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RESEARCH PAPER

Environmental risk assessment of Saman cement factory in Kermanshah city of Iran by AHP and TOPSIS methods

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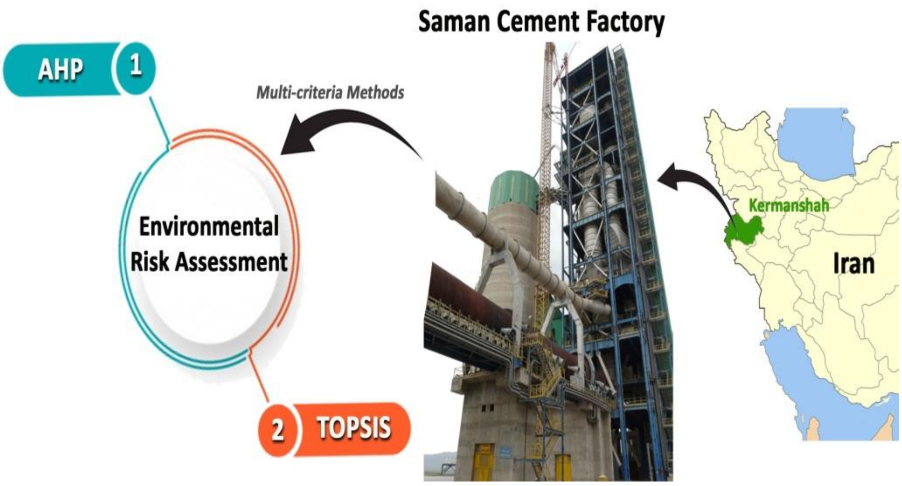
Highlights

- The activity of Saman cement factory in Kermanshah causes dangers and pollution to environmental and biological factors.
- The criteria were weighted and prioritized using the AHP and TOPSIS methods.
- High and low risky type of activities of Saman cement factory was identified.
- Needed strategies and recommendations have been suggested to eliminate or reduce risk factors for human health and the environment.

Graphical Abstract



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Abstract

The main objective of this study was to investigate the environmental risks of the Saman cement factory in Kermanshah city (Iran) using multi-criteria methods. This was a field and applied research that has been carried out with field visits to identify, categorize, and evaluate of the most important environmental risks of Saman cement factory by AHP and TOPSIS multi-criteria methods (2016). Firstly, the field of the factory visited and then produced four sets of questionnaires and distributed among the environmental experts in the factory and the environmental organization of Kermanshah province. After collecting the required information, data analysed through the relevant software. The results showed that physicochemical, biological, and socio-economic risks were the most significant and had priority. Finally the efficient strategies and suggestions have been presented to eliminate or reduce risk factors for human health and the surrounding environment.

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1. Introduction

Nowadays, with the growth of the population, the need for some goods is more felt. In the meantime, cement is of particular importance as a commodity used in all infrastructures and construction sectors and causes environmental pollution, and it requires the work that results from its activity (Therivel, 1993; Chaghakaboodi et al., 2021). To provide sufficient information to enable us, with proper and informed management, to take certain control measures when necessary. Although these factories are being built to improve people's lives for development, as well as increased employment and production, their environmental consequences should not be ignored. In general, risks cannot be completely eliminated but can be reduced to acceptable or tolerable levels (Jamali et al., 2017). 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 (Mensi et al., 2015; Bakhshi et al., 2021).

A study entitled "Using coal waste to reduce pollution instead of cement" showed that appropriate measures should be taken to minimize the release of pollutants into the environment and reduce the environmental effects of coal washing in a coal-fired plant. On the other hand, due to the fact that cement is one of the main materials of concrete, but the production of this material is costly and with a lot of pollutants, and on the other hand, waste from coal washing in coal plants is mostly without The use is stored around coal production centers. In this research, it has been tried to investigate the properties of concrete by replacing cement with coal waste tailings from coal washing tailings in Central Alborz Coal Company. In a study entitled "Assessing the effect of training on risk assessment by quantified occupational safety analysis method in one of the units of the cement company" showed that the JSA method is a complete method to identify and of course assess the need for training and provide control solutions. While training and developing specialized occupational safety guidelines for each job can have a significant impact on reducing accidents and increasing safety knowledge about the dangers of that job, given the existence of a variety of safety risks and Unacceptable hygiene in the loading unit of the cement plant It is necessary for safety operators and supervisors to carefully investigate and eliminate safety discrepancies as soon as possible, and according to the proposed corrective measures to reduce the number of accidents and control the risk in the unit.

In a study entitled Prospective Management of the Effects of Pollutants from Sistan Cement Factory Activities on the Ecology of Southeastern Iran, it was shown that cement production in cement plants by creating dust from the process of separation, crushing and grinding Raw materials, production of nitrogen and sulfur gases from the combustion of required fuels such as coal, etc. in various cementing activities, release of heavy elements in the raw materials needed to make cement as well as furnace fuels, and ... and the release of organic matter and toxic metals from the incineration of oil and organic waste in raw materials causing increasing and destructive pollution of air, running and groundwater, soil, loss of vegetation and threat to animal life And the destruction of the human ecosystem, etc (Khwedim et al., 2015). In the surrounding areas, this plant, like other cement factories, has many pollutant emissions, although less reported, and has a forward-looking management of cement industry in this factory seeks to identify the destructive effects of various pollutants on the ecosystem in the southeastern region of Iran (Hasanbeigi et al., 2011).

One of the ways to prevent the damaging effects of cement factories can be to evaluate the environmental impact of the unit and the application of the system and environmental management monitoring programs (Saffari et al., 2019). during their research in Saman Cement Factory Concluded that the air pollution protection system in terms of suspended materials has a good performance in all of its outputs, since the results of the analyzed data with the national standards of the Environmental Protection Agency, according to Article 15 of the Constitution, are less indicative of the syntax of avoiding air pollution. But with a higher standard than standard needs of the output should be more controls in the field are done. Therefore, with regard to the destructive and sometimes unpredictable and costly effects of the cement industry, an environmental risk assessment is being carried out to manage hazardous substances (Therivel, 1993). In spite of important economic interests, cement plants create negative environmental impacts due to environmental pollution (Ostad-Ahmad-Ghorabi and Attari, 2013). Therefore, the main objective of this paper is to identify the most important risks of this plant by using Delphi's questionnaire and methodology from environmental experts and their analysis in the mentioned software and presenting the results and suggestions for eliminating, controlling or reducing the most significant risk it is for each environment individually (Zeidali et al., 2021b; Haghshenas and Ghanbari, 2021; Farokhian et al., 2021; Zeidali et al., 2021a).

In industrial production units, including cement production plants, they can have a destructive effect on the environment through the introduction of various pollutants (Hashemi and Alesheikh, 2011). These destructive effects can be exacerbated by the inadequate deployment and non-compliance with the principles of environmental management resulting from inappropriate evaluation. One of the ways to prevent the damaging effects of cement factories is to evaluate the environmental impact of the unit and the application of the system and environmental management monitoring programs. Therefore, this research has been carried out to identify the risk factors arising from the activity of the cement factory in Kermanshah province in Iran, so that after identifying the environmental risk risks, if possible, they are completely eliminated or minimized (Source, author).

Today, in order to achieve sustainable development, attention is paid to the industries that, while preserving the environment, will improve the lives of the people of the community and exploit the principles of resources and will not endanger the future generation (Bermudez et al., 2010). Cement production is necessarily linked to the environment and is a major part of the process of cement production, supply and preparation of raw materials. Our cement is produced from natural materials and materials such as cement-based concrete have long been durable. The production of cement with the production of dust in the environment, which, given the type of production from the point of view of particle diameter, can produce adverse environmental and health effects at different intervals and at different times. Contamination in the cement industry can be investigated from various aspects such as noise pollution, water and wastewater, energy, dust, gases, losses, non-productive waste, etc. But most importantly, pollution is caused by energy consumption (Aref, 2010). This issue, in addition to the strategic view of energy consumption and its constraints, is important in terms of emissions. In fact, today's world is faced with two serious energy and environmental crises, and these two issues have taken on the human mind at the same time.

The main purpose of this study was to investigate the environmental risks of Saman Cement Factory in order to prevent high-risk risks or reduce their effects because they are related to human health that can be divided to below parts:

a) Reduce and reduce potential hazards to prevent potential accidents.

b) Reducing the costs of the occurrence of risks.

c) Identification and evaluation of the most important deficiencies in Saman Cement Factory of West Kermanshah.

d) Achieving acceptable and standard risk level.

2. Materials and Methods

2.1. Project location

The geographical location of Kermanshah city: Kermanshah province with an area of 24,640 km² is the 17th province of the country in terms of its size. 45°20'39"E to 48°1'58"E and latitude 33°37'8"N. From north to Kurdistan province, south of Lorestan province and Ilam, east of Hamedan province and west to Iraq, and more than 330 kilometers of border with Iraq. It has 31 towns, 31 districts, 86 villages and 2793 inhabited villages (Hamidi et al., 2012).

In 2004, Mellad Industrial Group, under the auspices of the Supervisor, Mr. JavadMedael, decided to build a gray cement factory under the title "Saman-West Cement" to meet the growing demand of neighboring countries, especially Iraq, while meeting its domestic needs. The factory has two identical production lines with a production capacity of 3500-ton clinker per day and a total of 7,000 tons of clinker. Saman Cement Factory is located 14 km^2 far from Kermanshah-Islamabad, west of Kermanshah, 8 km^2 from Mahidasht, on the slopes of Mount Zangyan and 3 km^2 from the village of SayyidYa'qub as the nearest village. The plant is located in an area of approximately 100 hectares with a distance of 200 meters from the main mine and can load cement up to 10,000 tons per day in bulk and envelopes (Hamidi et al., 2012).

Fig. 1. Geographic location of Kermanshah province (Source: Kermanshah province).

Fig. 2. Satellite Image of Saman Cement Factory in Kermanshah (Source: Saman Cement Assessment Report).

The site of this research is Saman Cement Factory and its surroundings. In this study, the first research sites and journals were reviewed and available to libraries, dissertations and reports available for information. In the next step, a field survey of the Saman Cement Factory in Kermanshah was carried out. At this stage, we identified the activities and the risks of it and based on the information gathered from the types of activities and processes in the factory, Identification of risk-taking activities and equipment that has been conducted using field survey and talk with HSE department staff and workers as well as factory management.

In the next step, speaking with the staff of the laboratory and monitoring department of the environmental organization of Kermanshah province about the establishment of the license and the pollutants and the positive and negative effects of the plant were removed. Based on the information obtained, we prepared and distributed four series of questionnaires for the procedure. Delphi for entering information into the Expert choice environment in the AHP software environment. After weighing the information in this software, TOPSIS SOLVER software compares and categorizes the most significant and least important risks for each environment, which after analysis and the final analysis attempted to obtain a risk priority number or RPN that would rank the risks of each of the three environments. Considering that so far no field study has been carried out on the environmental risk assessment of the Saman Cement Factory in Kermanshah, and this study is being carried out for the first time, we seek to identify and rank the most important and low The most important environmental risks in the environment and the surroundings of the plant and their harmful effects on the environment is to minimize their negative impacts on the environment, so this research is an innovative aspect of the city (Hosseinian and Nezamoleslami, 2018).

2.2. Hierarchical decision-making method (AHP)

One of the most efficient decision-making techniques of the hierarchical analysis process, first proposed by Thomas Elstuy in 1980. This method of decision making is based on pair comparisons. This method is one of the most widely used multi-criteria decision-making methods (MCDM). This method is used to solve unstructured issues in various fields such as management, politics, economics, social sciences, medicine, engineering, genetics, and geography, and so on the AHP method can do two thing stat are 1)Finding weight (relative importance) Indicators and 2) Ranking Indices.

The AHP approach helps decision-makers set priorities based on their goals, knowledge and experience: so that their feelings and judgments are fully taken into account. To solve decision-making problems using the AHP method, at the outset, we have to draw a hierarchical structure diagram. The AHP method is based on the three principles that are a) The principle of the hierarchical tree b) Principle of elaboration and prioritization and finally c) The principle of logical compatibility of judgments.

2.3. TOPSIS method

The TOPSIS method was proposed by Huang and Yun in 1981. This method is one of the best multi-criteria decision-making methods and has many uses (Karimi et al., 2019). In this method, the m option is evaluated using an indicator. The basis of this technique is based on the notion that a selective choice must be the minimum distance with the ideal solution (A+: best possible) and the maximum distance with the ideal negative solution (A-: the worst possible state). The TOPSIS approach has the following steps:

a) Formation of Decision Matrix
b) Determination of Matrix of Weight of Criteria
c) Scaling Fuzzy Decision Matrix
d) Determining Matrix of Weighted Fuzzy Decision Making
e) Calculating the ideal solution (A+) and anti-ideal solution (A-) Fuzzy
f) Distance calculation of ideal and fuzzy anti-ideal solution
g) Calculate similarity index
h) Ranking options (Awadhossein 2015).

2.4. Finding out the software

The process of hierarchical analysis is one of the most popular multipurpose decision-making techniques, first developed by Thomas L. An Iraqi watch was invented in the 1970s. This method can be used when the decision-making action is faced with several competing options and decision criteria. The proposed criteria can be quantitative and qualitative. The basis of this decision-making method is based on pairwise comparisons. The decision maker begins by providing a decision hierarchy tree. The decision hierarchy tree shows the factors being compared and the competing options being evaluated in the decision. Then a series of pairwise comparisons are performed. These comparisons determine the weight of each factor in terms of competing options. Finally, AHP logic combines matrices from pairwise comparisons to make the optimal decision. The use of AHP in group decision-making will not only preserve the advantages of group decision-making techniques, but also eliminate their disadvantages (such as speed, cost and individuality).

- Physico-chemical environment including:

  Air pollution, water contamination, soil contamination and noise pollution.
- Biological environment including:

  Destroying the flora of the area, breaking the balance of the ecosystem of the region, destroying the animal species living in the area and destroying the wildlife sanctuary.
- Economic-social environment includes:

  The decline in the quality of agricultural land, the loss of the natural and beautiful landscape of the region, the increase in accidents and accidents on the road leading to the factory, is limiting the general health of the people of the region and the fluctuations of the consumer market (Valizadeh and Hakimian, 2019).

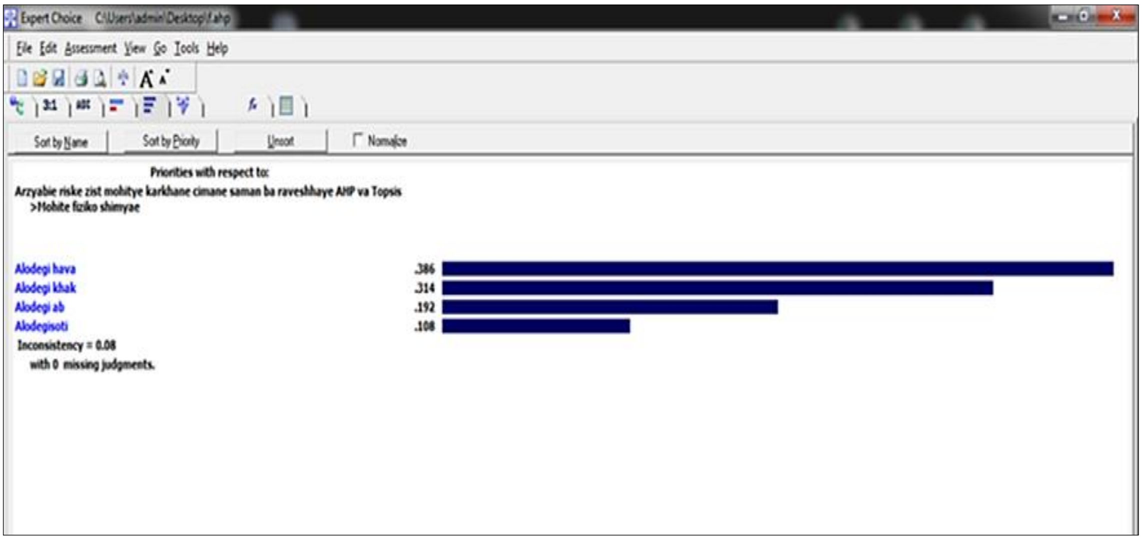

Fig. 3. Comparison of risks in the physicochemical environment using AHP software.

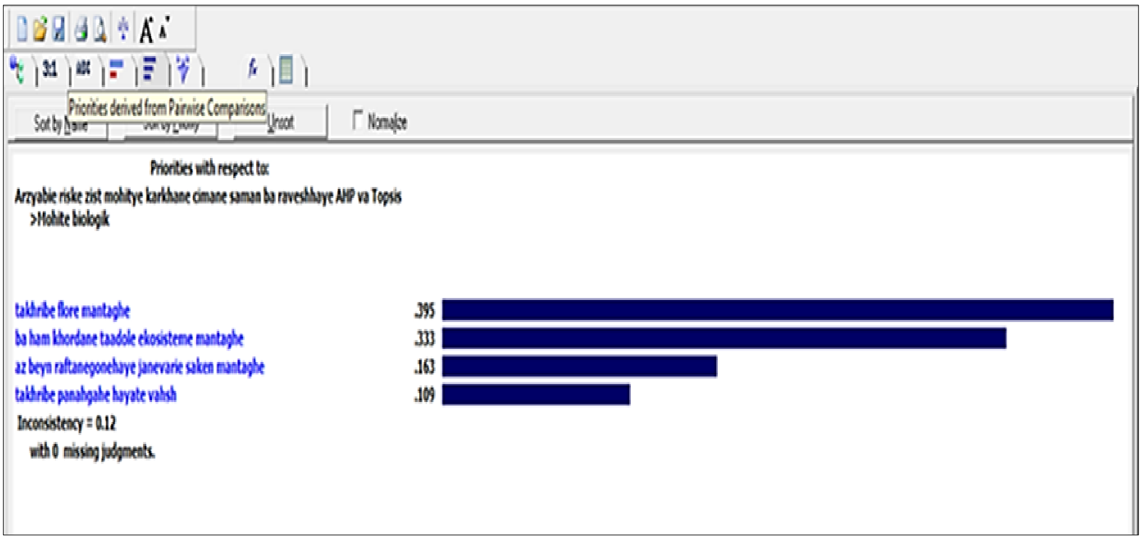

Fig. 4. Comparison of risks in a biologic environment using AHP software.

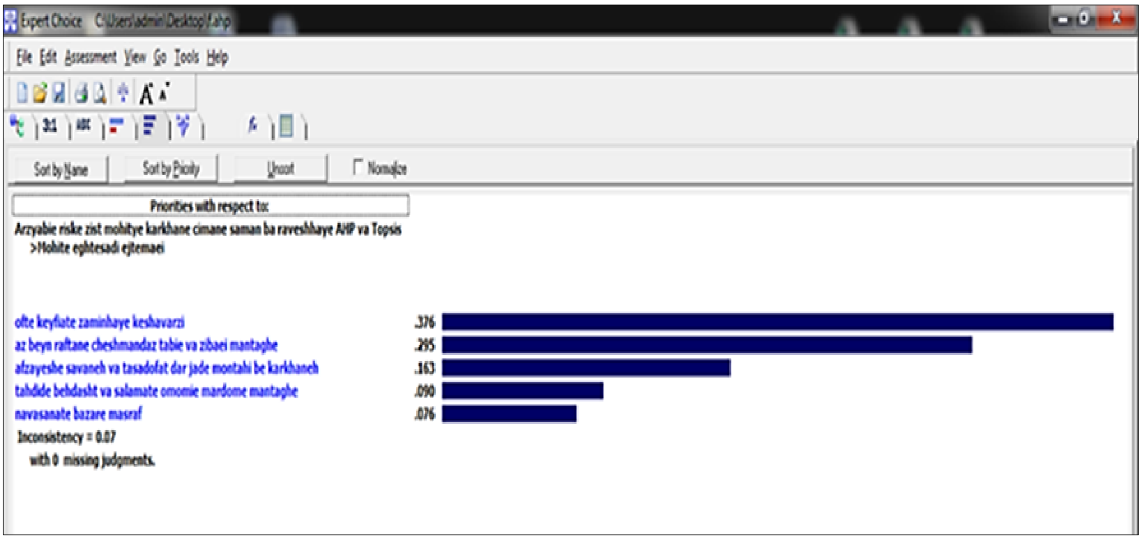

Fig. 5. Comparison of risks in the socio-economic environment using AHP software.

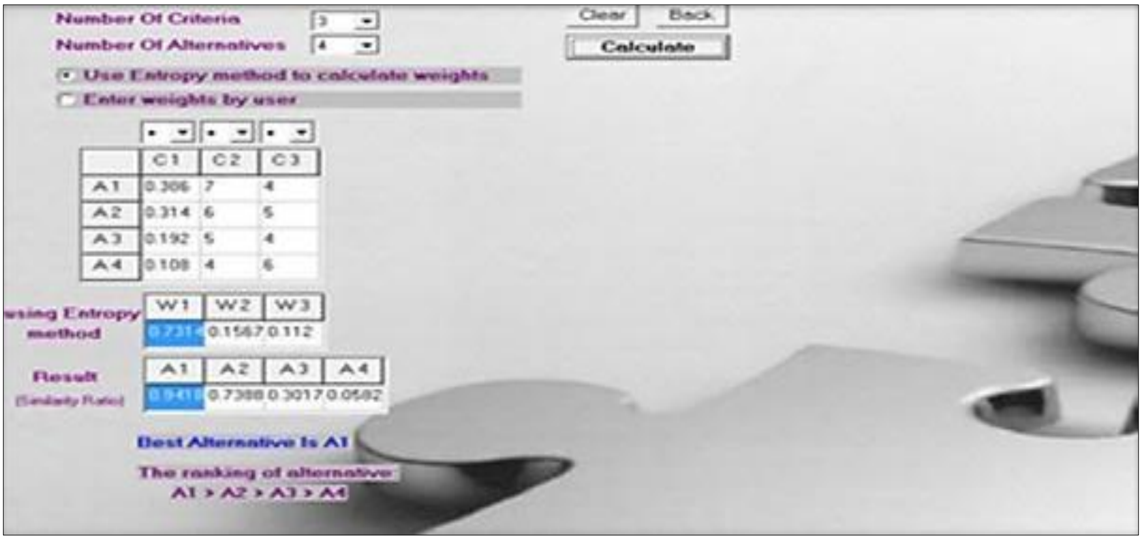

Fig. 6. Results from the TOPSIS solver software in the physical and chemical environment.

Fig. 7. The results of the TOPSIS solver software in a biologic environment.

Fig. 8. Results from TOPSIS solver software in the socio-economic environment.

3. Results and discussion

3.1. Calculating risk priority number (RPN):

In this article, the software used was new and had not been used to evaluate the cement factory in Kermanshah. On the other hand, the simultaneous use of two powerful softwares increases the accuracy of work and ensures results. This research has been obtained with complete accuracy and months of study and field visits. Methodologies designed to identify and eliminate the potential risks of production or process, to assess the risk with identifying and eliminating defects, to further rank the results in important areas and identify and carry out corrective actions to carry out FMECA and FMEA. To be Methodology the RPN priority number is a technique for risk analysis related to potential flaws identified in FMEA, FMECA. The risk priority number in the FMEA is calculated based on the potential causes of the defects (severity * occurrence *) and in the FMECA based on (the defects in question * the uncertainty ratio * the probability of inactivity).

Table 1. Calculate the priority number of risk in the physicochemical environment.

Row	Identified risks	Effect intensity	Chance of discovery	Probability of occurrence	(RPN)
1	air pollution	7	4	0.386	10.80
2	Pouring the soil	6	5	0.314	9.42
3	water pollution	5	4	0.192	3.84
4	Noise	4	6	0.108	2.52

Source: Research findings.

Table 2. Calculate the priority number of risk in the biological environment.

Row	Identified risks	Effect intensity	Chance of discovery	Probability of occurrence	(RPN)
1	Destruction of flora area coverage	7	4	0.333	9.324
2	Collapse the ecosystem balance of the area	6	3	0.395	7.110
3	Destruction of animal species living in the area	6	4	0.163	3.912
4	Destruction of wildlife sanctuary	5	5	0.109	2.725

Source: Research findings.

Table 3. Calculate the priority number of risk in the socio-economic environment.

Row	Identified risks	Effect intensity	Chance of discovery	Probability of occurrence	(RPN)
1	Loss of quality agricultural land	6	4	0.375	9
2	Destroying the natural and beautiful landscape of the area	5	4	0.297	5.94
3	Increased accidents and accidents on the road leading to the factory	6	3	0.163	2.934
4	Determining the general health of people in the region	7	3	0.090	1.90

Source: Research findings.

Table 4. Prioritize identified risks in all three environments based on TOPSIS and RPN techniques.

Row	Identified risks in all three study environments	Risk number priority number
1	air pollution	10.80
2	Pouring the soil	9.420
3	Destruction of flora area coverage	9.324
4	Loss of quality agricultural land	9.00
5	Collapse the ecosystem balance of the area	7.110
6	Destroying the natural and beautiful landscape of the area	5.940
7	Destruction of animal species living in the area	3.912
8	water pollution	3.840
9	Increased accidents and accidents on the road leading to the factory	2.934
10	Destruction of wildlife sanctuary	2.725
11	Noise	2.520
12	Determining the general health of people in the region	1.90
13	Market consumption fluctuations	1.79

Source: Research findings.

This research is applied research in terms of purpose. In the present study, after reviewing and analyzing the questionnaires through AHP and TOPSIS software and obtaining the priority number of risk, the most important risks of each environment are identified and rated that any higher risk-taking risk means more risk-taking And any risk that a smaller number is assigned to it means less risk for the environment and residents of the region.In the AHP software environment, for each separate environment, the types of risks are analyzed and weighted (Figs. 3, 4, and 5), then the TOPSIS software has been compared and finalized (Figs. 6, 7, and 8). The reason for using these two softwares is that the weakness of one is offset by using other strengths, so the results are highly accurate and can be cited. Then, we calculated the risk priority number that is visible in Tables (1, 2, and 3), and according to the results of Table 4, the final prioritization of all the risks in all three contexts and conclude to identify the riskiest. The lowest risk in the factory was paid (Valizadeh and Hakimian, 2019). From the 49 identified risks in the indoor and outdoor environments, 13 risks were finally identified in three physicochemical, biological, and socio-economic environments. The most significant risk identified in the physicochemical environment is the risk of air pollution with a numerical value (10.80). . Soil contamination with a numerical value (9.420) is the second indicator of risk, which reduces soil fertility and decreases soil quality in the region, especially the agricultural lands around the factory, due to sedimentation of pollutants on the surface of vegetation. The third risk of water pollution (3.840) is that the washing of equipment and health care in different sectors is one of the most important causes. Voice Pollution (2.520) is known as the last category of risk in this environment, with essential controls on its control, including the creation of sound-proofing equipment, and the timely provision of equipment and service, in which case any action that causes more control of noise pollution is needed more than ever.

Area degradation with a numerical value (9.232) is the most significant risk of a known biomedical environment, and the regional ecosystem balance (7.11) is the second identified risk in this environment. The construction and operation of the factory (the noise of equipment, the movement of machinery, and the production of various types of pollution) is destroying a large part of the land in the region, and as a result of the disappearance of the habitat of the species of animal in which the region is present. The third risk of this numerical environment (3.912) would be devoted to the loss of species living in the area. In the studied area near the Zangian range, it is far from the wildlife sanctuary, and this is not a particular concern for this, which has led the Wildlife Refuge Demonstration Index to have the lowest risk (2.725).

The results of this research indicate that the loss of quality of agricultural land (9.00%) is the most significant type of risk in this socioeconomic environment. The loss of the natural and beautiful landscape of the region (5.940) due to the proximity of the mine along with the factory and untapped exploitation. The road leading to the plant has a large volume of machinery traffic throughout the day, which increases the risk of accidents, which is the third-largest risk factor (2.934) that causes the natural face the area undergoes a fundamental change, resulting in a reduction in its beauty. The fourth type of public health risk limitation is the population of the region (1.90), consumer market volatility (1.79) is considered as the last risk In this environment, it causes this risk due to various reasons such as the lack of stability in foreign exchange prices and political and social aspects, including economic sanctions and the shortage of production or its increase, in order to further reduce it in cement production to political-social issues He also paid special attention.

The most commonly known risk factor for this plant is air pollution and, given that it cannot be eliminated, control and engineering measures such as installing and designing ventilation systems such as electrophilic, bag filters and bag houses and local ventilation for dust and in The last step is to use a protective mask in the last step. To control soil contamination, solutions such as preventing oil loss on the soil by placing oil cans, concreting under oil reservoirs and places where oil is discharged and loaded, can be applied immediately if the oil is thawed immediately with sawdust and sand. Cover and add oil-impregnated sand to the first product line to enter rotary kilns. In the case of contamination of industrial water treatment plants there is a wastewater treatment plant that is used in the green area, which will solve the problem of sewage and its consequences and also save water consumption**.** . In order to reduce the noise pollution, the installation of silencer should be considered as the head and insulation of the equipment. By increasing the amount of green space inside the plant and tree-planting around it, the degree of risk of degradation of the flora of the area and the collapse of the ecosystem's balance of the area can be counted.

If the mines have more principled exploitation and irrigated areas caused by harvesting of ore with vegetation and vegetation, the beauty and landscape of the area and the surrounding environment can be greatly enhanced. In the case of road accidents and road accidents, it is also possible to install high-speed crash trains by installing tips for driving, loading and transporting cement during less frequent hours, and encouraging drivers to pay more attention to the risks and warnings of driving. If all control measures are successfully implemented and implemented, then it can reduce the damage to the environment of the region and the species of animals in the area, as well as the risk of limiting public health in the region (Brunke and Blesl, 2014). As mentioned earlier, given that the Saman cement factory is far from the wildlife sanctuary and the protected areas, there is no particular concern in this regard to its activity. The decline in the quality of agricultural land can be reduced to some extent by controlling fertility measures, such as fertilizing and replacing fertile soil with old soils. Finally, in the case of volatility in the consumption market, cement production and storage should have the necessary economic forecasts and social policy aspects, since, in the absence of a sales market and surplus of real price production, the producer would suffer economic losses And if there is a shortage of production due to the consumption of cement in all construction and construction sectors, the high demand for this commodity will increase the actual price and, as a result, consumer dissatisfaction will result.

Conclusion

The main purpose of this study was to investigate the environmental risks of Saman cement plant in Kermanshah in western Iran by multi-criteria methods. At first, the criteria were weighted with a questionnaire and the AHP method, and the risks were analyzed and prioritized using the TOPSIS multi-criteria method. Finally, the high risky and low-risk environmental, physicochemical and biological factors were identified and suggestions were made to reduce or eliminate any risk.

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