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ORIGINAL ARTICLE

An Approach to the Control Management of Gaseous Pollutants Emissions from Power Plants Using Analytic Hierarchy Process (AHP)

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ABSTRACT

Population growth, industrial pollution and high-energy consumption, cause the release of significant amounts of pollutants in the environment. Power plants play an important role in the release of pollutants such as sulfur dioxide, nitrogen oxides, and carbon dioxide. If the necessary measures in the field of prevention and control do not be implemented, human health and other living creatures would be at risk. The aim of this study was to control management of gaseous pollutants emissions from power plants using Analytic Hierarchy Process (AHP). In this study, first, the emission rate of power plant pollutants from existing monitors was directly examined. In order to determine priority control from a variety of pollutants, SO_2, NO_X, and CO_2 gases were selected using the AHP method. Assessment criteria were determined using previous studies. To specify the priority control first the weight matrix of criteria determination and then the relative weight of each of the pollutants was identified. Finally, the ultimate weight of each pollutant was identified using the calculation of the arithmetic mean in the AHP method. Among the trio-selected pollutants determined for priority control, the NO_X with the final weight of 0.577 was regarded as the first priority, SO_2 with the final weight of 0.32 considered as the second priority and the third priority was specified to CO_2 with the final weight of 0.093. The present study is a new approach to identify and prioritize pollutants. It has provided the ability to plan and carry out the appropriate control design for power plant pollutants.

KEYWORDS: *Pollutant, Environment, Power Plant, Analytic Hierarchy Process*

INTRODUCTION

The environment is a collection of very huge and complicated of active factors that is caused by a gradual process of evolution of living creatures and components of the Earth's surface. This collection affects human activity and in the meantime, it will be affected. Environmental pollution is a byproduct of various industrial activities that makes the environment more exposed to the threat. Environmental assessment can be considered as the mechanism that provides the proper solution reduces the effect of industrial activities [1-3].

The occurrence of the industrial revolution besides providing the comfort and relative prosperity also conveyed another message; it means that although the new energy consumption in some areas can bring prosperity, but in other respects with the introduction of more new risk and endangering several environmental elements, even cast the nature of the human being at risk [4]. For various reasons, in under developing countries, which had rapid growth based on their potential, in

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many cases, the priorities of the development block the environmental priorities. Therefore, in such circumstances the occurrence of some obstacles and complications arising from the arrival of solid, liquid and gaseous pollutants to air, water and soil on the scale of local, regional, national and even international will be inevitable. The history of the environmental assessment and its legal significance dates back to the late 1960s in which the national environmental agency (National Environmental Policy Act) was established in the United States [5].

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Due to population growth and manufacturing industries and high consumption of electricity, the need to generate power has been demonstrated and the operation of power plants to meet the needs of electricity generation had adverse effects on the environment. During the past 30 years agricultural, industrial and domestic power consumption had an average of 9% growth that confirms the increasing need for electrical energy [6]. Power plants enter a large amount of pollutants through a chimney into the air such as sulfur dioxide, carbon oxide, nitrogen oxide, carbon dioxide, menu, suspended particles, etc.

According to the estimation in 2011, the emissions of pollutants such as sulfur dioxide, nitrogen oxide, carbon dioxide from power plants: steam, gas, diesel and hybrid cycle were 709408, 634884, 165184877 tons ,respectively [7-9].The sections of the power plant and transportation have the most emissions of the sulfur dioxide (78.6%) and nitrogen oxide (81.6%) and the sections of power plant, household, and commercial have been assigned the most emission of carbon dioxide [9]. The amount of each of the ingredients of pollutants depends on type, size of equipment, fuel quality and the fuel method. The rate of distribution of outputs at the level of the ground depends on the complex reactions among the physical characteristics of the chimney, physical and chemical characteristics of the outlet and the time of local atmospheric conditions. The outlet pollutants can be considered as the factors of the acidic rain creator. Acid rain has precipitated the demolition of the buildings and monuments, and changes the ecosystem of some lakes and destroys some forest ecosystems largely. As well as, the combustion of fossil fuels in power plants increases the incidence of global warming [10].

The power industry is currently undergoing remarkable organizational and legislation changes in relation to environmental issues. In this study, using the concept of hierarchical analysis the priority of existing pollutants of plant chimneys was examined. The hierarchical analysis method is one of the most efficient methods in the analysis of complex issues and multi –criteria [11].

The aim of this study was to determine the priority control of environmental pollution in a combined cycle power plant. In this study, the concept of AHP and binary comparisons were used to achieve the goal.

MATERIALS AND METHODS

After reviewing the outlet of the power plant chimney documentation (Name is preserved in Journal office), which was visible directly by the monitor in the control room gases of nitrogen oxide, sulfur dioxide, and carbon dioxide were selected for control priority. Using the previous studies and safety, health and environment experts' opinion social costs and threshold limit value (TLV) and outcome were determined as the assessment criteria of AHP method.

The social cost is the cost of the devastating effects of a pollutant or activity on the agricultural products, food, ecosystems and human health. In other words, social costs or the cost of destruction is the monetary fund, which can recompense damages caused by the release of greenhouse gas and pollutant emissions.

The conceptual framework of the process of hierarchical analysis: The process of hierarchical analysis that first time was invented by Thomas. L [12], is a general analytical theory and constructed based on the some of the principles of mathematics and psychology and has the ability to solve complex subjects in the various fields of qualitative and quantitative issues.

The process of hierarchical analysis launches by identifying and prioritizing elements of decision-making. These elements include goals and objectives, the criteria or attributes and possible options that can be used in the prioritization. The process of identification and relationship between

them led to the creation of a hierarchical structure. The next step in the process of hierarchical analysis is the calculation of the weight of criteria (coefficient of importance), the calculation of the weight of (coefficient of importance) options and the final score.

Modeling of AHP: Whenever the AHP is used as a decision-making tool, in the beginning a proper hierarchy tree expressing the issue that is under study must be provided. The process of hierarchical analysis is a tree Decision that according to the issue under consideration has multiple levels. The first level of each tree uniquely expresses the aim of decision. The last level of each tree is also expressed the options that can be compared with each other and for selection are in competition with each other. The other level (middle) represents the factors that are criteria for comparison of options.

The basic step in this procedure is to determine the factors upon which the competing options are compared with each other.

Paired comparisons: Comparative tables are formed based on the bottom-up hierarchy tree. Pairwise comparison is designed using the scale of equal preference to immeasurably preferable. Experience has shown that using the scale of 1:9 to 9 enables the decision maker to compare favorably. For this reason, Table 1 has become a standard in the comparative rating.

Determine the weights of criteria and alternatives: The first level of the hierarchy is formed by the main criteria. First, the certified questionnaire by the paired comparison of the main criteria based on the goal determines the priority of each of the main criteria. Therefore, the criteria should be compared based on the pairwise objective. After the determination of the weight of each of the criteria in the next step, options must be compared in pairs based on each criterion.

Extracting Priorities from the tables of Comparison group: The arithmetic mean method was used for determining priority. The first step to this concept is the accumulation of each column together. In the second step, each element in the matrix of paired comparison has been divided to its own column-accumulation to normalize the matrix of paired comparison. In the third step, the mean of the elements in each row of the normalized matrix has been calculated. Finally, in order to determine the priority the following formula is used:

The rate of each factor=the sum of the priority of the factor based on its criteria×the priority of criteria.

Table 1. A comparison of standardized rating based on the hierarchy tree

Value	Comparison of I to j	Details
1	Equally Preferred	The index *i* is equal to j or both are in the same importance
3	Moderately Preferred	The index *i* is little more important than j
5	Strongly Preferred	The index *i* is more important than j.
7	Very strongly Preferred	The index *i* is very more important than j
9	Extremely Preferred	The index *i* is absolutely more important than *j* and cannot be compared with *j*
6-4-2	Interval	shows the values between the two , for example 8 indicates greater importance than 7 lower than 9 for *i*.

RESULTS

The priority control of environmental pollution has been determined in a combined cycle power plant that these results have been shown in Tables 2 to 4.

The first, model of hierarchical analysis were modeled to determine the priority control of pollutant existed in the output of a power plant (Fig. 1).

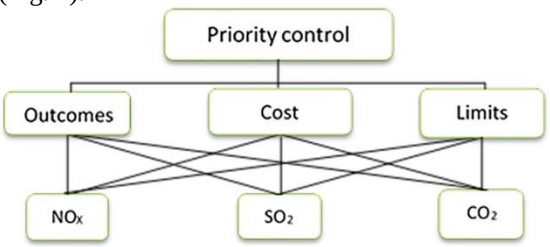

Fig 1. Overall hierarchy of power plant output control determination priorities

The relative weight of criteria was determined based on AHP method; that criteria of outcome was first priority (0.62) (Table 2). The relative weight of pollutants present in the stack outlet is given based on the criteria used (Table 3). Finally, Table 4 shows the final weight and priority control of each pollutant. Pollutant NO_X with the final weight of 0.577 was the first priority control and SO_2 with the final weight of 0.32 and CO_2 with 0.093 had the second and third priority control, respectively.

Table 2. The relative criteria weight

Criteria	The relative criteria weight
Limits	0.306
Cost	0.065
Outcomes	0.62

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Table 3. The relative pollutants weight determination according to the pollutants limits, social cost and outcome criteria

	The relative pollutants weight determination according to the criteria		
Pollutants	**Pollutants limits**	**Social cost**	**Outcome**
CO_2	0.14	0.057	0.076
NO_X	0.71	0.4	0.54
SO_2	0.14	0.529	0.38

Table 4. The final weight of the pollutants and their priority control

Type of Emission	The final weight	Priorities
NO_X	0.577	1
SO_2	0.32	2
CO_2	0.093	3

DISCUSSION

According to results of present study pollutant NO_X with the final weight of 0.577 was the first priority control and SO_2 with the final weight of 0.32 and CO_2 with 0.093 had the second and third priority control, respectively.

Najafzadeh in a study discussed the environmental economic assessment of the energy production technologies. In this study, three pollutants: SO_2, NO_X, and CO_2 were considered for environmental criteria and fixed and variable costs were taken into account for the financial criteria. Finally, using the AHP method of present power plant, thermal and combined cycle power plants had higher priorities [11].

In a similar study, using ANP method presented a method for the assessment of health, environmental and safety risk in a power plant [13]. Dealing with machinery and equipment of oil or gas pipeline during excavation had the highest priority point. The cause of the difference between the results of the present study and the recent study was due to the implementation of appraisal on the stage of construction of the power plant [13].

Jozi et al. evaluated the environmental risks using the multi-criteria decision methods of AHP and TOPSIS in Yazd combined cycle power plant. The results of this study indicate that the amount of groundwater is the most important risk identified from the environmental perspective [14].

Regarding to important risk assessment in power plant other studies have been done by Zegordi and Sayadi [15-16], however, due to differences in the method of risk classification, the results of these studies vary with the present study.

There are several ways for prioritization that each has their advantages and disadvantages. The efficacy of a selected method in the industry depends on many conditions including design, structure, type of activity, and environmental conditions of the study area. So far, several studies are presented in the country using the AHP method for environmental assessment of power Plant, but most of these studies have been carried out during the project construction phase not at the stage of plant operation. As well as, in some other studies [4,14-15], the method of classification of category compared was very huge; therefore, the results will vary with the findings of the present study.

CONCLUSION

In this study, a new approach to the measurement of the power plant pollutants and ranking them was provided. Precise identification and prioritization of pollutants provide proper planning, design, and have a significant effect on the biological conservation. Flexibility, simplicity of calculations, the possibility of employing qualitative and quantitative criteria and at the same time the possibility of the final ranking of the options is the advantages of the hierarchical method.

It is recommended that in future studies the additional criteria used for environmental assessment of power plants. As well as, other environmental pollutants from power plants can also be examined in some detail.

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