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Environmental Risk Assessment of Sugar Industries Using the EFMEA Method and Providing Environmental Management Solutions

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Abstract: *Risk assessment approach is one of the main pillars of deploying and deploying management systems in organizations. Management systems that are integrated today into the health, safety and environmental management system. Organizations are able to meet the requirements that lead to an error prevention approach. Sugar and Sugar Industry are one of the oldest and largest sugar production units in the West Azerbaijan region. These industries are one of the main energy-consuming industries in the food industry and also have potential environmental aspects. The method of this research is a qualitative method aimed at identifying and assessing environmental aspects and environmental risk management and providing effective and practical preventive measures to reduce or eliminate environmental risks in sugar factory activities using the method (Analysis of failures and errors and their effects on the environment). The result of this assessment indicates that out of 29 plant activities, 104 environmental hazards have been identified in this industrial unit, of which 23 / 44% Environmental aspects at a low risk level of 42.31% at a risk level of 13.66% at a high risk level It was accepted that the control measures and corrective 58/60 of environmental aspects at the level of low risk, 54/36% in medium risk and 88/2 percent were at high risk. Finally, based on the comparison of the results of the risk assessment, the presentation of effective strategies.*

Keywords: *Efmea Technique, Risk Assessment, Sugar Industry, Environment.*

INTRODUCTION

Risk assessment an organized and systematic approach to hazard identification and risk estimation is acceptable for ranking risk decisions to an acceptable level. Investigating the factors and identifying emerging and hazardous points in the organization for the sugar industry of the country since 1274, with the construction of a factory in Tehran, has already started, and has now reached 117 years of existence in Iran. Currently, the number of factories Sugar is 46 countries. The process of sugar production is very complex, energy-intensive and has a coherent thermal network that has potential environmental aspects and, in the absence of knowledge and control, causes environmental hazards. Therefore, it was attempted to understand the environmental strategies of the plant in The field of identification of processes affecting the environment and the full respect of environmental issues should be taken towards raising the level of awareness and stakeholder awareness of the core processes of the organization, especially key environmental processes. (Barro, 2001)

Environmental risk assessment is a step beyond the risk assessment. In addition to examining and analyzing different aspects of risk, the addition the full recognition of the environment of the affected area, the sensitivity of the environment, as well as the special environmental values of the region are considered. In professional literature and in practice, many FMEA methods can be identified in management areas. FMEA in Quality Management, FMEA in Occupational Safety and Health Management and EFMEA[1] in Environmental Management. EFMEA is a method that integrates environmental measures to improve or improve production and management. EFMEA's goal is to identify in a timely manner the most important environmental aspects affecting the status of product development based on the ability to identify and evaluate the elements and processes of that product or service. (Jozi et al., 2012)

Environmental risk assessment, the process of qualitative analysis of potential risks and the coefficient of actualization of the potential risks in the project, as well as the sensitivity or vulnerability of the perimeter environment. (Alamtabriz and Hamzehi, 2012)

Risk Management is a systematic process of identifying, analyzing, and responding to project risk that seeks to maximize the likelihood and outcome of adverse events and minimize the probable consequences of adverse events and negatively impact on project goals. EFMEA's goals in environmental management include: environmental risk assessment and compilation

Solutions to its effects, identification of critical components and potential of weaknesses, early detection of potential hazards and environmental impacts, avoiding major environmental problems, improving systems, products, and processes in the environmental aspect. This technique has the ability to Eco-friendly design in the product range, technology, machinery and equipment in manufacturing processes. Of course, it should be noted that in general risks cannot be completely eliminated, but can be reduced to acceptable or tolerable levels. Therefore, the purpose of risk management is to create a systematic and continuous framework for identifying, assessing, eliminating, controlling, preventing, reducing and communicating risks. Therefore, in the process of risk management, decisions are made based on the comparison of the results of the risk assessment and the specified risk levels.

Below are some of the most important research backgrounds in the **study area.**

In a 2009 Jennings, study by the United States Environmental Protection Agency at the Radford Army Ammunition Facility, concluded that EFMEA's methodology was based on the preparation for systematic identification, follow-up, and communication of risks The environment has been developed at the level of activities. (Jennings, 2009)

Chegoni et al. (2014) concluded in a study entitled "Environmental Risk Assessment of Sugarcane Industries" using the FMEA methodology and environmental management guidelines that the risks and consequences of natural disasters, the presence of lead in sewage from the austerity test, the likelihood of fire The burning of office and chemicals, steam turbine, turbine, and dry powder depot, produced waste from the experiments at a high-risk level. Based on the comparison of risk levels, 10% of the risks were at high risk, 15% at medium risk and 75% at poor risk levels, and finally, based on comparing the results of risk assessment, providing effective solutions to each process and Control measures are tailored to its type and types of pollution in reducing environmental risks.(Chegoni et al., 2014)

In 2013, in a study entitled Environmental Risk Assessment by SAW and EFMEA, Makvandi et al. Concluded that the risks to the pollution of wetlands from industrial and petrochemical waste have been prioritized. After determining the risk priority number by SAW, the risk levels determine which management priorities to control the risks. (Makvandi et al., 2013)

[1] Environmental failure mode and effects analysis

Ghaderi et al., In a2016, survey conducted by the EFMEA methodology in Tehran and Suburbs Metro Risk Assessment and Management, concluded that among the 46 environmental risks identified at Sadeghieh terminal, 8.7% of the aspects Environmental is at a low level, 78.3% is at medium risk level and 13% is at a high-risk level. (Ghaderi et al., 2015)

In 2010, Mirjalili concluded that the Zagros Petrochemical Company identified and evaluated the environmental risk using the EFMEA method and concluded that among the investigated risks, 11 cases with a low priority, 55 were medium risk and 16 were risk High priority was set. The highest risk associated with cleaning the pumps with a risk priority number of 189 and the lowest risk priority number related to the fluctuation of the return flow with the priority number of risk 6. (Mirjalili et al, 2011)

Bandarja, in the year 2014, during a study entitled Environmental Risk Assessment by Analyzing Failure Modes and its Effects on the EFMEA Environment in a Hydrochloride Unit, the Bandar Abbas Oil Refining Company concluded that 10% of the priority number of risks was higher than the degree of obscurity Priority has been given to defining corrective and control measures. (Bandarja and Jozi, 2014)

Research Methodology

EFMEA's method for assessing environmental risk has been used in this study. Failure mode and environmental impact analysis is a systematic tool based on team work that is used to define, identify, evaluate, prevent, eliminate or control the states, causes, and effects of potential errors in a system, process, scheme. In other words, EFMEA is an analytical method for environmental risk assessment and is a part of the FMEA subcategory. This method identifies and ascertains as far as possible the potential risks in the area in which the risk assessment is carried out, as well as the causes and effects associated with it. This tool is one of the most effective models for error prediction. EFMEA's goal is to identify in a timely manner the most important environmental aspects affecting the environmental situation within the range affected by ongoing activities and processes. In order to apply the EFMEA method, each of the identified aspects is divided into two groups: 1. Environmental aspects that cause the release or production of various types of contaminations, waste, waste and sewage in the environment. 2. Environmental aspects that reduce or eliminate natural resources or energy from their use. Accordingly, to calculate the environmental degradation factor of the first group, the product is derived from the product of the probability intensity in the range of contamination, and for the second group the intensity-probability formula is used in the possibility of recycling. (Darvishi et al., 2019)

(Possible recycle) Pollution range * Likelihood of occurrence * Severity = Environmental degradation factor

Table 1: intensity rating of EFMEA)

severity	Define severity	score
Intense / catastrophic	Very harmful or potentially damaging / wasteful or very resource consuming	5
Serious	harmful but not destructive/ Losing or consuming too much resources	4
medium	Fairly harmful. Loss or medium Consumption of Resources	3
Mild	loss or low consumption of resources	2
Minor losses	Losses are negligible/ loss or low consumption of resources	1

Table 2 : EFMEA probability rating

Probability of occurrence	score
Certain event /may occur everyday	5
Ordinary event/ may occur during the week	4

Probable and Moderate Event (May occur during the month	3
Low incidence (may occur during the year)	2
Impossible and unlikely occurrence (may occur every 10 years)	1

Table 3: EFMEA Recycling Capability Ranking

recyclability	score
Waste of resources with easy retrieval and repair	5
Waste of unrecoverable resources and hard repair	4
Waste of unrecoverable resources	3
Renewable resources consumption	2
Unrecoverable resource consumption	1

Table 4: EFMEA Pollution Range Ranting

Pollution range	score
Regional	5
Factory area	4
At the factory level	3
At the unit level	2
At the workstation level	1

(Darvishi et al., 2019)

In Figure 1, the stages of the research are shown:

Understanding Unit and Process

↓

Collecting basic information, identifying environmental aspects

↓

Identification of risk factors

↓

Complete the worksheet by EFMEA

↓

Analyzing the implications of known aspects of EFMEA

↓

Calculate RPN[2] Risk Priority Number

↓

Provide control measures and secondary risk assessment

↓

Provide environmental risk management plans for controlling, reducing, eliminating or transferring risk

↓

[2] **Risk priority number**

Supervision and inspection on implementation by the environmental department and HSE

According to the methods used, a checklist was designed to evaluate the environmental degradation factor. In this checklist, variables such as process identification, environmental aspects, effects of environmental consequences, initial assessment of environmental aspects (severity, occurrence probability, extent of contamination with the possibility of recycling, RPN, risk level), control action and secondary assessment of environmental aspects (severity, occurrence probability, extent of contamination with the possibility of recycling, RPN, risk level) was studied as an environmental aspect.

Calculate RPN Risk Priority Number:

The RPN value was calculated from the product of the three factors of severity in the probability of occurrence in the range of contamination or the possibility of recycling. In the end, the risk rank or index number of risk preference index was calculated using the frequency distribution method and the final calculations. Using SPSS software, the number of classes was first calculated from the following formula and the length of the category of the difference is the smallest value and the highest number of risk priority numbers was obtained on the number of classes.

$$LOG_N \quad 1+3/3= \text{ Category number}$$

Further, the limits of the class were calculated, and in the end, based on the mid-range of the most commonly used category, the degree of risk was calculated. Then, based on the degree of risk, ranking was made and the environmental risk level of each activity was determined. In the following, aspects whose risk priority number was higher than the degree of risk aversion was considered as critical activity requiring corrective action. Data were analyzed and analyzed using EXCEL software and the results were analyzed.
(Vazdani et al., 2017)

Table 5: Determine the degree and level of environmental risk to prioritize corrective and control measures

row	RPN range	Risk level	Show the level of risk
1	0-24	Acceptable level (weak)	L
2	25-48	Tolerable level (medium)	M
3	49-80	Unacceptable level (high)	H

Findings:

The most important environmental risks identified at a sugar factory are presented in Table 6.

Table 6: Environmental risk assessment using the EFMEA technique

activity	environmental aspects	Environmental consequences	initial assessment of the environmental aspects					Corrective and controlling actions	Secondary assessment of environmental aspects				
4. Output of raw syrup from the bottom of the diffusion (extraction)	1. Syrup leakage	Waste of resources- soil pollution	5	5	1	25	M	1. Continuous inspection of equipment and periodic maintenance 2. Replacing leaking taps 3. Keeping tools	3	5	1	15	L

								clean and sugar beet storage to avoid syrup fermentation.					
	2. Loss of sugar	Ground level pollution-soil pollution	3	4	1	12	L	1.Gathering waste in a sequential manner 2.Make a technical examination of the device	2	4	1	8	L
	3. Formalin leakage when injected	Soil and water pollution	4	4	1	16	L	1.Continuous and on time inspection of equipment and periodic maintenance 2.Replacing leaking taps 3.Proper ventilation for controlling and leaking gas	3	4	1	12	L
	4. The smell of incomplete burning of raw materials in the fermented extract	Air pollution-creation of unpleasant odor in the environment	4	5	3	60	H	1.Use of ceiling fans for general factory air conditioning 2.Supervision and inspection of equipment performance 3.Use silicone separators 4.Use of bag filters	3	5	3	45	M
	5. Falling and leaking of oil and grease	Water, air, and soil pollution	2	4	1	8	L	1.Replacing worn parts, or Changing the type of parts 2.Replacing leaking taps	1	4	1	4	L
	6. Loud noise	Noise	4	5	3	60	H	1.Install the muffler system in the input system 2.Use the protective device during the operation 3.Use of acoustic cabins	3	5	3	45	M

								4.Use of vibrators to reduce vibration of machinery 5.Install the protective cover plate for voice control					
7.Saturation and adding sulfur gas to raw syrup	1.Carbon gas leakage from fittings and tanks in the drainage tank	Air pollution	4	5	2	40	M	1.Use of electrostatic precipitators 2.Continuous control of temperature and fuel 3.Supervision and inspection of equipment performance 4.Supervision of mechanical engineer for leakage control 5.Ventilation for controlling and leaking gas	3	5	2	30	M
	2.Limestone from lime production process	Ground level pollution-soil pollution	3	4	1	12	L	Collection of waste and lime in a succession	2	4	1	8	L
	3.Leakage of toxic substances	Water, air, and soil pollution	5	4	1	20	L	1.Continuous leakage control 2.Perform environmental monitoring 3.Ventilation for controlling and leaking gas	3	4	1	12	L
	4.Create unpleasant odor in the workplace	Air pollution	4	5	3	60	H	Creating ceiling fans for the workplace	3	5	3	45	M
9.Syrup treatment (cartridge filters, pressure filters, membrane filters, sulfitation and syrup bleaching	1.Probability of leakage of syrup in case reservoirs decay	Air and soil pollution	5	5	2	50	H	1.Leak detection by leak detection device 2.Supervision and inspection of equipment performance	3	5	2	30	M
	2.?	Water pollution	4	4	2	32	M	1.Use of electrostatic purifiers	3	4	2	24	L

							2.Injection of.SO_2 gas for bleaching and alkaline removal					
	3.Production of chloride-containing vapors	Thermal pollution	4	5	2	40	M	Use of ceiling fans for factory air conditioning and reduction of the concentration of produced vapors	3	5	2	30	M
	4.The possibility of a fire	Air pollution	4	3	4	48	M	Exhaust emissions from combustion	3	3	4	36	M
	5.Carbon dioxide emissions	Air pollution	4	3	4	48	M	1.Operator use of special filtered mask 2.Use of ceiling fans for air conditioning	3	5	2	30	M
	6.Oil spill from machinery	Ground level pollution-soil pollution	2	4	1	8	L	1.Identification of leaks by leak detection device 2.use of right pieces 3.Timely and preventive maintenance 4. Proper ventilation for controlling and leaking gas	1	4	1	4	L
10.Evaporation or concentrated syrup	1.ammonia gas leakage due to condensation	Air pollution-Ground level pollution-Chemical pollution	4	5	2	40	M	1.Identification of leaks by leak detection device 2.Replacement of leaking taps 3.Technical examination of devices 4.Evaporate and transfer the mixture to saturation and super saturation 5.Proper ventilation for controlling and leaking gas 6.The use of wet cleaners to	3	5	2	30	M

								remove unpleasant smells from substances that absorb water Such as absorbed ammonia in the process of drying beetroot					
	2.Exit of vapors from the body of evaporators	Air pollution	4	5	2	40	M	1.Continuous control of temperature and fuel 2.Technical examination of devices 3.Use of air conditioning	3	5	2	30	M
	3.Exhaust syrup impurities from mechanical filters	Ground level pollution-water pollution	4	5	2	40	M	1.Electrostatic precipitators 2.Inspection of equipment performance 3.Collection of syrup in special pots and pumping it to the production line	3	5	2	30	M
	4.Formation of sediments	Water pollution-ground water pollution	3	4	1	12	L	1.Removal of sediments by sedimentation methods and introduction of antiscalant substances 2.The use of substances that absorb water Such as absorbed ammonia in the process of drying beetroot	2	4	1	8	L
16.Industrial wastewater treatment	1.Sludge residue and treated wastewater	Water and soil pollution	4	4	2	32	M	1.Packing sludge and transferring them to landfills approved by the Environmental	3	4	2	24	L

								Protection Agency 2.Use of biological controlling methods 3.Use of reverse osmosis					
	2.Creation of an unpleasant smell in the environment	Water and wastewater pollution	4	5	3	60	H	Use of ceiling fans in the workplace	3	5	3	45	M
	3.Production and disposal of sewage	Chemical pollution-water pollution-underground water pollution	4	4	2	32	M	1.Collection and transfer of sewage to urban sewage collection system 2.Establishment of a central laboratory, calibration and environmental monitoring unit 3.Setting up a standard environmental management system	3	4	2	24	L
22.Furnace and steam turbine	1.Steam production of furnaces and turbines	Air pollution-Energy consumption	3	4	3	36	M	1.Prevent steam generation from turbines 2.Use the Niessner device to remove steam from water 3.Inspection of equipment performance 4.Control of the exhaust emissions from combustion of organic materials in the boiler 5.Use of Pinch Technology to reduce the percentage of steam used to optimize energy consumption	2	3	3	18	L

								6.Saving energy by installing heat recovery equipment					
	2.Loud noises	Noise pollution	5	5	3	75	H	1.Perform technical examinations 2. The use of sound absorbent 3.Enclosing noisy machines	4	5	3	60	H
	3.Heat rise	Air pollution-Energy loss	5	5	3	75	H	1.Use proper cooling system 2.Use of ceiling fans for workplace air conditioning 3.The use of Pinch technology	4	5	3	60	H
	4.The leakage of oil and grease from pumps	Soil and ground level pollution	2	4	1	8	L	1.Calibration and technical examination of devices	1	4	1	4	L

Table 7: Comparison of environmental risk levels before controlling and corrective actions

Row	RPN Range	Risk level	Show the level of risk
1	46) 23/44(%	weak	L
2	44)31/42(%	Medium	M
3	14)46/13(%	high	H

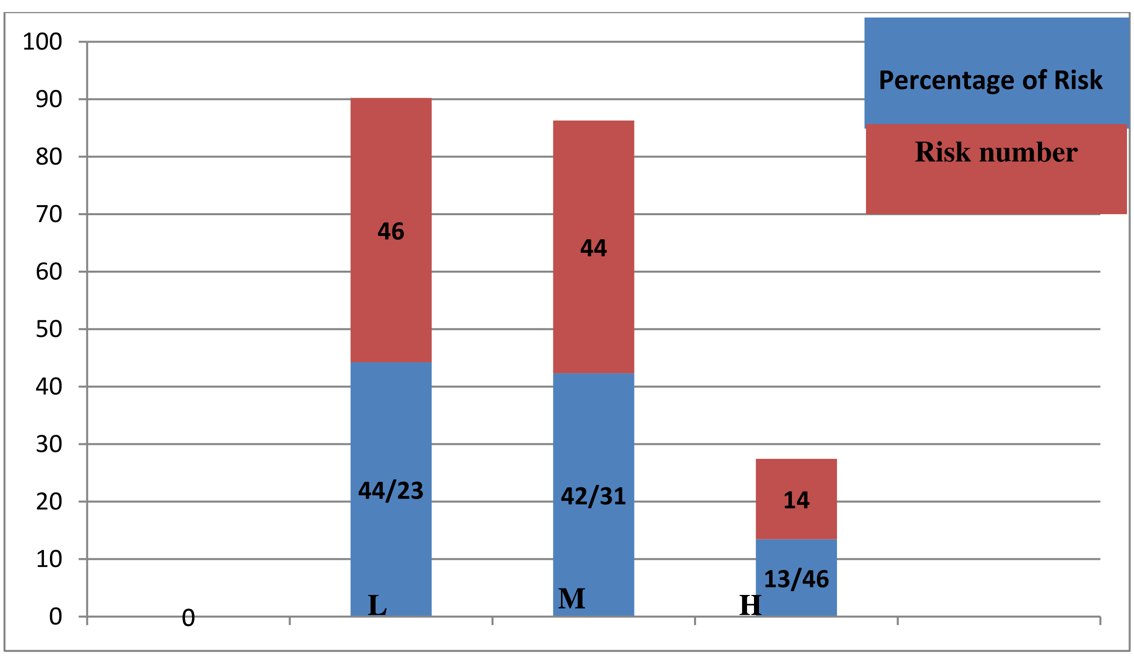

Figure 1: environmental risk levels before controlling s and corrective actions

Table 8: Comparison of environmental risk levels after controlling and corrective actions

Row	RPN Range	Risk level	Show the level of risk
1	63)58/60(%	weak	L
2	38)54/36(%	Medium	M
3	3)88/2(%	high	H

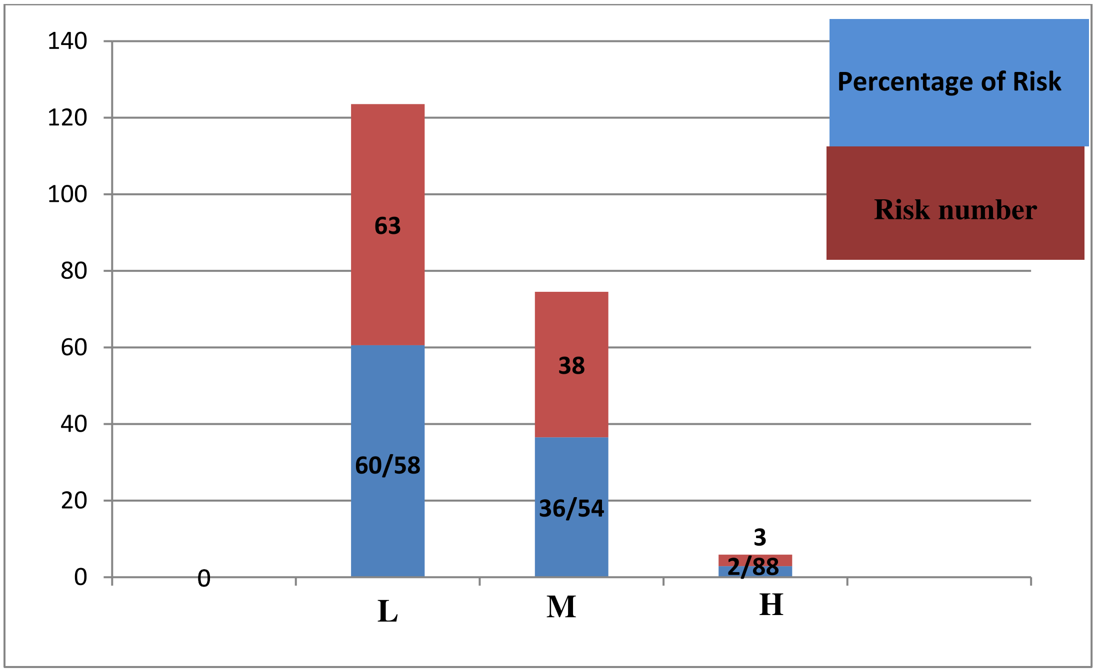

Figure 2: Environmental risk levels after controlling and corrective actions

Discussion and Conclusion

According to EFMEA's Environmental Risk Assessment Results, 104 environmental risks were identified which after 60.58% of risk control with a low priority of 36.44% of the risk with a moderate priority and 2.88% of high-priority risk were also examined. In other words, after applying the control measures, 63 types of aspects at low risk level, 38 medium-risk and high-priority risk categories. In the chart above, the percentage of environmental risk is shown.

Risk management Although initially, it seems costly and time-consuming, but in the long run, reducing potential crash events reduces the cost of corrective action. Establishing a monitoring and environmental measure and controlling environmental issues will create this capability in the sugar factory, which always identifies and evaluates its environmental consequences and, through corrective action or the implementation of environmental plans, the ratio To reduce or control them. The environmental emergency refers to the condition that, if it occurs and is not controlled, there is a risk of severe environmental pollution through the sudden and extensive release of one or more pollutants. In this situation, we can use suggested solutions. Finally, it should be noted that even with all environmental regulations, part of the risks may remain at some risk, which should be accepted. Acceptable or unacceptable risk is a management department that varies depending on each organization.

The results of studying the environmental risk aspects of activities showed that the highest risk priority number related to thermal pollution and noise pollution in the furnace and steam turbine and the creation of exhaust smoke from the carriers of beet carriers, each of which control measures to reduce the risk and The necessary correction was made according to the type of activity and the proposed process. Control and corrective actions such as scheduling and timely implementation of maintenance and repair, monitoring of sound level, monitoring of air and pollution levels, periodic inspection of management systems, implementation of periodic monitoring programs, technical examination of vehicles and fixing of technical defects, Regular water spraying of the enclosure and vehicle traffic routes, the use of proper cooling system, the use of ceiling fans for public air conditioning, inspection of inspection of the correct operation of the equipment, the use of acoustic cabins, the use of pinch technology to reduce the percentage of steam Consumables, use of shakes to reduce machine vibrations, replace parts Worn, continuous temperature and fuel control, the use of the Niessner device for steam separation from water and energy saving through the installation of thermal recovery equipment provided. The study showed that the EFMEA method can identify the affected environment and adopt preventive and control measures or implement environmental plans to reduce or control them.

Proposals such as: 1. Re-implementation of the EFMEA technique after the reforms to assess the impact of reforms; - Applying techniques related to environmental assessment; 3. Applying another valid method in this regard; and comparing the number and type Identified errors and suggested solutions.

Reference

1. Alamtabriz, A., & Hamzehi, E. (2012). Project risk evaluation and analysis using risk management based on pmbok standard and rfmea technique.
2. Bandarja, M., & Jozi, S. A. (2014). Health, Safety, and Environmental Risk Assessment for Hydrocracker Unit of Bandar Abbas in Refinement of Oil Company by EFMEA Method.
3. Barro, H.J., (2001). Principles and methods of environmental management. M. Andarody, Trans. Tehran, Iran: Congress Publication.
4. Chegoni, M. & et al., (2014), Assessment of Bio Environment risk in Naghsh Jahan Sugar Co.by using, FMEA, Mode and showing environment managing procedure.
5. Darvishi, S., Jozi, S. A., Malmasi, S., & Rezaian, S. (2019). Environmental risk assessment of dams at constructional phase using VIKOR and EFMEA methods (Case study: Balarood Dam, Iran). *Human and Ecological Risk Assessment: An International Journal*, 1-21.
6. Ghaderi, S., Rahimi, A., Hedayatifar, M. & Arab, N.S.M., (2015). Eenvironmental Risk Management And Assessment Of Tehran Urban & Suburban Metro By Using EFMEA Method.
7. Jennings, B. (2009). Radford Army Ammunition Plant's Environmental Failure Mode and Effects Analysis (EFMEA) process has been developed to provide for the systematic identification, tracking and communication of environmental risks at the "task level.
8. Jozi, S. A., Saffarian, S., & Shafiee, M. (2012). Environmental Risk Assessment of a Gas Power Plant Exploitation Unit Using Integrated TOP-EFMEA Method. *Polish Journal of Environmental Studies*, *21*(1).
9. Makvandi, R., Astani, S., & Cheraghi, M. (2013). Environmental risk assessment of wetlands using SAW and EFMEA (Case study: international wetland Anzali). *Journal of Wetland Ecobiology*, *5*(3), 61-72.
10. Mirjalili, N., Jozi, S. A., & Faraji, S. H. (2011). Environmental management and risk assessment and restart distillation unit Zagros Petrochemical Co techniques using EFMEA. In *The Fifth Conference of Environmental Engineering. Tehran: Tehran University* (pp. 1-23).
11. Vazdani, S., Sabzghabaei, G., Dashti, S., Cheraghi, M., Alizadeh, R., & Hemmati, A. (2017). FMEA techniques used in environmental risk assessment. *Environment & Ecosystem Science (EES)*, *1*(2), 16-18.