Environmental Risk Analysis of Abadan Gas Power Plant Using TOPSIS Method

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Received: Sep., 2010 Accepted: Jan., 2011

Introduction

Pollution and environmental degradation are unwanted byproducts of various industrial activities, threatening the environment much more than ever. Nowadays, environmental crisis, moving towards sustainable development, is eliminating non-tariff barriers existed in economy, preventing the waste of resources and creating conditions for mutual understanding on economic issues. This can be considered as a cause for bringing up the environmental management system. In this view, simultaneously coordination of qualitative, environmental and safety and health reinforcements is a criterion for choosing services and products in a civilized society. Therefore, organization management based on safety as well as environment and quality maintenance must be counted among the essential basis of each organization. Moreover, by proper planning as a result of accurate recognition of these systems, such aforementioned system can be established.

Undoubtedly, electrical energy has been played a fundamental role in the formation and development of human civilization. On the other hand, the consumption of large amounts of water, energy and chemicals in different processes of electrical energy production has caused these industries to bear adverse environmental risks. Hence, understanding of these risks and adopting appropriate methods as well as proper management systems will play important role in reducing its adverse consequences. Abadan Gas Power Plant with approximately 21 ha area, located on southwest of Iran (south of Khuzestan Plain), is under investigation in the present study. It is located 9 Km far from Abadan-Mahshahr Road, in the longitude of 48°, 21′ E and between the latitudes of 30° 24′ and 30° 58′ N. The power plant with the production capacity of 493.3 MW is situated in Shadegan Protected Area. Sections such as Electrical, Mechanical and Accurate Instrument Units were considered as the study scope and studied from the environmental point of view.

Materials and Methods

In this study, multi attribute decision making methods (entropy, eigenvector and TOPSIS) have been applied as quantitative approaches in the analysis of environmental risks of Abadan Gas Power Plant. In the first step, some experiments were conducted in environmental sections of Abadan Gas Power Plant. Subsequently, in order to analyze the results obtained from measuring indoor power plant pollutants, the descriptive statistics (minimum, maximum, mean, variance, standard deviation and mean deviation) as well as Statistical Tests of Means were measured to be compared with standards.

At the second step, to obtain a full understanding of the implications, identifying the dimensions and components of the research issue, surveys were performed to utilize the contribution of experts and managers of various units in the power plant.

Finally, according to the research literature and evaluation of the existing situation of the power plants, 95 criteria and main indices influencing on environmental risk assessment were identified for the 9 sections (Accurate Instrument, Operation, Mechanical and so on) of the power plant.

Then, using Delphi questionnaires and ratios of hypothesis test at the level of 0.05, risk criteria were decreased to 80 cases. After identifying the most important criteria, TOPSIS questionnaire was completed by the research team (employees of each power plant unit). Subsequently, by implementing 6 steps of TOPSIS, the identified risks of each unit were prioritized. Finally, the most important unit of the power plant in terms of environmental index was determined. Thus, the most important risk factors were identified in the whole power plant.

Results and Discussion

Carbon dioxide (CO_2) test shows that CO_2 concentration is equal to 4.26µg/m^3. Its highest and lowest values are respectively tantamount to 5.47 and 3.36 belonging to unit No.4 with gas fuel and the chimney of unit No.1 with liquid fuel (gasoil) in operational state. Mean carbon monoxide (CO) through conducted measures is equal to 12.65µg/m^3. Its highest and lowest values are respectively equal to 68 and 0 referring to the chimney of unit No.4 with gas fuel and the chimney of unit No. 4 with gasoil fuel in the production state. The carbon monoxide mean level is less than the standard limits at the output points of No. 1, 2, 3 and 4 units. Results show that Nitrogen monoxide (NO) mean level equals to 189.1. Its highest and lowest values are respectively equal to 231 and 164 relating to the chimney of unit No.4 with gas fuel and the chimney of unit No. 3 with gasoil fuel. Nitrogen oxides (NOX) mean is tantamount to 189.571, while its highest and lowest values are respectively equal to 231 and 164 belonging to the chimney of unit No.4 with gas fuel and the chimney of unit No. 3 with gasoil fuel. The average amount of nitrogen oxide at units 1, 2, 3 and 4 output is less than the standard limits. The mean and lowest SO_2 amounts are equal to 48.983 and 4.30 respectively, while its highest amount is tantamount to 117.30 related to unit No.3 in two states of gas and gasoil fuels. Average amount observed for $C_x H_y$ is equal to 288.422. The highest and lowest amounts of $C_x H_y$ are respectively equal to 549.40 and 0.18 related to the chimney of unit No. 1 with gas oil fuel and the chimney of unit No. 2 with gasoil fuel in operational state. Total mean of air temperature outputted from the chimney of unit No. 4 is equal to 523°C. Its highest and lowest amounts are respectively equal to 427 and 563 belonging to No. 3 and 4 units with gasoil fuel. The average of O_2 concentration was obtained to be 13.585 through the conducted experiments. Its highest amount is tantamount to 10.80 belonging to unit No. 1 with gasoil fuel, while the lowest value equaled to 15.10 is attributed to unit No.1 with gasoil fuel. The total average of H_2S, NO_2 in all cases and confines is tantamount to zero (Table 1).

Table 1: Descriptive statistics of atmospheric pollutants in different stations of Iran gas power plant

parameter	N	Minimum	Maximum	Mean	Std. Error of Mean	Std. Deviation
CO_2	7	3.36	5.47	4.262	0.385	1.21
NO_X	7	164	231.6	189.571	8.544	22.607
NO	7	164	231.6	189.1	8.64	22.87
SO_2	7	4.30	117.3	48.943	20.821	55.089
CO	7	0	68	12.657	9.427	24.943
T-Gas	7	427	563	523	16.614	43.958
T-Amb	7	21	40	31.571	3.517	9.306
O_2	7	10.8	15.1	13.585	0.538	1.424
$C_x H_y$	7	0.18	549.4	288.422	103.137	272.875

Sound evaluation of Abadan Gas Power Plant indicated that noise level at all stations is less than the permissible limit. Data analysis of produced waste suggested that among 19 materials identified in the power plant, 10 cases are known as non-hazardous maters, while 9 of them have been classified into the hazardous materials category. Dangerousness of the materials was determined based on UNEP list, RCRA, or according to having one of the four features of toxicity, flammability, severe corrosion and affinity. The results of identifying criteria using Delphi Method showed that 86% of the criteria have been accepted. To prioritize (analyze) risk factors, TOPSIS algorithm was applied. The results of this analysis for different units showed that the main risks of each unit are respectively as follows:
Electrical Unit: transformers visits; Administrative Unit: working with computer; Clinic Unit: injections; Firefighting Unit: washing the fin fan; in Post Unit: visiting post equipment; Service Unit: food preparation and distribution; Storage Unit: fuel delivery; Operation Unit: unit commissioning with gas fuel; Mechanical Unit: working on the liquid fuel pump clutch; Accurate Instrument Unit: cleaning and servicing the accurate instruments. Finally, to evaluate the differences between various power plant units Tukey, Duncan and LSD Tests were used in which Mechanical and Operation Units had significant differences with other units of the power plant.

Key words
Environmental risk assessment, Multi criteria decision making methods, TOPSIS, Abadan Gas Power Plant