Prioritization of Effective Strategic Parameters in the Removal of VOCs from the ROP System by Using AHP: A Case Study of Abadan Oil Refinery

Ladan Khajeh Hoseini[1], PhD student; Reza Jalilzadeh Yengejeh[2], PhD; Ali Mahmoudie[3], MSc; Maryam Mohammadi Rouzbehani[1], PhD; Sima Sabz Alipour[1], PhD

[1]Department of Environment, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
[2]Department of Environmental Engineering, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
[3]Abadan Oil Refinery Environmental Officer, Ahvaz, Iran

Correspondence:
Reza Jalilzadeh Yengejeh, PhD;
Department of Environmental Engineering,
Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
Tel: +98 9124794322
Email: jalilzadehreza@yahoo.com
Received: 15 April 2021
Revised: 22 May 2021
Accepted: 27 June 2021

Abstract

Background: The spread of urbanization and industrialization, as well as changes in lifestyle and consumption patterns in recent years, especially in developing countries, has led to the production of huge volumes of pollution in urban and industrial areas. How to plan and manage them is one of the issues and problems in the world today. And if the environment is not taken into account at the same time as the industrialization of a society, not only will economic development not be achieved, but there will be many problems so that sometimes the long-term benefits of an industry are spent on compensation.

Methods: The isa descriptive-analyticalstudy. Various steps were taken, including the results of statistical analysis, Delphi questionnaires, analysis of validity and reliability of the research, and extraction of influential factors affecting the performance of the ROP unit of Abadan Oil Refinery in 2019 until 2020. Finally, the results of weighting and ranking of effective strategic parameters in decision-making, decision-making and policy-making processes of different items including factors (components), criteria, sub-criteria, and strategic plans are presented. Using Expert Choice 2000 software, we weighed the parameters, and Cronbach's alpha was determined to be 0.932.

Results: The results of weighting and ranking of effective strategic parameters in the decision-making process and policymaking of various items are presented.Finally, the component of human environment around the refinery with a weight priority of 0.288 in the first rank, the component of natural environment, the HSE component of the refinery with a weight of 0.244 in the second rank, and the components of technical characteristics and conditions of the refinery with a weight of 0.112 were in the third place.

Conclusion: In this case study, we found thatthe greatest need for management was specific to the human environment, such as land use and development plans around the refinery, and the state of air and soil pollution and water resources.

Please cite this article as: Khajeh Hoseini L, Jalilzadeh Yengejeh R, Mahmoudie A, Mohammadi Rouzbehani M, Sabz Alipour S. Prioritization of Effective Strategic Parameters in the Removal of VOCs from the ROP System by Using AHP: A Case Study of Abadan Oil Refinery. J Health Sci Surveillance Sys. 2021;9(3):199-205.

Keywords: Humans, Economic development, Industrial development, Urbanization, Water resources

Introduction

Developing and advanced countries in their development process have faced the problem of wastewater from oil, gas, petrochemical and energy industries,[1,2] which is one of the problems of their industrial development process, as one of the important sources of environmental pollution.[3] There are currently many efforts around the world to overcome this problem.[4] Given the process of industrial development of countries and the increasing use of oil and energy resources,[5, 6] the existence of wastewater in related industries is an inevitable phenomenon that requires proper management.[7, 8]

Refineries are one of the most widely used water sources in Iran which are often in the center or adjacent to large cities and even some within cities. Abadan Oil Refinery, due to its location in the city centre, causes a lot of pollution and produces unpleasant odors in the region. This affects the health of the refinery staff and the residents. In this research, to strategically manage the ROP system of Abadan Oil Refinery wastewater treatment plant, we usedAHP.[9, 10] The ROP (Recovery Oil Plant) unit is the one used to purify petroleum products at the Abadan Oil Refinery. At the beginning of this unit, there is a uniform pool where the unit effluent first enters. In this pool, the flow rate decreases to a large extent and the flow alleviates, so the oil materials have a higher chance of rising due to being lighter than water.[11-13] They are found on the surface and the suspended solids settle in the structure. After that, the oil that has accumulated on the surface of the water enters the separating ponds with the water. AHP is one of the decision-making methods.[14, 15] The term AHP stands for Analytical Hierarchy process, meaning the analysis of hierarchical process.[16, 17] Selection of the criterion is the first part of AHP analysis.[18, 19] Candidates are then assessed based on the identified criteria. The word options or candidates also means the word alternative or candidates and is used interchangeably. The reason for the hierarchical reading of this method is that we must first start with the goals and strategies of the organization at the top of the pyramid, and by expanding them, we can identify the criteria to reach the bottom of the pyramid. This is one of the most widely used methods for ranking and determining the importance of factors, which is used to prioritize each of the criteria using pairwise[20] comparisons. The goal of the analysis of hierarchical process technique is to select the best option based on different criteria through pairwise comparison. This technique is also used to weigh the criteria. Because increasing the number of elements in each cluster makes it difficult to compare the pairs, they usually divide the decision criteria into sub-criteria.

Methods

Area of Study

Khuzestan province in the southwestern region of Iran between 23 degrees and 58 minutes to 29 degrees and 58 minutes north latitude and 47 degrees and 41 minutes to 50 degrees and 39 minutes east longitude with an area of 64.266 square kilometers is a relatively large area of the geographical border of our country. It is in the plains and has a warm climate due to its proximity to the Great and Burning Desert, such as the Great Sahara Desert and Iraq. The existence of huge oil and gas industries in this region has caused a lot of heat and pollution in this region (Figure 1).

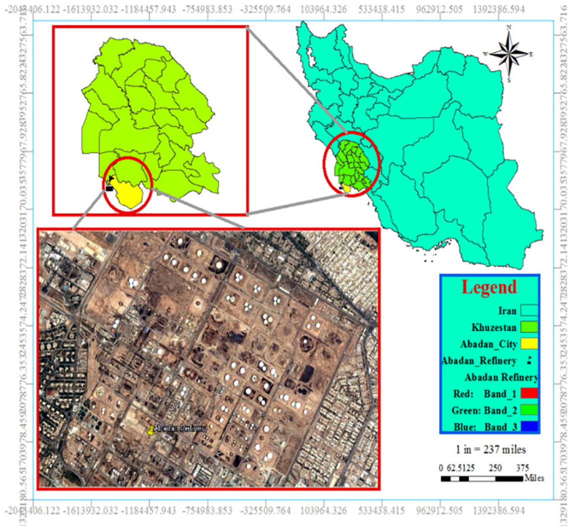

Figure 1: Geographic location of the study area

Techniques Used

At first, we studied the technical, design, spatial and process characteristics of oil refinery treatment systems,[20-22] and also the current situation of the environment, with emphasis on the environmental situation in the operational area of the refinery according to field operations and field observations and analysis of technical documents. Then, to use the opinions of experts, we used the Delphi questionnaire, which, according to Cochran's formula, was modified for limited communities by 40 selected individuals from the target five groups. These groups included university professors, specialists in consulting engineering companies, experts in the executive positions, managers of the oil refinery, and related officials at the national and regional levels.

The statistical analysis of the results was performed based on the pairwise comparisons of 141 identified variables. In order to statistically analyze the completed Delphi questionnaires, we calculated each common statistical parametric indicator,[20, 23] including arithmetic mean, geometric mean, standard deviation, variance, fashion, range of change, minimum and maximum, using software Excel and SPSS, statistical analysis, Delphi questionnaires, validity and reliability analysis of the questionnaire, extraction of external and internal influential factors affecting the performance of ROP unit of Abadan Oil Refinery; finally, we weighted and ranked the results of strategic parameters affecting the decision-making process using Expert Choice 2000 which was conducted and the decision-making and policy-making of various items including factors (components), criteria, sub-criteria and strategic plans were presented.

Based on the conditions and characteristics of the present applied research, among the various and common statistical formulas and methods for determining the Delphi sample size, the modified (corrected) Cochran's formula for limited communities was implemented. The research was done as follows, and accordingly the number of Delphi questionnaires (40 questionnaires) was estimated in the following order:

N: Volume of statistical population

Z: The value of the normal variable of the standard unit, which is equal to 1.96 for the 95% confidence level.

e: Permissible error, the amount of which is calculated using this formula: e=y-μ

d: Degree of standard deviation of Delphi questionnaire questions, using a sample of pilot questionnaires (introductory)

The function is shown in Eq. 1.

$$n = \frac{N\delta^2 Z\frac{\sigma 2}{2}}{e^2(N-1) + \delta^2 Z\frac{\sigma 2}{2}} \quad (1)$$

$$n = \frac{57(2/3)^2(1/96) * 2/6}{0/5^2(57-1) + (2/3)^2 1/96 * 2/6} = 37.7$$

According to the allowable error rate of 3%, the number of questionnaires, equivalent to 40, was estimated in the researcher's agenda.

After completing 40 Delphi questionnaires filled outby selected individuals in the five target groups, the statistical analysis of the results was performed based on pairwise comparisons of 141 identified variables. In order to statistically analyze the completed Delphi questionnaires, we calculated each of the common statistical parametric indices, including arithmetic mean, geometric mean, standard deviation, variance, fashion, range of changes, minimum and maximum, using software Excel and SPSS.

On this basis, after the pre-test stage was implemented and the correction-optimization operation was performed, the Delphi questionnaire was finalized. Based on the studies performed in this regard, it can be acknowledged that the Delphi questionnaires designed in this study, in accordance with the pre-test, had the necessary and expected validity and validity.

Results

Based on the results of the present studies, as well as the desired number for distribution and completion of Delphi questionnaires designed by selected individuals, the characteristics of different types of Delphi target groups were as follows:

• The first target group: university professors (academic specialists), 7 people

• The second target group: 10 professional engineers in environmental consulting engineering companies for water and wastewater, 10 people

• The third target group: 5 experienced experts in related executive bodies

• Fourth target group: 16 experts, managers and those involved in Abadan oil refinery

• Fifth target group: 2 policy-makers and related officials at the national, regional and local levels

After completing 40 Delphi questionnaires used by selected individuals in the five target groups, the statistical analysis of the results, based on pairwise comparisons of 141 identified variables, was performed. In order to statistically analyze the completed Delphi questionnaires, we calculated each of the common statistical parametric indices, including arithmetic mean, geometric mean, standard deviation, variance, fashion, range of changes, minimum and maximum, using software Excel and SPSS.

Table 1 show how to level the components, criteria and strategic sub-criteria were extracted in the present study:

AHP enables decision makers to give relative priority to each factor by comparing the pairs.[9, 20] In order to make decisions, we screenedthe decisions and strategic environmental policy in the project under study and reviewed them; they were alsoreviewed by experts in terms of the structure and expected technical-scientific content. Accordingly, after the pre-test and correction-optimization operations, the Delphi questionnaire was finalized. Based on the studies conducted in this regard, it can be acknowledged that the Delphi questionnaires designed in this study, in accordance with the pre-test, had the necessary and expected validity and validity.[17, 19]

Based on the pairwise comparisons made by the target groups of the Delphi questionnaires designed and completed, the extracted statistical results are presented separately according to the components, criteria and sub-criteria, as well as the desired strategies, in the form of the following detailed forms.

Based on pairwise comparisons performed by the target groups of Delphi questionnaires designed and completed, the extracted statistical results were presented by components, criteria and sub-criteria, as well as the desired strategies in the form of tables, as described below (Figure 2).

Table 1: Strategic components and criteria

Row	Component	Row	Criteria	Sub-criteria
1	Component of the natural environment around the refinery	1-1	Climate of the region	Temperatures
				Rainfall
				Compass
				Relative humidity
				Uncertainties
		1-2	Water resources of the region	Types of water resources
				How to distribute water resources
				Uncertainties
		1-3	Vegetation and surrounding green space	Types of plant species
				Vegetation density
				Herbal formations
				Uncertainties
2	The human environmental component around the refinery	2-1	Land use	Land use pattern
				Land use intensity
				Areas occupied by spaces
				Uncertainties
		2-2	Demographics of the region	Relative population density
				Family size
				Population rate
				Uncertainties
		2-3	Surrounding development plans	How to distribute development plans
				Local development programs
				Uncertainties
		2-4	Surrounding health status	Diseases caused by air pollution
				Diseases caused by water and soil resources
				Uncertainties
		2-5	Environmental pollutants	Air pollutants
				Water pollutants and soil
				Uncertainties
3	HSE in refinery	3-1	Environmental status of the refinery	Environmental indicators
				Environmental hazards
				Uncertainties
		3-2	Health status in the refinery	Health Indicators
				Health hazards
				Uncertainties
		3-3	Safety status in the refinery	Safety indicators
				Safety hazards
				Uncertainties
4	Component of technical characteristics and conditions of the refinery	4-1	Technical features and refinery design	Types of functional units
				The way to locating units
				Uncertainties
		4-2	Process and functional characteristics of the refinery	Types of production processes
				Refinery production capacity
				Types of refinery products
		4-3	VOC features in the refinery	VOC generating resources
				VOC index status
				VOC control system
				VOC control system performance
				Uncertainties
		4-4	Features of ROP system in refinery	How to install ROP system
				System process in the ROP section
				ROP system capacity and efficiency
				Uncertainties
		4-5	Criteria for refinery effluent characteristics	Types of refinery effluents
				Wastewater quality indicators
				Wastewater treatment system efficiency
				Uncertainties

5	Strategy characteristic of refinery	5-1	Upside documents and legal requirements	Related upside Documents Related legal requirements Uncertainties
		5-2	Refinery Development Programs	Refinery development programs Space Development Programs - Bodybuilding Uncertainties
		5-3	Refinery Strategic Document	The mission of the refinery strategy Refinery Strategic Perspective Uncertainties
		5-4	Strategic goals of the refinery	The strategic goals of the refinery Refinery micro-strategic goals Uncertainties
		5-5	Strategic issues of the refinery	ecosystem strategic issues

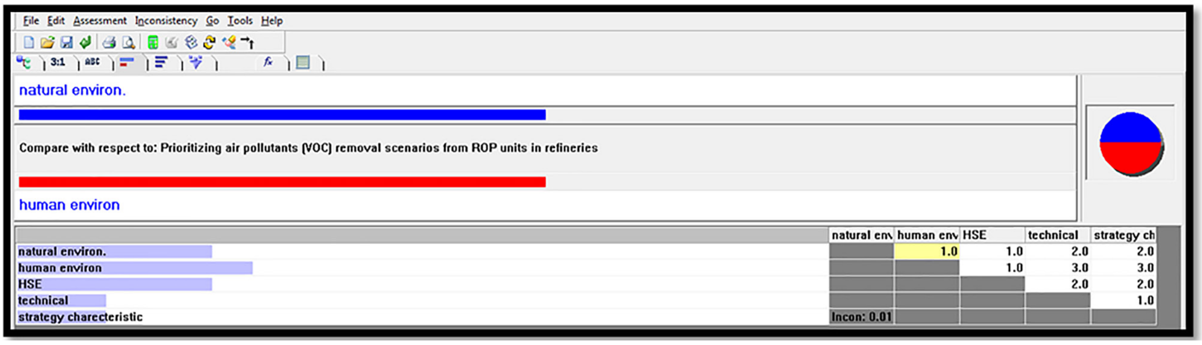

Figure 2: Paired comparison of the studied components in relation to each other

Table 2: General results of Cronbach's alpha calculation in research

The type of parameter to be calculated	Number of items	Cronbach's alpha
Mean	141	0.932

According to Mr. Saati,[23] the founder of the Hierarchical Analysis method, if the incompatibility rate is less than 0.1, the compatibility of the comparison matrix is approved and acceptable. However, if the inconsistency rate is greater than 0.1, it indicates a discrepancy in the evaluations and judgments of experts. Therefore, in hierarchical analysis, calculating and declaring incompatibility rates is a serious and necessary need.

As can be seen in the Table above, the values of total Cronbach's alpha coefficients in the completed Delphi questionnaires are equal to 0.932 on average, which will confirm the reliability of the research due to exceeding the numerical basis index of 0.7 (Table 2).

Discussion

Regarding the output, it can be said that this is a regular and complete review of all the characteristics of the oil refinery. This method reduced the time required to perform the AHP analysis. This is an advantage for senior decision makers. By reducing the time, the rest of the time can be used to improve the quality of the output and analyze the results. Also, there is no need for a consultant for the board meeting. The output is much more objective and easy to understand. The more knowledge is gathered from different experts, the higher the quality of the analysis. If the number of experts increases, they will ask for more information through questions to provide their opinion. Thus,the number of questions should be limited. One of the advantages of this method is the use of more expert knowledge. As a limitation, we can point out that there is no freedom of action in answering the questions. In any case, this method is one of the scientific methods of decision making around the world.

The method used in this study can be used for similar cases. It is more appropriate to use a larger sample to capture more heterogeneity in preferences. To collect information from a large sample, you can use the mail letter review method or provide a place for respondents to gather and ask them to devise the factors and agree on a two-to-two comparison.

In this study, it was foundthatthe greatest need for management is specific to the human environment, such as land use and development plans around the refinery and the state of air and soil pollution and water resources.

Conclusion

The results of weighting and ranking of effective

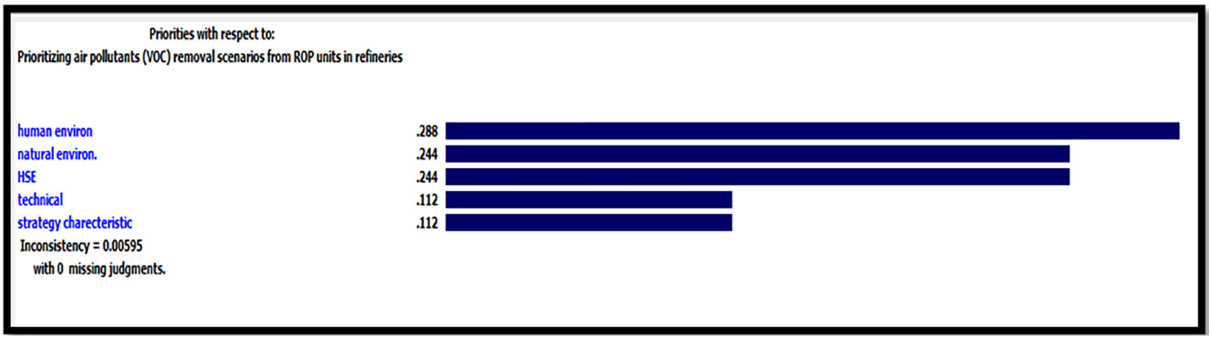

Figure 3: Paired comparisons of components that remove volatile contaminants from the ROP system

strategic parameters in the decision-making process, decision-making and policy-making of various items are presented.Finally, the component of human environment around the refinery hada weight priority of 0.288 in the first rank, the component of natural environment and the HSE component of the refinery with a weight of 0.244 were in the second rank, and the components of technical characteristics and conditions of the refinery hada weight of 0.112 were in the place (Figure 3).

As the results of this study are from a small sample, caution should be excercized in using these findings in a broader context. A large sample is highly desirable to capture greater heterogeneity in preferences and to make generalizations. A mail survey approach can be followed to gather information from a large sample. Alternatively, respondents can be invited to convenient locations and ask them to deliberate the factors and come to a consensus on pair-wise comparison. One of the problems of this approach is that some people may dominate the deliberations and influence the choice. It would be interesting to compare the results of individual responses with those from group consensus.

Conflict of Interest: None declared.

References

1 Barraza F, Uzu G, Jaffrezo J L, Schreck E, Budzinski H, Le Menach K, Dévier MH, Guyard H, Calas A, Perez M I, Villacreces L A, Maurice L. Contrasts in chemical composition and oxidative potential in PM10 near flares in oil extraction and refining areas in Ecuador.2020;223_ 117302.

2 McGuire J B, Leahy J E, Marciano J A, Lilieholm R J, Teisl M F. Social acceptability of establishing forest-based biorefineries in Maine, United States. 2017;105: 155-163.

3 Mahmoudi E, Jodeiri N, Fatehifar E. Implementation of material flow cost accounting for efficiency improvement in wastewater treatment unit of Tabriz oil refining company. 2017;165: 530-536.

4 Jakrawatana N, Pingmuangleka P, Gheewala S H. Material flow management and cleaner production of cassava processing for future food, feed and fuel in Thailand.2016;134: 633-641.

5 Christ K L, Burritt R L. (2015).Material flow cost accounting: a review and agenda for future research. 2015;108: 1378-1389.

6 Yang Z, Wang J. A new air quality monitoring and early warning system: Air quality assessment and air pollutant concentration prediction. 2017;158: 105-117. doi: 10.1016/j.envres.2017.06.002.

7 Fakoya M B, van der Poll H M. Integrating ERP and MFCA systems for improved waste-reduction decisions in a brewery in South Africa.2013;40: 136-140.

8 Esfahani Kashitarash Z, Samadi MT, Naddafi K, Afkhami A, Rahmani A.Application of iron nanaoparticles in landfill leachate treatment – casestudy: Hamadan landfill leachate.2012. J Environ Health Sci Eng.

9 Görener A, Toker K, Uluçay K. Application of Combined SWOT and AHP: A Case Study for a Manufacturing Firm, Procedia.2012; 58, 1525-1534

10 Giurca A, Späth P. A forest-based bioeconomy for Germany, Strengths, weaknesses and policy options for lignocellulosic biorefineries. 2017;153: 51-62

11 Brunnhofer M, Gabriella N, Schöggl J P, Stern T, Posch A. The biorefinery transition in the European pulp and paper industry – A three-phase Delphi study including a SWOT-AHP analysis, 2020; 110_101882

12 Etongo D, Kanninen M, Epule T E, Fobissie K.Assessing the effectiveness of joint forest management in Southern Burkina Faso: A SWOT-AHP analysis.2018; 90: 31-38.

13 Caetani A P, Ferreira L,Borenstein D. Development of an integrated decision-making method for an oil refinery restructuring in Brazil. 2016; 111, 197-210.

14 Hellsmark H, Mossberg J, Söderholm P, Frishammar J. Innovation system strengths and weaknesses in progressing sustainable technology.2016 .the case of Swedish biorefinery development, Journal of Cleaner Production,2016;131: 702-715.

15 Kurttila M, Pesonen M, Kangas J, Kajanus M. Utilizing the analytic hierarchy process (AHP) in SWOT analysis — a hybrid method and its application to a forest-certification case. 2000;1(1): 41-52.

16 Aragonés-Beltrán P, Chaparro-González F,

Pastor-Ferrando J P, Pla-Rubio A. An AHP (Analytic Hierarchy Process)/ANP (Analytic Network Process)-based multi-criteria decision approach for the selection of solar-thermal power plant investment projects. 2014;66, 222-238.

17 Choudhary D, Shankar R. An STEEP-fuzzy AHP-TOPSIS framework for evaluation and selection of thermal power plant location: A case study from India. 2012; 42(1): 510-521.

18 Ertay T, Ruan D, Tuzkaya U R.Integrating data envelopment analysis and analytic hierarchy for the facility layout design in manufacturing systems.2006;176(3): 237-262.

19 Kumari Muniyandi S, Johan S, Azman H, Siti SM.Converting non-metallicprinted circuit boards waste into a value added product. 2013; 11:2.

20 Chen C T. Extensions of the TOPSIS for group decision-making under fuzzy environment. 2000;114(1): 1-9.

21 Kajanus M, Kangas J, Kurttila M. The use of value focused thinking and the A'WOT hybrid method in tourism management. 2004;25(4): 499-506.

22 Saeidi M, Abesi A, Sarpak M. Locating a suitable place to bury hazardouswaste using GIS rating and AHP: case report of Shahid RajaeePowerhouse. 2009; 11(1):231–241.

23 Rosenfeld PE, Feng L. Risks of Hazardous Wastes. Boston. 2011.William Andrew Publishing.