current study focused on assessing the chemical risks using SEIRICH software and performing a preventive action plan. The methodology deployed in SEIRICH is part of a national agreement on preventing chemical hazards. It involves numerous partners, including the French Ministry of Labour, the Occupational Risk Directorate of Social Security and several trade organisations. This tool includes the changes due to the classification of substances and mixtures according to the EU Classification and Packaging (CLP) Regulations (EC 1272/2008). The SEIRICH methodology includes five steps implemented as functionalities. To achieve our objectives, the five steps of the SEIRICH software will be followed in the next sections.

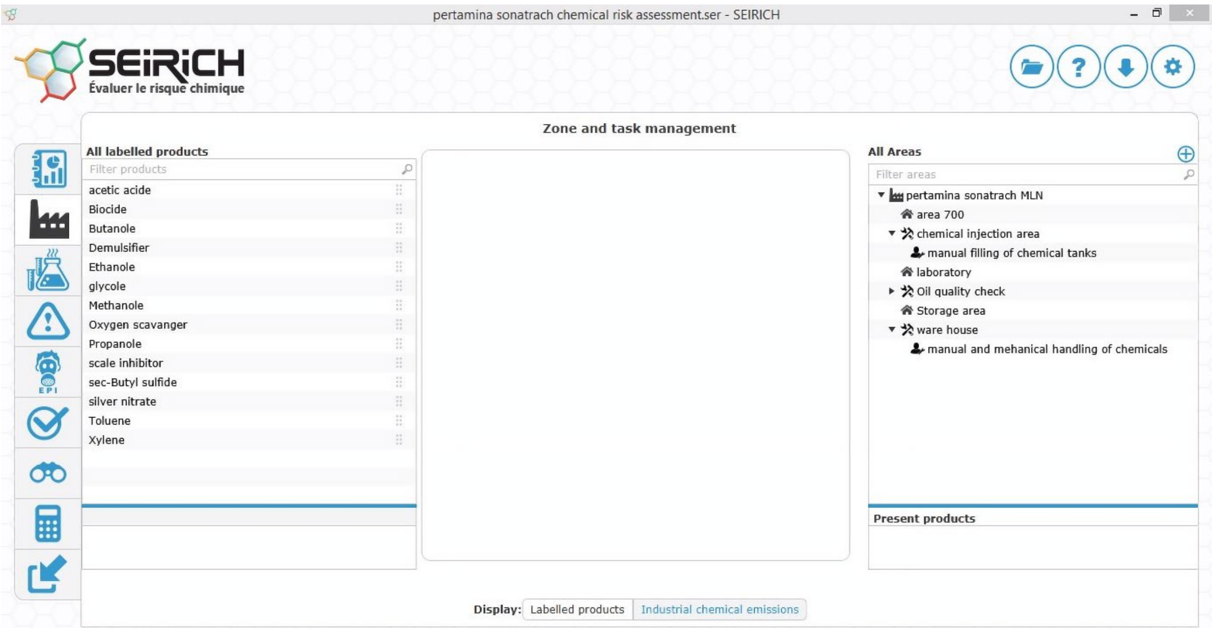

Figure 2. Hierarchical organisation of work areas in PERTAMINA (By SEIRICH software).

First Step: Definition of zones and tasks

The presence of chemical products in large quantities inside the warehouse is a challenge for industrial safety, as it can be a source of deviations from normal behaviour. These deviations cause incidents or accidents (Bouloiz et al., 2013) mainly if they are not classified according to the standards and regulations. PERTAMINA is an oil and gas company with many units for performing different tasks in the presence of large quantities of chemical substances. In this paper, we will focus on the units that present a high chemical risk: the storage area, the injection area, and the laboratory.

Storage area: Contains all chemicals the company needs to process crude oil. Workers store all those chemicals automatically to use later when needed; the store building is located near the company's main gate. It is separated from other units because it contains many chemicals that may lead to fire or explosion. In addition, daily exposure to hazardous chemicals, even in small amounts, may cause occupational diseases such as cancer, harming workers inside this warehouse.

Injection area: A Chemical Injection process involves introducing specialised chemicals to the oil & gas flow stream or reservoir to perform certain specific processes.

Laboratory: Oil quality monitoring is considered the main task of the laboratory; workers take samples daily to check them and ensure that they comply with international standards. To perform this process, the testers mix chemicals with the samples taken. The daily use of chemicals has significant risks to workers' health, mainly if these products cause cancer or emit toxic fumes (Li et al., 2021, Mourry et al., 2020). On the other hand, these chemicals may be flammable or cause a fire due to their interaction (Guidotti, 2002, Musu, 2006, Masri et al., 2021). The significant threat in the laboratory is that the chemicals are stored inside a cupboard with a ventilation system; if this system fails, a fire or explosion may occur due to the pressure produced by the excessive heat inside the cabinet.

Second step: Inventory of labelled products and emitted chemical substances

After defining the different areas concerned by the use of chemicals in the PERTAMINA plant, we will now proceed to determine the list of chemicals included in each area, which have been listed using Material Safety Data Sheets (MSDS), the SEIRICH software has classified them according to figure 2.

The chemical inventory in PERTAMINA is significant because it presents most chemicals that negatively affect operators mainly and cause a fire or explosion, so we have summarised them in the following table (Table 1).

Third step: Prioritisation of potential risks

The SEIRICH software evaluates and classifies after giving input related to chemicals, such as hazardousness, annual consumption, physic-chemical properties (flash point, physical state) and collective protection (see Figure 3).

Fourth step: Residual risk assessment

The residual risk analysis is based on the study of the actual work and the operating conditions in the injection area, warehouse and laboratory. It, therefore, requires complete information on the characteristics of the various tasks performed by operators. When we entered all the necessary information (exposure duration and daily consumption), SEIRICH software transformed and classified them into a straightforward document, as represented in the next section (see Figures 4 and 5).

Table 1. Label products with the necessary data, zone and quantity

Chemical Product	Workstation	Existing of MSDS	Yearly consumption
Demulsifier	Injection area	Yes	33790 L
Biocide	Injection area	Yes	6460 L
Oxygen scavenger	Injection area	Yes	5814 L
Glycol	Injection area	Yes	5440 L
Scale inhibitor	Injection area	Yes	4862 L
Butanol	laboratory	Yes	200 ml
Propanol	laboratory	Yes	200 ml
Acetic acid	Laboratory	Yes	4 L
Sec butyl sulfide	Laboratory	Yes	200 g
Ethanol	Laboratory	Yes	3 L
Methanol	Laboratory	Yes	5 L
Silver nitrate	Laboratory	Yes	200 g
Xylene	Laboratory	Yes	1 L
Toluene	Laboratory	Yes	1 L
Acide sulfirique	laboratory	Yes	2 L
Demulsifier	Warehouse	Yes	6000 L
Biocide	Warehouse	Yes	3000 L
Oxygen scavenger	Warehouse	Yes	4000 L
Glycol	Warehouse	Yes	4000 L
Scale inhibitor	Warehouse	Yes	4000 L

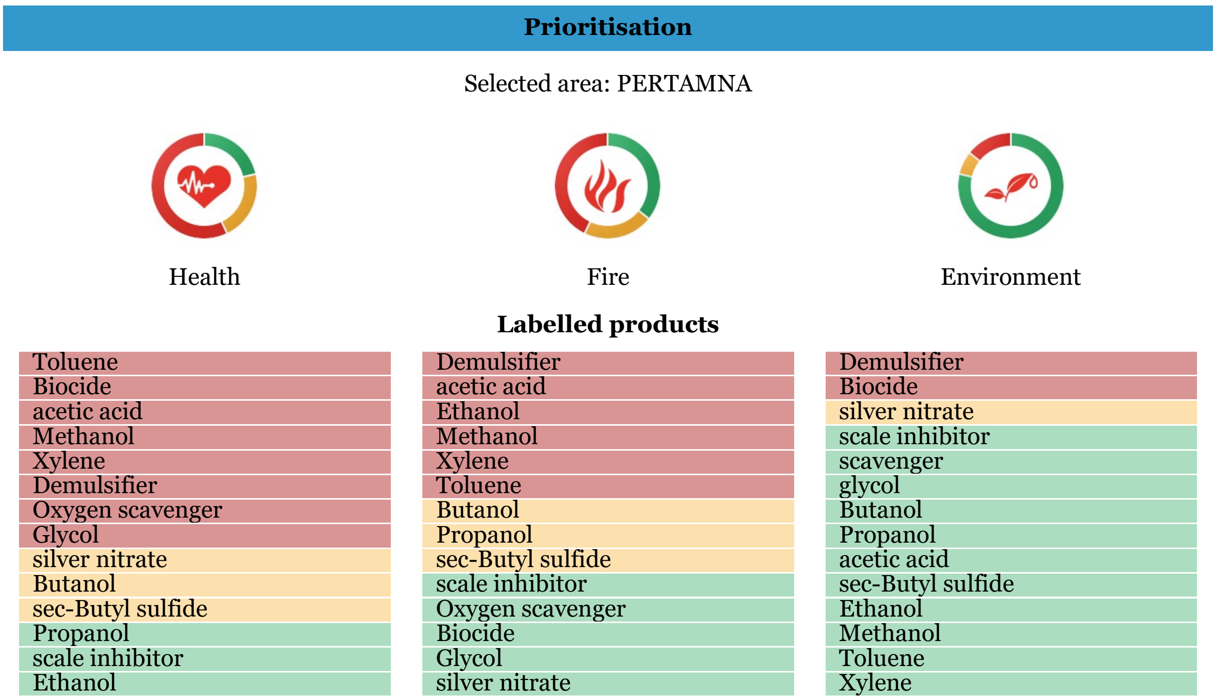

Figure 3. Prioritising potential risks in the different zones of PERTAMINA (By SEIRICH software).

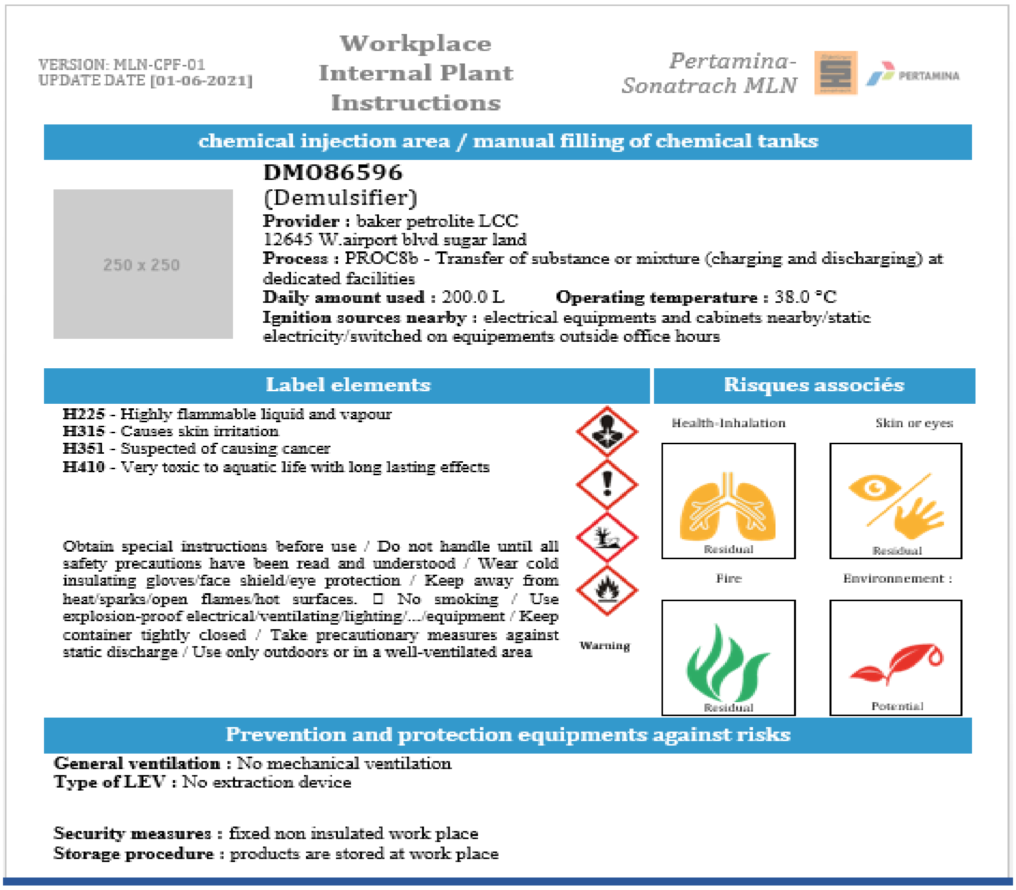

Figure 4. SEIRICH Software represents the residual risk sheet (By SEIRICH software).

Fifth step: Development of a prevention action plan

Once the risk and exposure assessment phase has been completed, the company must prioritise the risks and set up a prevention action plan. The legislation outlines how prevention measures must be implemented: training, information, substitution, collective protection measures (capturing and ventilation), use of personal protection equipment, etc. Managing chemical risk in the company is thus the result of a set of preventive measures that must be implemented with the active support of all those involved to be fully effective.

The pre-determined study must be very accurate by collecting as much information as possible about the nature of chemicals in the workplace with the amount used and individual and collective protection equipment. It is also essential to know about PERTAMINA Plan and response regarding chemical hazards so that we can modify or add new procedures that allow the safe use of hazardous substances.

There are many safety instructions that the company can follow to eliminate or reduce the risks arising from daily exposure to chemicals in the warehouse, injection area and laboratory.

When coping with chemical hazards, the five elements listed below should be addressed as a prevention strategy:

– *Eliminate the hazard*

The priority of the measures to be implemented must be eliminating or substituting hazardous chemicals and procedures with other, less hazardous products or procedures. When CMR products are used, their substitution is a regulatory obligation when technically possible. When neither elimination nor substitution is feasible, a set of actions must be taken to reduce as much as possible the level of risk, the quantities of hazardous chemicals, the number of employees exposed or the frequency or duration of exposure. PERTAMINA lists hazardous chemicals that should be replaced, like (demulsifiers, acetic acid, ethanol, methanol, Xylene, and toluene). In the most straightforward cases, contacting different product suppliers may be enough to find a solution quickly. Getting closer to professional organisations about a network of companies encountering the same substitution problems is also possible.

Residual risk

Selected area: PERTAMINA

Inhalation	Skin – Eye	Fire
	Labelled products	
manual and mechanical handling of chemicals – Biocide	manual and mechanical handling of chemicals - Oxygen scavenger	manual and mechanical handling of chemicals – Demulsifier
Oil quality monitoring - Methanole	manual and mechanical handling of chemicals – Biocide	Oil quality monitoring - Methanol
Oil quality monitoring - Xylene	Oil quality monitoring - Methanol	Oil quality monitoring - Xylene
manual and mechanical handling of chemicals – Demulsifier	Oil quality monitoring - Xylene	manual and mechanical handling of chemicals - Oxygen scavenger
manual and mechanical handling of chemicals - Oxygen scavenger	manual and mechanical handling of chemicals – Demulsifier	manual and mechanical handling of chemicals – Biocide
manual and mechanical handling of chemicals – glycol	Manual and mechanical handling of chemicals - scale inhibitor	Manual and mechanical handling of chemicals - scale inhibitor
Manual and mechanical handling of chemicals - scale inhibitor	manual and mechanical handling of chemicals – glycol	manual and mechanical handling of chemicals – glycol

Figure 5. Residual risk assessment in PERTAMINA (By SEIRICH software).

– *Install a ventilation system.*

Outside, the optimum is a mechanical ventilation system in a sufficiently ventilated room sheltered from the weather by a canopy-type injection space. Inside a closed room (warehouse), the minimum is natural ventilation with an air inlet in the lower part of the room and an air outlet on the opposite side, in the upper part.

The laboratory contains a ventilation system following Article R. 4222-20 of the Labour Code, which states that the employer must maintain all installations in good working order and check them regularly. This control can be carried out internally by a competent person. The Algerian decree of October 8, 1987, relating to the periodic inspection of ventilation and sanitation installations in workplaces, specifies the ventilation system's checking procedures.

–*Action on the work organisation:*
Acting on the work organisation amounts, on the one hand, to defining suitable operating methods, specifying the rules of handling and hygiene and on the other hand to being interested in the rules of storage and flow of products in the community. Waste management and disposal (collection, storage, and disposal) must also be considered.
Handling rules - Hygiene rules: When handling chemicals, a few essential hygiene rules must be observed by agents:

- Do not eat or drink, do not smoke;
- Use clothing dedicated for this purpose;
- Wash the hands properly after use;
- Take a shower afterwards, if possible.

The instructions must make it possible to limit the number of people exposed as well as the duration of the exposure.

Storage rules: In terms of storage, specific rules must be scrupulously observed:

- The number of hazardous chemicals stored in workshops or work areas must be limited to daily needs to limit the risk of fire or accidental poisoning;
- Chemical products must be stored in a room separate from the workstations. However, when the quantities of products are low, their storage is possible in cabinets specifically adapted to the risks, including a retention and ventilation system as well as appropriate signals;
- Each container must be appropriately labelled and stored in strong and suitable packaging. Storage devices (pallets, shelves, cupboards, etc.) must include adequate and appropriate retention. The retention capacity should be at least equal to the following:
  - 100% of the capacity of the largest container;
  - 50% of the total capacity of the associated.

Products must be classified by type of risk:

- Incompatible products must be separated to avoid dangerous reactions such as exothermic, explosive or potentially toxic substances being released into the atmosphere (see Fig. 6). For example, acids and bases (labelled as corrosive) must be stored in individual basins
- Easily flammable products must not be placed on or under stairs, in passages and corridors, or near exits from premises and buildings (See Fig 6). Oxidising and flammable products must be stored separately (different shelves forming retention and at a distance from each other);
- Toxic and CMR products must be isolated (separate shelf).

Access to premises where hazardous chemical agents are used is limited to persons whose mission requires it. These premises are subject to signs reminding them of the requirement needed to enter them and the existence of dangerous emissions to health.
Storage room: Depending on the nature of the products stored, and depending on the results of risk analyses, several "good practices", some of them regulatory, can be considered for storage premises:

- Non-combustible construction elements;
- An impermeable floor, resistant to chemicals, sloping slightly towards an evacuation channel connected to a recovery pit;
- One or more access doors equipped with an anti-panic opening device that can be locked;
- Sufficient ventilation;
- Electrical equipment by regulations concerning areas at risk of fire and explosion;
- A sign prohibiting smoking or the use of an open flame affixed in the room;
- Fire-fighting means adapting to the risks (suitable and sufficient extinguishers, sand or earth, etc.) Easily accessible, clearly marked and checked periodically. Their handling should be familiar to staff;
- Absorbent materials or products available to collect spilt products;
- A nearby water point;
- Personal Protective Equipment (PPE) is stored in a cabinet outside the room;
- Bins for the recovery of empty packaging (waste);
- Gratings were installed to isolate stored products from the ground.

Management and disposal of hazardous products: Waste chemicals must be collected and disposed of through a specialist company (Torretta et al., 2015, Dharwal et al., 2021, Ho et al., 2021). To do this, the agent must have various methods of packaging waste available, take into account the hazardous properties of each of them and clearly and legibly distinguish each packaging. In addition, products reported as dangerous for the environment must not be dumped into the sewer.

–*Protect the worker*
Personal Protective Equipment (PPE): adapted to the risks involved and the activity must be made available to agents likely to be exposed to dangerous products: breathing apparatus, gloves, glasses, screen masks, coveralls, gowns, boots, etc. The employer maintains this equipment and clothes, especially in the injection area (area 700). The existing respiratory equipment (FFP3) must be adapted to fill chemical tanks. Nevertheless, PPE should not be privileged to the detriment of collective protection measures. They can be used as a supplement or as a last resort. Implementing technical protection measures must be accompanied by training and information.
Medical examination before exposure: The employee exposed to "hazardous" chemical agents must undergo a prior medical examination attesting to the absence of any contraindication. Reinforced medical surveillance is then put in place periodically.
Delivery of a notice to each worker: Establish instructions for each workstation exposing

workers to hazardous chemicals. This notice informs about the risks and recalls the hygiene rules and the instructions for using collective protection equipment and/or personal protection. It must be readable and understandable by all.

– *Training - information*

- Receive periodic information on dangerous chemical agents (name, health risks, oils);
- Have access to Material Safety Data Sheets (MSDS);
- Receive training and information on the precautions to be taken (safety measures, hygiene, use of personal protective equipment).

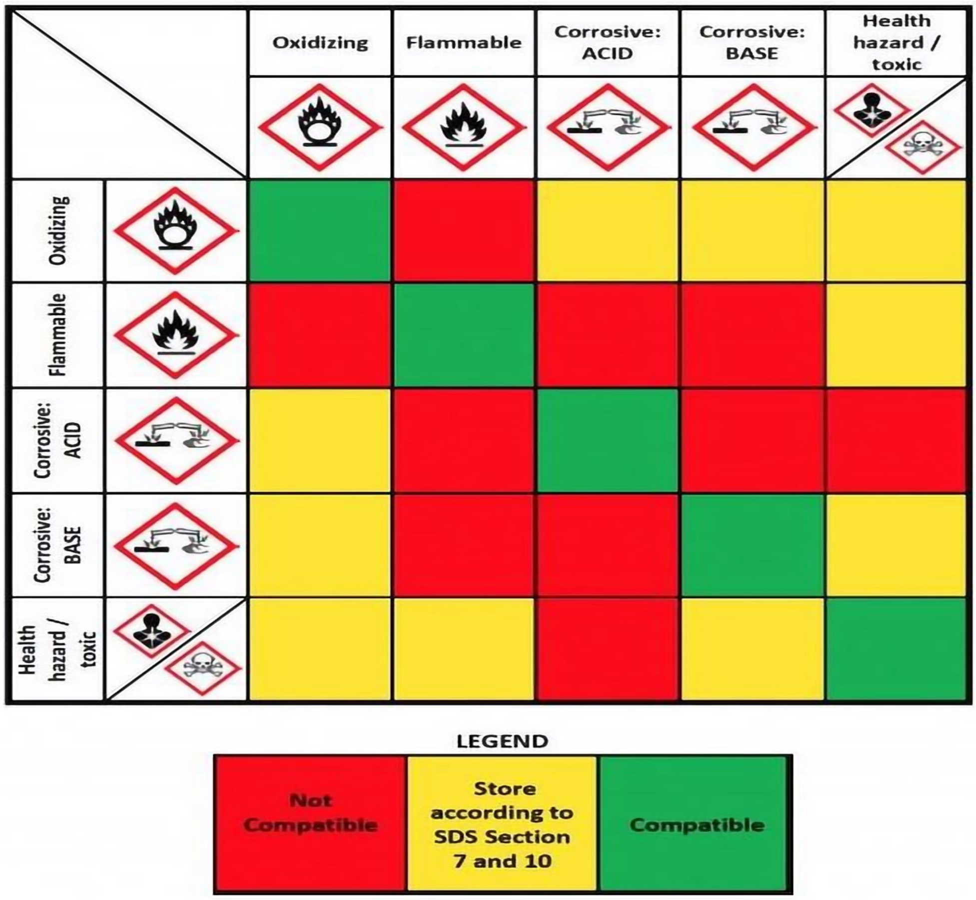

Figure 6. Chemical incompatibility sheet (By SEIRICH software).

– *Specific measures*

Concentration measurements: Carry out concentration measurements regularly. Any overrun of the binding OEL (Occupational Exposure Limits) must give rise to immediate control and, if the overrun is confirmed, implement actions corresponding to the return to normal. Conversely, exceeding the indicative OELs must give rise to a new assessment.

Install chemical warning signs in the workplace: Rooms, where dangerous chemical agents are used, must have limited access and be the subject of specific hazard warning signs.

Management of incidents, accidents, and emergencies: Anticipate emergencies, incidents, and accidents and organise alert, rescue and first aid procedures.

Maintenance of collective and individual protection equipment: The company shall ensure the maintenance and regular verification of collective and personal protective equipment. The results of these checks are entered in the safety register. A notice must be drawn up and set out the conditions for the maintenance and monitoring of this equipment. When clothing is cleaned outside the company, the external service provider shall be informed of possible contamination risks.

In this part, we have applied the chemical risk assessment methodology within the PERTAMINA Company after collecting all information about workstations and the chemicals used in each united. Then, all those data are uploaded to the SEIRICH program to extract the necessary results to develop a preventive plan.

After SEIRICH showed the results, it was found that most chemicals are dangerous and cause serious harm to workers who are exposed to them periodically. On the other hand, there is some need for more collective protection equipment, which means that the risk level gradually rises in the previous workstations.

Exposure sheet with a list of workers: Establish an exposure sheet (See Fig.7) for each worker, including:

- The nature of the work performed.
- Product characteristics.
- Exposure periods.
- Other risks or nuisances of physical, chemical or biological origin;
- The dates and results of the usual exposure checks at the workstation and the duration and extent of the exceptional exposures.

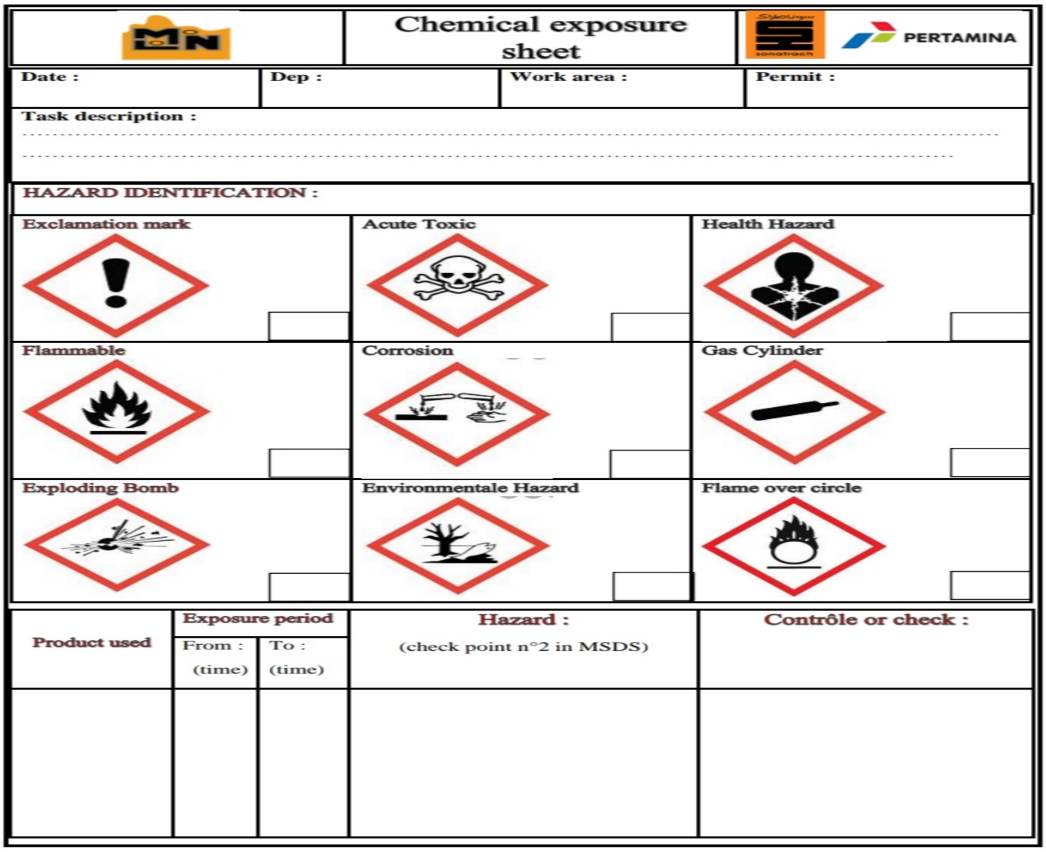

Figure 7. Chemical exposure sheet model

This sheet (See Fig. 7) should be filled and attached with a permit to work before doing any jobs that directly contain chemicals.

CONCLUSION

To know the most significant negative effects resulting from daily exposure to chemicals and to find an effective chemical risk assessment methodology in the workplace, this in-depth study was applied in PERTAMINA company, through it an inventory was made of the different areas and chemicals used, as well as exposure methods, etc. These details were loaded into the SEIRICH software to facilitate chemical risk assessment.

SEIRICH made it easier to assess chemical hazards inside the factory by classifying chemicals according to their severity. In addition, it allowed us to develop a preventive plan to improve competencies in dealing with hazardous substances.

Based on the results of SERICH, a preventive action plan was proposed. Correctly implementing those guidelines and preventive actions can effectively reduce and prevent accidents and provide a practical tool for enhancing safety production.

Finally, it should be remembered that chemical risk must be taken into account in the occupational risk assessment process. Therefore, the chemical risk assessment and prevention proposed in this case study contribute to improving and giving a greater perspective on the results of an occupational risk management process in an industrial company.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding this article.

FUNDING

The research underpinning this publication was undertaken independently and was not contingent upon any external financial endorsements or grants.

REFERENCES

Aachimi, A., & Clerc, F. (2020). Cohérence entre l'évaluation des risques du logiciel Seirich et les données d'exposition de la base Colchic. Archives des Maladies Professionnelles et de

l'Environnement, 81(5), 727.
Aachimi, A. (2022). Amélioration des algorithmes d'évaluation des risques chimiques dans le logiciel Seirich (Doctoral dissertation, École des Hautes Études en Santé Publique [EHESP]; Institut national de ...).
Bendib, R., Mechhoud, E., Rodriguez, M., & Zennir, Y. (2021). A systematic approach for risk assessment in LPG storage tanks area–SKIKDA refinery. Algerian Journal of environmental science and Technology.
Blandin, M., Pachura, S., Magot, D., & Staudt, J.-P. (2018). Un outil d'aide à l'évaluation du risque chimique par inhalation pour l'activité de soudage. Archives des Maladies Professionnelles et de l'Environnement, 79(2), 147-159.
Bouasla, S., Mechhoud, E., Zennir, Y., Bendib, R., & Rodriguez, M. (2021). Evaluation of Safety Instrumented System in a petroleum plant and its impact on the environment. Algerian Journal of environmental science and Technology.
Birrer, C., & Delva, F. (2021). Évaluation des risques chimiques reprotoxiques en milieu professionnel: recensement des sources de données en ligne. Archives des Maladies Professionnelles et de l'Environnement, 82(3), 295-304.
Chettouh, S., Hamzi, R., & Benaroua, K. (2016). Examination of fire and related accidents in Skikda Oil Refinery for the period 2002–2013. Journal of Loss Prevention in the Process Industries, 41, 186-193.
Chettouh, S., Hamzi, R., & Chebila, M. (2018). Contribution of the lessons learned from oil refining accidents to the industrial risks assessment. Management of Environmental Quality: An International Journal, 29(4), 643-665.
National Research Council (1983). Risk assessment in the federal government: managing the process.
El-Harbawi, M., Abd Raman, A. A., & Al-Mubaddel, F. (2020). Development of a chemical health risk assessment tool for health risk assessment from exposure to hazardous chemicals. Biomedical Journal of Scientific & Technical Research, 28(3), 21715-26.
European Economic Commission (1994). Technical guidance document in support of the commission directive 93/67. EEC on Risk Assessment for New Notified Substances and the Commission Regulation (EC), 1488(94.
Gustavsson, M., Sverker, S., Backhaus, T., & Kristiansson, E. (2023). Risk assessment of chemicals and their mixtures are hindered by scarcity and inconsistencies between different environmental exposure limits. Environmental Research, 115372.
Hanekamp, J. C., & Calabrese, E. J. (2021). Reflections on chemical risk assessment or how (not) to serve society with science. Science of The Total Environment, 148511.
Phneah, S. L., Hassim, M. H., & Ng, D. K. S. (2017). Review of chemical hazard based occupational health assessment methods for chemical processes. Chemical Engineering Transactions, 56, 1813-1818.
Morash, M. G., Kirzinger, M. W., Achenbach, J., Venkatachalam, A. B., Cooper, J. P., Ratzlaff, D. E., Woodland, C. L., & Ellis, L. D. (2023). The contribution of larval zebrafish transcriptomics to chemical risk assessment. Regulatory Toxicology and Pharmacology, 138, 105336.
Moon, H.-I., Han, S.-W., Shin, S., & Byeon, S.-H. (2021). Comparison of the Qualitative and the Quantitative Risk Assessment of Hazardous Substances Requiring Management under the Occupational Safety and Health Act in South Korea. International journal of environmental research and public health, 18(3), 1354.
Stepa, R. A., & Haiducu, M. (2022). SSD SmartRisk, a decision support system to help non-expert decision makers in case of chemical accidents.
Miraval, S. (2018). Seirich: outil d'aide à l'évaluation des risques chimiques. Archives des Maladies Professionnelles et de l'Environnement, 79(3), 391.
Omrane, A., Chebbi, F., Jlassi, O., Khedher, A., Mars, N., Harrathi, C., & Bouzgarrou, L. (2018). Évaluation du risque chimique dans un centre hospitalo-universitaire Tunisien. Archives des Maladies Professionnelles et de l'Environnement, 79(3), 389-390.
Espinoza, M. C., & Vonarx, J. (2018). Repérage des perturbateurs endocriniens dans une entreprise de mécanique industrielle. Archives des Maladies Professionnelles et de l'Environnement, 79, 396-406.
Villanti, N., & Bousquet, V. E. (2020). PRICA, action pluridisciplinaire de prévention risques chimiques dans l'aéronautique. Archives des Maladies Professionnelles et de l'Environnement, 81(5), 578.
Harrathi, C., Omrane, A., Guetari, L., Chebbi, F., El Mhamedi, S., Bouzgarrou, L., & Khalfallah, T. (2022). Évaluation du risque chimique lié aux travaux de nettoyage et désinfection pendant la pandémie COVID-19 dans un hôpital public. Archives des Maladies Professionnelles et de l'Environnement, 83(4), 380-381.
Rousset, N., Battaglia, A., Galliot, P., Pertusa, M., Ruch, M., Le Bouquin-Leneveu, S., Huneau, A., Balaine, L., Riolland, C., & Soumet, C. (2022). Use of disinfectants from hatchery to slaughterhouse, what are the health risks for users? Animal-science proceedings, 13(5), 617-618.
Kechiched, R., Haddane, A., Foufou, A., & Ameur Ziameche, O. (2013). Caractérisation pétrophysique des réservoirs à l'aide de l'analyse statistique: Application sur les données de la Zone 17–Champ de Hassi Messaoud–Algérie.
Bouloiz, H., Garbolino, E., Tkiouat, M., & Guarnieri, F. (2013). A system dynamics model for behavioral analysis of safety conditions in a chemical storage unit. Safety Science, 58, 32-40.
Li, X., Zhang, L., Zhang, R., Yang, M., & Li, H. (2021). A semi-quantitative methodology for risk assessment of university chemical laboratory. Journal of Loss Prevention in the Process Industries, 72, 104553.
Mourry, G. E., Alami, R., Elyadini, A., El Hajjaji, S., & Zouhdi, M. (2020). Assessment of Chemical Risks in Moroccan Medical Biology Laboratories in Accordance with the CLP

Regulation. Safety and Health at Work, 11(2), 193-198.

Guidotti, T. L. (2002). Chapitre 95. Les services d'urgence et de sécurité. Encyclopédie de sécurité et de santé au travail, Genève, Organisation internationale du travail, 95.1-95.23.

Musu, T. (2006). REACH au travail. Les bénéfices potentiels de la nouvelle politique européenne sur les agents chimiques pour les travailleurs, ETUI-REHS, Bruxelles.

Masri, S., Miller, C. S., Palmer, R. F., & Ashford, N. (2021). Perte de tolérance induite par les substances toxiques pour les produits chimiques, les aliments et les médicaments: évaluation des modèles d'exposition derrière un phénomène mondial.

Torretta, V., Rada, E. C., Ragazzi, M., Trulli, E., Istrate, I. A., & Cioca, L. I. (2015). Treatment and disposal of tyres: Two EU approaches. A review. Waste Management, 45, 152-160.

Dharwal, M., Srivastava, A. K., Sarin, V., & Gola, K. (2021). The state of solid waste management for sustainable development in India: Current state and future potential. Materials Today: Proceedings.

Ho, H.-J., Iizuka, A., & Shibata, E. (2021). Chemical recycling and use of various types of concrete waste: A review. Journal of Cleaner Production, 284, 124785.

Shao, R., Pan, H., & Huang, J. (2022). Safety risk assessment of chemical production process based on local and global objectives. Journal of Loss Prevention in the Process Industries, 79, 104827.

Song, Q., Jiang, P., & Zheng, S. (2020). Application of evolutionary game theory in safety management of chemical production. Processes, 8(4), 472.