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Original Article

An Assessment of Greenhouse Gas Emissions Caused by the Fire of Strategic Diesel Tanks and Providing an Environmental Management Plan Based on the McKinsey 7S Model

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Abstract

Background & Aims: Storage tanks for crude oil and petroleum products are always prone to various accidents such as fire and explosion. Depending on the volume and content of these tanks, these incidents can lead to environmental consequences. Ahvaz oil field is considered the third largest oil field in the world with many storage tanks. The present research was conducted to evaluate the emission of greenhouse gases caused by the fire of strategic diesel tanks in the Shahid Almasi field and provide an environmental management plan based on the McKinsey method in 2022.

Methods: In this descriptive-analytical study, the risks of fire and tank explosion accidents were identified and evaluated in the field based on the hazard analysis and operation management (HAZOP) method. The technical information on the reservoirs was obtained from the National Iranian South Oil Company. The emission coefficients of the main greenhouse gases (CO2, CO, CH4, and N2O) were based on the OAQPS standard, and the global warming potential was calculated in the scenarios according to Flessa et al. Then, the McKinsey 7S method was used to evaluate the state of environmental management. The validity and reliability of the McKinsey Questionnaire were assessed by the content method and Cronbach's alpha method, respectively, using SPSS 19.

Results: The explosion of strategic fuel tanks due to an attack, wall decay, and human error with priority of 200, 168, and 120 were the most important risks of fuel storage. The results of the greenhouse gas emissions analysis due to accidents showed that the total global warming potential (GWP) for the fire of diesel tanks in the Koreyt Camp of Ahvaz is 8 277 143 kg of CO2 equivalent. The results of a gap analysis by the McKinsey method also revealed that the lowest average score was related to the strategy dimension (3.67), and the highest efficiency was related to the system dimension (4.82).

Conclusion: The occurrence of an accident for diesel storage tanks in the Koreyt Camp complex in the Ahvaz oil field led to significant environmental effects such as the release of air pollutants and greenhouse gases.

Keywords: Environment, Global warming, Greenhouse gases, Diesel tanks, McKinsey, HAZOP

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1. Introduction

Major accidents in the oil industry cause the release of environmental pollutants and greenhouse gases [1,2]. Controlling and reducing the effects of pollution caused by oil industries to protect the environment are the most important issues and concerns of countries, especially oil-rich countries [3]. Environmental pr oblems such as the emission of greenhouse gases, which mainly originate from these industries, have dangerous consequences and disrupt the biological nature of human societies as well as wildlife [4]. Given the nature of the activities and processes carried out, oil industries can exert adverse effects on the environment due to the production of effluents, emissions of pollutants, greenhouse gases, and hazardous wastes [5,6]. In general, oil and gas stations need a large number of tanks to store crude oil, gas, and various petroleum products. The number of these tanks depends on the distance and proximity of the unit to crude oil supply sources, the number and capacity of refining units, the variety of manufactured products, and finally how to transfer and distribute the products [7].

Fuel tank fires are always considered one of the threatening factors for working people and the surrounding residents [8]. On the other hand, fire caused by oil derivatives is one of the key parameters in determining factors affecting biological resources [9]. The environmental, economic, and social effects caused by fire and explosion of oil and chemical tanks are extremely noticeable. One of the most important effects of these events is global warming and climate change [10]. The consequences of climate change can be classified into direct and indirect (economic) damages. The Intergovernmental Panel on Climate Change (IPCC) has declared that the phenomenon of global warming and climate change is attributed to human activities, and most importantly, industrial activities [11].

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The American National Academy of Sciences (NAS) also identifies human activity and the production of greenhouse gases as the main causes of this phenomenon. Major accidents in industries can release a huge amount of greenhouse gases into the environment at once [12], including Deep-water Horizon in 2010 and Piper Alpha in 1988. Risk and consequence analysis is one of the measures that play a role in identifying the causes and preventing their occurrence [13,14]. Risk analysis is a common method for investigating different types of risks related to activities, facilities, methods, and processes [15]. A robust body of research has been conducted on the environmental consequences of fire and explosion of chemical tanks in Iran and worldwide. James and Renjith [16] assessed the safety risk and environmental effects of the explosion of liquefied natural gas (LNG) tanks in eastern India. They reported their damage potential as high and the level of environmental risk as controllable. Khorram [17] assessed the environmental consequences of cyanogen release in the Bushehr nuclear power plant using ALOHA and PHAST software and reported the environmental effects caused by the release of this toxic substance on aquatic animals and citizens as extremely significant. Yang et al [18] also evaluated the potential of propylene release and explosion from pressure vessels in Shanghai. Studies on the potential of explosion and fire accidents in petroleum derivatives and chemical tanks are of particular importance because these events have safety, health, environmental, economic, and credit consequences.

In general, there are about 11 000 types of ground tanks all over Iran containing all kinds of chemicals and petroleum derivatives such as gasoline and crude oil. Shahid Almasi fuel supply center in the Ahvaz oil field is located in Koreyt Camp to support oil production operations in oil-bearing areas and provide services such as receiving, storing, and sending annually more than 200 million liters of oil and gas needed by drilling rigs to perform in-well operations, coiled tubing, oil-based mud plant, well-processing plan, and the like. It should be noted that the Ahvaz oil field is the largest in Iran and the third largest oil field in the world. In this research, in addition to the risk assessment of strategic diesel tanks and determining the global warming potential (GWP) caused by the fire of strategic diesel tanks, the model for developing an environmental management plan for fuel tanks is presented based on the McKinsey gap analysis method.

2. Materials and Methods

The current descriptive-analytical study evaluated greenhouse gas emissions caused by the fire of strategic diesel tanks in the Shahid Almasi fuel supply center and provided an environmental management plan based on the McKinsey method in 2022 in a refueling station within the oil field.

The information related to the technical specifications of the fuel tanks, capacity, and geographical location was collected through the National Iranian South Oil Company (NISOC). Possible scenarios included fire or explosion of two diesel tanks (a 650 000-L tank and a 2.3-million-liter tank) at the Shahid Almasi fuel center. The height of the oil tanks above sea level is 22 m and the area of the station is 77 568 m^2. The geographical location of the 650 000-L tank is 31°13’35.44”N and 48°57’51.27”E, and the 2.3 million-liter tank is 31°13’34.42”N and 48°57’48.30”E. Figure 1 presents the geographic location of the reservoir.

In the first step, possible risks that lead to the occurrence of fire and explosion of tanks were identified and evaluated using the hazard analysis and operation management (HAZOP) method. In the risk analysis using the HAZOP method, the possible scenarios of the accident were evaluated. The risk priority number in this method is the multiplication of three indicators: incident severity, probability of occurrence, and risk detection capability. Risk priority criteria in the HAZOP method include:

2.1. Severity of risk

The severity of risks indicates the extent and range of damages and losses that will be caused if the risk occurs (Table 1).

2.2. Hazard risk

The risk probability factor indicates the possibility of a risk occurring in a certain period (Table 2).

2.3. Detectability

This criterion assesses the potential to detect the risk (Table 3).

The hazard risk matrix integrates the elements of hazard severity and probability tables to provide an effective tool for estimating the acceptable level of risk degree (Table 4). The keywords used in the evaluation process are also presented in Table 5.

Scoring of risk indicators in the HAZOP method, based on Fuentes and collegues’ [20] suggestion, was done by ten health and safety experts with relevant education (occupational health, environment, and industrial safety) and at least five years of work experience. After determining the priorities of the risk of fire and explosion in the diesel tanks of Shahid Almasi fuel station using the HAZOP method, the amount of greenhouse gas emissions, including carbon dioxide (CO2), carbon monoxide (CO), nitrous oxide (N2O), and methane (CH4), was estimated from possible incidents. To estimate the emission factor of pollutants and greenhouse gases, the EPA method (EPA, 2002) was used [21].

Figure 1. Geographical location of the investigated reservoirs on the Google Image

Table 1. Classification of accident severity

Criterion	Evaluation	Degree
Mass death/damage over one million dollars	Disaster	10
Death of one person/damage over five hundred thousand dollars	Disaster	9
Loss of a body part or disability/working in an environment with a harmful factor higher than limit/damage over one hundred thousand dollars	Very dangerous	8
The third-degree burns/permanent partial disability/damage over 50 thousand dollars/lost days more than 30 days	Very dangerous	7
Injuries and severe fractures/second-degree burns/lost days more than 23 days and less than 31 days/damage between 10 and 50 thousand dollars	Dangerous	6
Moderate injuries and fractures/lost days more than 17 days and less than 24 days/damage between 5 and 10 thousand dollars	Dangerous	5
Injuries and minor fractures/lost days more than 11 and less than 18 days/damage over one thousand and under five thousand dollars/first-degree burn	Dangerous	4
Injuries and partial fractures/degree burns/1 days lost more than 5 days and less than 11 days/damages over $500 and under $1000	Dangerous	3
Minor injury/lost days more than 1 day and less than 6 days/damage between 100 and 500 dollars	Dangerous	2
Outpatient treatment/days lost one day/damage less than one hundred dollars	Dangerous	1

Note. Source [19].

2.4. Calculation of the emission of air pollutants and greenhouse gases (carbon dioxide, carbon monoxide, nitrous oxide, and methane) due to the explosion or fire of fuel tanks

CO2 as a greenhouse gas is produced and emitted as a result of fuel combustion. Assuming complete fuel combustion, Equation 1 determines the combustion and CO2 emission [22]. The emission equations of CO (equation 2), CO2 (equation 3), CH4 (equation 4), and N2O (equation 5) from diesel burning are also presented [23].

$$C_x H_y + (x + y/4 - z/2)\ O_2 \rightarrow (x)CO_2 + (y/2)\ H_2O \quad \text{(Eq. 1)}$$

$$C_8H_{18} + 12.5O_2 = 8CO + 9H_2O \quad \text{(Eq. 2)}$$

$$2C_8H_{18} + 25O_2 = 16CO_2 + 18H_2O + C \quad \text{(Eq. 3)}$$

$$2C_8H_{18} + 35O_2 = 16CO_2 + 18H_2O + CH4 \quad \text{(Eq. 4)}$$

$$2NO = N_2O + 1/2\ O_2 \quad \text{(Eq. 5)}$$

The emission of CO_2 is caused by the oxidation of hydrocarbons during the combustion process. Due to the defects of diesel combustion systems, they do not always get enough oxygen from the fuel carbons; thus, CO gas is produced. CH4 emission may also occur as a result of incomplete combustion of fuel in the form of unburned CH4. Furthermore, N_2O is produced and released during a series of complex reactions during the combustion

Table 2. Classification of risk probability in the HAZOP method

Criterion	Evaluation	Degree
Danger occurs less than once a year	Unlikely probability (unlikely risks)	2
Danger occurs 1 to 11 times a year	Very low probability (rare risks)	4
Danger occurs 1 to 2 times a month	Low probability (casual risks)	6
Danger occurs 1 to 6 times a week	Medium probability (repetitive risks)	8
Danger occurs one or more times a day	High probability (unavoidable risks)	10

Note. HAZOP: Hazard analysis and operation management; Source [19].

Table 3. Risk classification based on detectability in the HAZOP method

Criterion	Evaluation	Degree
Risk is definitely tracked and detected with existing controls**.**	Detectable risk	1
In less than 24 hours, the risk is tracked and detected**.**	Detectable risk	3
In less than a month, the risk is tracked and detected**.**	Detectable risk	5
In less than six months, the risk is tracked and detected**.**	Detectable risk	7
In less than a year, the risk is tracked and detected**.**	Detectable risk	9
There is no control or, if there is, it is unable to detect the hazard**.**	Undetectable risk	10

Note. HAZOP: Hazard analysis and operation management; Source [19].

Table 4. Risk matrix in HAZOP method

Risk classification	Risk criterion
The score of severity and detectability is 9 and above/ the probability score is 9 and above / Risk greater than 500	Unacceptable
The effect intensity score (worsening rate) is 7 and 8/detectability is 7/probability of occurrence 6/risk between 100 and 500	Unfavorable
Risk between 100 and 500	Acceptable but in need of revision
Risk less than 50	Acceptable

Note. HAZOP: Hazard analysis and operation management; Source [19].

Table 5. Keywords used in the risk assessment process using the HAZOP method

Keywords	Description of deviations
None	The physical process is not done.
More than	The relevant physical properties are more than they should be.
Less than	Physical properties are less than they should be.
As well as	There are other cases than those defined.
Part of	The composition of the process is different from the composition it should be.
Reverse	The reverse process happens.
Other than	Sometimes abnormal operations occur.

Note. HAZOP: Hazard analysis and operation management; Source [19].

process. Unlike CO_2, the emission of CH4 and N2O depends on the type of fuel and the form of combustion. In general, the emission of CH4 and N2O (based on CO_2 equivalent) in combustion sources is significantly lower than the emission of CO_2 [24].

The emission coefficients of greenhouse gases under the condition of complete combustion follow a certain pattern based on the hydrocarbon structure of the combustible material. The emission coefficients of air pollutants and greenhouse gases from petroleum compounds are provided in the Office of Air Quality Planning and Standards (OAQPS) of the United States. The coefficients related to diesel are described in its AP-2 standard [25]. Therefore, it is possible to determine the emission coefficients of greenhouse gases and air pollutants using an online calculator, based on the volume of combustible material. The chemical characteristics and criteria of emergency response planning guidelines (ERPG) and immediately dangerous to life and health (IDLH) for diesel are presented in Table 6.

2.5. Calculating the greenhouse effect

After determining the emission coefficient of greenhouse gases caused by the fire of diesel tanks, the possible greenhouse effect was calculated for the burning of all the fuel content of diesel tanks. Table 7 presents the greenhouse effect of each of the greenhouse gases based on the CO_2 equivalent provided by Flessa et al [27].

2.6 Gap analysis by McKinsey 7S model

To evaluate the environmental management priorities of oil reservoirs, it is necessary to determine the current state of environmental management and the gap between the current situation and the optimal conditions. Therefore, after identifying and prioritizing the risks, pollution potential, and the effect of global warming caused by the fire or explosion of diesel tanks in the Shahid Almasi fuel station, we evaluated the environmental management situation related to emergencies using the McKinsey 7S Model. It is a framework and management model that expresses seven factors to organize a company in a general and effective way [28]. In a study conducted by Carrier, the change and movement of the organization are affected by the interaction between the seven dimensions of structure, strategy, systems, style, employees, skills, and common values (superior goals) and called it the 7S framework. Since their research was done at McKinsey Consulting Company, their framework is also known as McKinsey 7S. The main elements of this system are strategy, common values, staff (manpower), management style, skills, system, and structure [29].

A questionnaire was used in the process of gap analysis in the McKinsey method. The subscales of each of the dimensions were collected from different sources, and

Table 6. Chemical specifications and ERPG and IDLH criteria for gasoline

Chemical agent	Molecular weight	ERPG-1	IDLH	LEL	UEL	Degree of ignition	Freezing point
Gasoline	72 g/mol	200 ppm	5 mg/m³	14000 ppm	74000 ppm	126.7 °C	-40 °C

Note. ERPG: Emergency response planning guidelines; IDLH: Immediately dangerous to life and health; LEL: Lower explosive limit; UEL: Upper explosive limit; Source [26].

Table 7. The greenhouse effect of each greenhouse gas based on CO_2 equivalent

Parameter classification of the effect	Unit	Compounds	Characterization Factor	Reference
Global warming Climate change	Co_2 (kg) – Eq.	N_2O	296	Flessa et al [27]
		Co_2	1	
		CH_4	23	
		CO	1.57	

Note. CO2: Carbon dioxide; N2O: Nitrous oxide; CH4: Methane; CO: Carbon monoxide.

43 items related to the dimensions and criteria were compiled. In this regard, according to Guest et al [30] who considered ten experts as the minimum number of experts to conduct qualitative studies using a questionnaire, 20 environmental experts were used to design and score the items on a five-point Likert scale. The dimensions of the questionnaire and the number of items related to each dimension are presented in Table 8.

The validity of the questionnaire was assessed by the content method, and its reliability was assessed using Cronbach's alpha method. To assess validity, the questions were sent to 20 environmental management experts and examined in terms of simplicity, relevance, and clarity. The weighted average method was used to determine the average level of scores for each item. In this method, to interpret the subject's scores, the score of McKinsey dimensions on a Likert scale and the total score of the questionnaire were compared with the mean score of the scale. If the subject's score was higher than the average, the spectrum scale was positive, and if it was lower than the average, the spectrum scale was negative. The scale average was calculated by equation 6.

$$M = (NK + 1K)/2 \qquad \text{Eq. 6}$$

where M is the mean score of the scale, K is the number of questions, and N is the number of answer levels (5 levels). After calculating the average score of the McKinsey dimensions, the results were compared with the optimal situation in the gap chart. Finally, the priorities of the response plan in emergencies and the gap between the current situation and the desired situation were determined, and solutions were provided to reduce the gap degree.

3. Results

Table 9 presents the results of the analysis of risks leading to the occurrence of fire and explosion accidents in diesel tanks. Nine potential risks of fire and explosion of tanks were identified and evaluated, and seven risks were classified at an unacceptable level.

The results indicated that the occurrence of air attack, decay and corrosion of tank walls, and human errors with a risk priority factor of 200, 168, and 120, respectively, are the most important possible causes of fire as well as explosion of 650 000-L and 2.3 million-liter diesel tanks. Assuming the complete burning of the content of two diesel tanks, the emission coefficient of greenhouse gases will be based on the OAQPS-AP-2 standard as described in Table 9 [27].

Regarding the emission coefficient of the greenhouse gases caused by the fire and explosion of diesel tanks, the highest release level was related to CO_2 (7 811 000 kg), as depicted in Table 10. N2O with 14850, CH4 with 897, and CO_2 with 625 kg were other greenhouse gases released from these tanks. Table 11 illustrates the amount of greenhouse gas emissions caused by fire or explosion of diesel tanks. The total GWP caused by the fire of the 650 000-liter tank was estimated as 1 823 330, the 2.3 million-liter tank was 6 446 063, and all tanks were 12 259 913 kg CO_2 equivalent (Table 10). Furthermore, Figure 2 presents a comparison of the GWP caused by each of the greenhouse gases during fire or explosion of diesel tanks.

3.1. The results of a gap analysis by McKinsey method

Considering the potential of major accidents in the studied fuel station, it seems necessary to use an effective management system and face these emergencies. Identifying current management deficiencies through gap analysis is an important tool to achieve this goal. Therefore, the gap analysis method using the McKinsey 7S method was used. After compiling 43 items in seven investigated dimensions, Cronbach's alpha was employed to assess the validity, and the content method was used to assess the reliability of the questionnaire. Considering that the minimum acceptable level of reliability is 0.7 [28], the reliability of the dimensions of management style, common values, skills, and staff was acceptable, structure was at a good level, and strategy and system were at an excellent level. The content validity ratio (CVR) was also used to assess the validity of the questionnaire. Given that the number of experts was 20, the minimum acceptable CVR value is 042 [29]. The validity of the questionnaire was confirmed according to Table 12. Moreover, to interpret the scores of the questionnaire, the weighted average method was used.

Table 8. The Criteria of Each Dimension of the McKinsey Method and the Number of Items in Each Dimension

McKinsey Dimensions	Criteria	Number of Items
Strategy	Vision, mission, goals, and strategies	4
Structure	Centralization of decision-making, specialization, formalization, and geographical dispersion	6
Systems	Data and information management, the temporal and spatial domain of the system, and technologies	19
Skills	Skills required at all levels	2
Management style	Steering committee, senior management support, project management, resource allocation, incentive and punishment policies, and communication	5
Staff	Training, project team, participation, and experience	4
Shared values	General culture	3

Table 9. Results of risk assessment of accidents leading to fire and explosion in diesel tanks by HAZOP method

Row	Operation parameter keywords	Risk	Risk consequence	Probability of Occurrence	Severity of Event	Probability of Detection	RPN	Acceptance Criteria
1	Construction of foundation (Less Than)	Unfavorable quality of foundation concrete	Land subsidence (under the tanks)	2	6	1	12	Needs to be checked
2	Diesel storage (Less than)	Rotting and corrosion of tank walls	Leakage from diesel tanks	8	7	3	168	Unacceptable
3	exploitation operation (other than)	Collision of objects and machines with tanks	Leakage from oil and diesel transmission lines	2	10	1	10	Unacceptable
4	Diesel storage (Less than)	Weakness in insulation	Evaporation from diesel tanks, fire	4	2	3	24	Needs to be checked
5	exploitation operation (other than)	Sabotage or air raid	Explosion, fire of diesel tanks	2	10	10	200	Unacceptable
6	exploitation operation (other than)	Occurrence of lightning	Explosion, fire of diesel tanks	2	10	4	80	Unacceptable
7	Facility repairs (As well as)	Welding in the tank area	Explosion, fire of diesel tanks	2	10	1	20	Unacceptable
8	Diesel storage (Reverse)	Clogged pipelines, failure of pumps	Overflowing of diesel tanks, fire	2	10	3	60	Unacceptable
9	exploitation operation (as well as)	Human errors (Complete closing of the tank drain valve)	Gasoline emission in the environment and fire	4	10	3	120	Unacceptable

Note. HAZOP: Hazard analysis and operation management; RPN: Risk priority number.

Table 10. The emission factor of greenhouse gases caused by the fire of diesel tanks based on the OAQPS-AP-2 standard

	N_2O (kg)	CO_2 (kg)	CO (kg)	CH_4 (kg)
650 000-L diesel tank	335	1 721 000	105	92
2.3 million-liter diesel tank	1150	6 090 000	520	495
Total	1485	7 811 000	625	897

Note. OAQPS: Office of air quality planning and standards; N2O: Nitrous oxide; CO2: Carbon dioxide; CO: Carbon monoxide; CH4: Methane.

Table 11. Calculation of GWP caused by fire or explosion of diesel tanks

	Greenhouse gas	Greenhouse gas emissions	Equivalent kg Co_2/kg	** Weighting Indices	Ultimate capacity of GWP
650 000-L diesel tank	Co_2	1 721 000	1	0.2	1 721 000
	N_2O	335	298	59.6	99830
	CO	105	1.9	0.38	199.5
	CH_4	92	25	5	2300
2.3 million-liter diesel tank	Co_2	6 090 000	1	0.2	6 090 000
	N_2O	1150	298	59.6	3 427 000
	CO	520	1.9	0.38	988
	CH_4	495	25	5	12375
Total	Co_2	7 811 000	1	0.2	7 811 000
	N_2O	1485	298	59.6	4 425 300
	CO	625	1.9	0.38	1187.5
	CH_4	897	25	5	22425
	Total GWP		--	-	12 259 913

*Note***.** GWP: Global warming potential; CO2: Carbon dioxide; N2O: Nitrous oxide; CO: Carbon monoxide; CH4: Methane.

The results of a gap analysis by the McKinsey method in Figure 3 demonstrate that the average scores of the seven investigated dimensions were 3.18, which is a significant distance from the optimal limit (four). These results show the unacceptable conditions of safety and environmental management for emergencies in the Koreyt Camp diesel tanks. The lowest average score was related to the strategy dimension (2.67). Likewise, the shared values dimension was at a low level of efficiency with an average score of 2.69. The highest efficiency was obtained in the system dimension (3.92). These results suggest that the dimensions of strategy, organizational culture, and staff skills were at a relatively unfavorable level and required the implementation of environmental management programs to reduce the potential of emergencies in the area. The results of a gap analysis by the McKinsey

Table 12. Cronbach's alpha results related to the components of the McKinsey questionnaire dimensions

Variables	Number of items	Cronbach's alpha	CVR
Structure	9	0.84	0.45
Common values	4	0.72	0.52
Systems	12	0.91	0.56
Skills	5	0.7	0.49
Management style	4	0.71	0.73
Staff	6	0.76	0.57
Strategy	3	0.95	0.46

Note. CVR: Content validity ratio.

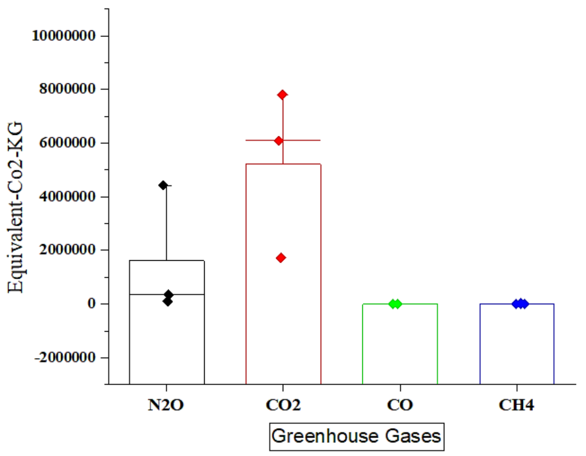

Figure 2. Comparison of the GWP Caused by the Greenhouse Gases during Fire or Explosion of Diesel Tanks. *Note.* GWP: Global warming potential

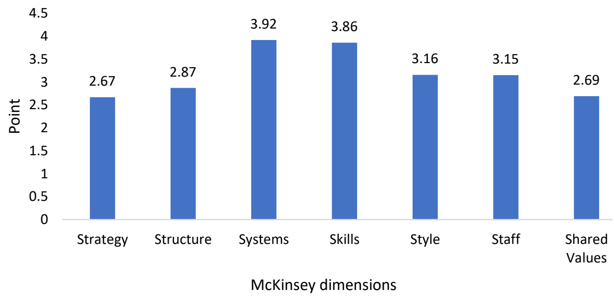

Figure 3. The average scores of the items in each of the McKinsey dimensions

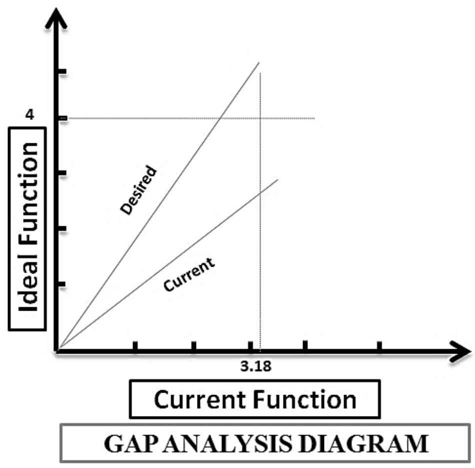

Figure 4. The Results of a Gap Analysis by the McKinsey Method (Difference between the Existing Situation and the Desired Situation)

method are presented in Figure 4.

4. Discussion

Controlling and reducing the effects of pollution caused by oil industries to protect the environment are the most important issues and concerns of all countries, especially oil-rich countries. Between 2016 and 2021, energy consumption has increased by 3.2% in the world, in which the oil industry plays the main role [31]. The major environmental problems of these industries, especially regarding non-compliance with environmental regulations and standards, bring dangerous consequences and disrupt the biological nature of human societies and wildlife. Major accidents such as explosions or fires of oil tanks are among the events with considerable effects on the natural and human environment. Risk assessment studies are the basis of such studies. This research used the HAZOP method to identify the potential for accidents in strategic reservoirs. The effectiveness of this method in evaluating the potential of accidents in oil tanks and chemical industries has been confirmed in various studies [32,33].

Our results indicated that fire and explosion in fuel tanks, in addition to safety and health consequences, lead to the release of air pollutants and greenhouse gases at a relatively high level. Imamura et al stated that large-scale events have a strong potential to cause global warming [34]. The strategic diesel tanks investigated in this study are among the largest storage tanks for fuel derivatives in the country, and the fire and explosion incidents of these tanks are classified in the large-scale group.

The total GWP for the fire of the diesel tanks in the Koreyt Camp of Ahvaz city was estimated to be 12 259 913 kg of CO_2 equivalent. Beyer et al [35] showed that the GWP in the Deepwater Horizon oil spill (Gulf of Mexico) was more than 5 billion kilograms of CO_2 equivalent, which was caused by the leakage of 4.9 million barrels (about 775 million liters of crude oil) of oil in the sea. Cho et al [36] estimated the GWP of a scenario for the explosion of a nuclear power plant in eastern Japan to be 4.5 billion kilograms of CO_2 equivalent. This severe consequence of the greenhouse effect is due to the use of the synthetic iodine-131 isotope in these power plants, which can cause a sustainable fire during eight days by changing carbon absorption and surface deposition. However, there is no reabsorption and surface diffusion in the fire caused by fossil fuels. The research results revealed that CO_2 with a GWP equal to 7 811 000 is responsible for 63.7% of the GWP caused by the fire of diesel tanks. Annamalai et al [37] showed that, on average, 70% of the GWP is induced by the burning of fossil fuels caused by CO_2. Tong et al [38] asserted that the lowest GWP caused by fossil fuels is related to natural gas, while diesel has the highest level of CO_2 emissions after crude oil. Environmental consequences caused by fire or explosion of oil tanks suggest the necessity of developing an environmental plan. The results of the gap analysis by the McKinsey method in this research showed that the weakness of environmental management in the Koreyt Camp oil complex is related to strategies and common values (environmental culture). Cordes et al [39] reported the strategy factor as the most important foundation of environmental management. Monazami [40] stated that environmental culture plays an important role in predicting environmental damage. Functional priorities in the management plan are derived from the current performance of the environmental management system [41]. Therefore, it is necessary to continuously assess the environmental management situation to determine the gap between the current and the desired situations and to prevent and deal with sudden events affecting the environment.

5. Conclusion

The results of this research showed that an accident with diesel storage tanks in the Koreyt Camp complex in the Ahvaz oil field, in addition to the safety and economic consequences, caused significant environmental effects such as the release of air pollutants and greenhouse gases. It should be noted that the current research is based on the possible scenario of the accident, and although the worst scenario (fire of the entire content of the fuel tanks) is considered in the evaluation of the consequences of greenhouse gas emissions, other uncontrolled factors are possibly effective in increasing the severity of the consequences. Moreover, considering the high number of storage tanks in oil-rich areas, it is necessary to develop environmental management plans to prevent these accidents and be prepared to deal with emergencies. It is thus suggested to conduct an environmental impact assessment study for similar incidents in other reservoirs of oil derivatives and chemicals in Iran.

Authors' Contribution

Conceptualization: Mahnaz Mirza Ebrahim Tehrani.
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Formal analysis: Nader Boveirehi.
Funding acquisition: Mahnaz Mirza Ebrahim Tehrani.
Investigation: Nader Boveirehi.
Methodology: Mahnaz Mirza Ebrahim Tehrani.
Project administration: Seyed Ali Jozi.
Resources: Mahsa Bakhshaei.
Software: Nader Boveirehi.
Supervision: Seyed Ali Jozi.
Validation: Seyed Ali Jozi.
Visualization: Mahnaz Mirza Ebrahim Tehrani.
Writing–original draft: Nader Boveirehi.
Writing–review & editing: Nader Boveirehi.

Competing Interests

The authors declare no conflict of interests.

Ethical Approval

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