APPLYING FUZZY AHP TO EVALUATE THE CARBON FOOT PRINT ON THE WORKPLACE IN EDUCATIONAL INSTITUTIONS

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Abstract

Laboratories in educational institutions needs methods to determine the heat emitted from those in a simple manner. The objective of this study was to construct a practical approach based on "fuzzy Analytic Hierarchy Process"(FAHP) for selecting the least heat emission laboratory. In this paper 5 alternatives and 5 criteria are considered which are from the experts "Knowledge and Judgments". Fuzzy Analytic Hierarchy Process applied for calculating relative weights of each criterion. It is the effective assessment tool for selecting the least heat emission laboratory. The analyzed results had identified the relative weight of the criteria taken in laboratory and heat emissions in different laboratories were compared. Thus the study results will provide a practical reference for the persons engaged in the work in laboratory.

***Keywords**: Heat emission from laboratories, fuzzy analytic hierarchy process, multi criteria decision making.*

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1. INTRODUCTION

The institutional laboratories have containing much electronic equipment and are increasing heat emission to the environment. The increasing number of users using the equipment results in the higher heat emitted from the equipment's. As a consequence of an increasing equipment's used in laboratories, the persons engaged in the laboratories have been faced an higher thermal condition environment. They may not aware of amount of thermal conditions inside the laboratory. For taking as a reference this study will provide a practical reference for them. Hence the selection of least heat emitted laboratory is an important factor that determines the thermal condition in that.

Evaluating and selecting the least heat emission laboratory can be regarded as multi criteria decision making(MCDM)process in which the users and decision makers chooses under the several selection criteria, [2] the best thermal condition of laboratory among the alternatives.The MCDM is an Analytic hierarchy process (AHP) is introduced by saaty(1980). A lot of researchers have applied AHP to solve many MCDM process in various areas such as project selection, finance management, performance evaluation, economic planning.

This research involves the process of identifying important criteria that should be considered in terms of selecting the alternatives of laboratories in educational institutions. Then next process is to apply Fuzzy AHP for calculating weights and importance of each criterion and rank the alternatives.

2. LITERATURE REVIEW OF FUZZY AHP

The calculation of AHP is based on the methods and concepts developed by Buckley (1985) and the trapezoidal fuzzy numbers (TrFN) of Buckley (1985) are substituted by Triangular fuzzy numbers.

AHP involves three principles to solve the problems. (SarfarazHashemkhani et al., 2012).

1. Structure of the hierarchy.
2. The matrix of pair wise comparison ratios.
3. The method for calculating weights.

AHP can breakdown any complex problems into several parts in terms of hierarchical level where the criteria are selected for each level of hierarchy to each parts of problem.

- Develop the hierarchical structure for the problem of investigation and derive a fuzzy pairwise comparison matrix.
- Calculate the relative weights and fuzzy positive reciprocal matrix.
- **Defuzzification:** conversion of fuzziness into exact values is defined as defuzzification. (Normalization and the hierarchy coordination.

Many methods and applications of Fuzzy AHP are expressed by various researchers[1]. The FAHP method is used to determine the relative weights of criteria for decision makers by individual opinion. This method is chosen to calculate the weights of selected methods in order to reduce the fuzziness and ambiguity of information and ranking. It displays that the Fuzzy AHP method for selecting the thermal condition of laboratory can be useful and effective assessment tool.

3. METHODOLOGY

Over the years the complexity of heat emission in a laboratory has rapidly increases, thus identifying the importance of developing and implementing practical and effective quantitative analysis techniques for evaluation of least heat emission laboratory in educational institutions.(MCDM) technique is an advanced research operation, gives decision makers and analysts a broad range.

To investigate a number of alternatives in lights of conflicting priorities multi criteria analysis (MCA) gives a structure for breaking a problem into its constituent parts. Multi criteria are selected based on the knowledge of experts and data collected from the institutional laboratories. Therefore this study aims to use FAHP to evaluate the heat emission in laboratory which serves as a basis of reference and rank the least heat emitted laboratory among the alternatives.

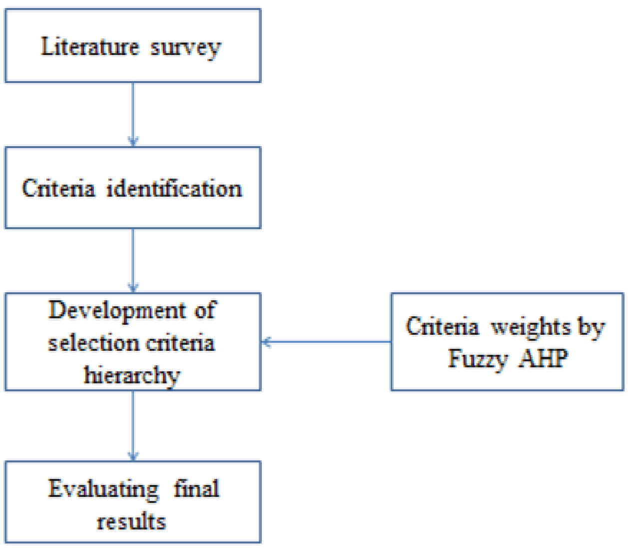

Fig1: Framework of research

3.1 Fuzzy Analytic Hierarchy Process

In (1983) FAHP method was developed by Laarhoven and Pedrycz based on the AHP method proposed by Saaty (1980) [4]. FAHP has been widely engaged in number of different issues which can define and analysesthe problems efficiently. Therefore the FAHP method is used in this study to find out the weights of each criterion selected for evaluation of least heat emitted thermal conditional laboratory.

3.2 Criteria Selection

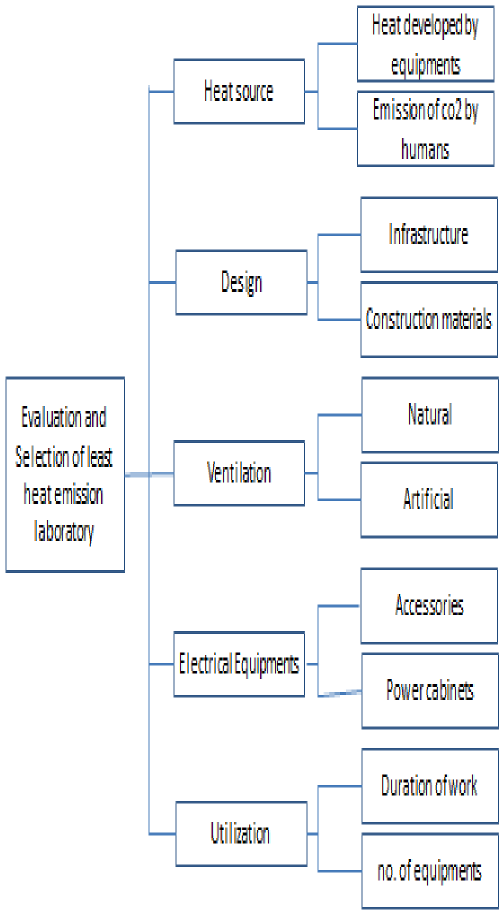

Fig2: Research hierarchical structure

3.3 Application

The objective of this paper is to choose ideal institutional laboratory based on fuzzy AHP method. In this research , five alternatives and five criteria have been plotted. Alternatives (A1), Cad lab(A2), Cam lab(A3), Electronics lab(A4), and Electrical lab(A5). The motive behind for selecting these alternatives is the highest heat emitting workplace in educational institutions. This study criterion includes Heat source(C1), Design(C2), Ventilation(C3), Electrical Equipment's(C4), and Utilization(C5). These criteria through interviews with workplace authorities and experts has been selected and taken out. Then the pairwise comparisons surveyresulting to criteria and alternatives were provided. Fuzzy AHP method was used to weight the criteria and alternatives. After this method, the best Laboratory has determined. According to the criteria and alternatives, the research hierarchical structure has shown in figure 3.

As cause of variance between experts' judgments and for minimizing vagueness and uncertainty in decision making process, Fuzzy AHP method is suggest for group decision making process. According to the table 1 each decision maker independently was using pairwise comparison based on Saaty's 1-9 scale [1].

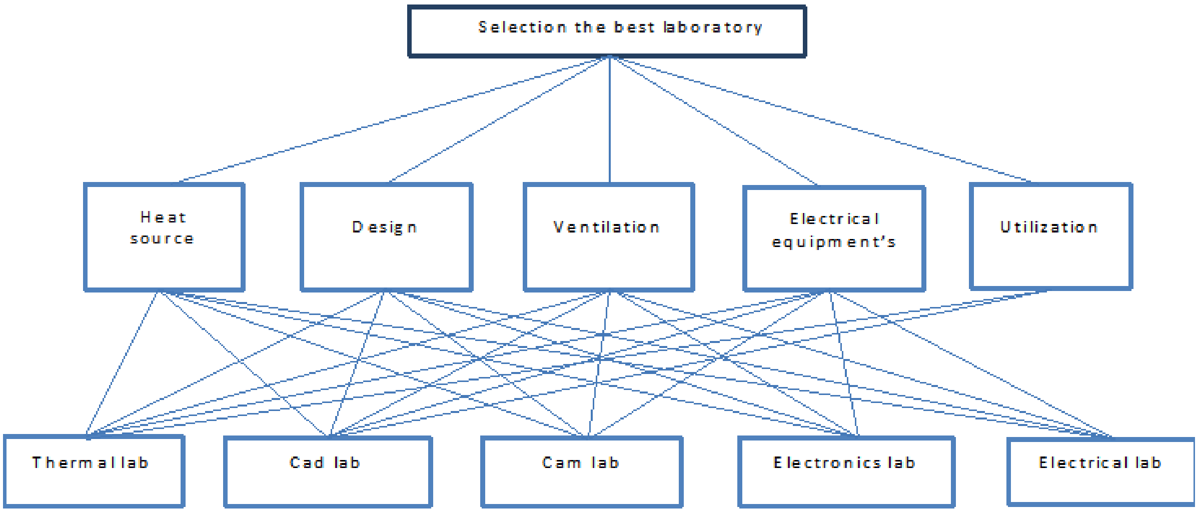

Fig 3: The hierarchy structure of selection green laboratory in educational institution

Table 1: Pair-wise comparison scale (Saaty, 1980)

Fuzzy number	1	3	5	7	9	2,4,6,8
Definition	Equally important	Moderately more important	Strongly more important	Very strongly more Important	Extremely more important	Intermediate values Between the two adjacent Judgments.

3.4 Calculation

Table 2: Fuzzy criteria weight number for alternatives

	Heat source	**Design**	**Ventilation**	**Electrical equipment**	**Utilization**	**Product**	**5th root of product**	**Normalized weight**
Heat source	1	7	5	7	9	2205	4.66318	0.59769
Design	1/7	1	3	5	1	2.14286	1.16466	0.14928
Ventilation	1/5	1/3	1	7	5	2.33333	1.18466	0.15184
Electrical equip	1/7	1/5	1/7	1	3	0.01224	0.41456	0.05314
Utilization	1/9	1	1/5	1/3	1	0.00741	0.37492	0.04805
Sum of the coloumn	1.5968	9.5333	9.3429	20.3333	19.0000		7.8020	
Sum * normalized weight	0.9544	1.4231	1.4186	1.0804	0.9130		5.78960	

Table 3: Fuzzy paired-wise comparisons matrix according to heat source (C1)

	Thermal Lab	**Electrical lab**	**Cad Lab**	**Cam Lab**	**Electronics Lab**	**Product**	**5th root of product**	**Normalized weights (NW)**
Thermal Lab	1	1/3	1/7	1/5	1/7	0.00136	0.26714	0.03792
Electrical lab	3	1	3	5	7	315.00000	3.15982	0.44852
Cad Lab	7	1/3	1	3	5	35.00000	2.03617	0.28903

Cam Lab	5	1/5	1/3	1	3	1.00000	1.00000	0.14195
Electronics Lab	7	1/7	1/5	1/3	1	0.06667	0.58181	0.08259
Sum of Column	23.0000	2.0095	4.6762	9.5333	16.1429		7.04494	
Sum x NW	0.8722	0.9013	1.3515	1.3532	1.333168049		5.81140	

Table 4: Criteria C1 Results

CI	0.202849
RI	1.21
CR	0.167644

Table 5: Fuzzy paired-wise comparisons matrix according to Design (C2)

	Thermal Lab	**Electrical lab**	**Cad Lab**	**Cam Lab**	**Electronics Lab**	**Product**	**5th root of product**	**Normalized weights (NW)**
Thermal Lab	1	1/9	1/7	1/5	1/3	0.00106	0.25405	0.03147
Electrical lab	9	1	3	5	9	1215.00000	4.13919	0.51272
Cad Lab	7	1/3	1	3	7	49.00000	2.17791	0.26978
Cam Lab	5	1/5	1/3	1	5	1.66667	1.10757	0.13719
Electronics Lab	3	1/9	1/7	1/5	1	0.00952	0.39424	0.04883
Sum of Column	25.0000	1.7556	4.6190	9.4000	22.3333		8.07295	
Sum x NW	0.7867	0.9001	1.2461	1.2896	1.090645057		5.31323	

Table 6: Criteria C2 Results

max	5.31323
CI	0.078308
RI	1.21
CR	0.064717

Table 7: Fuzzy paired-wise comparisons matrix according to ventilation (C3)

	Thermal Lab	**Electrical lab**	**Cad Lab**	**Cam Lab**	**Electronics Lab**	**Product**	**5th root of product**	**Normalized weights (NW)**
Thermal Lab	1	1/7	1/5	1/5	1/3	0.00190	0.28574	0.03682
Electrical lab	7	1	3	5	9	945.00000	3.93628	0.50725
Cad Lab	5	1/3	1	3	7	35.00000	2.03617	0.26239
Cam Lab	5	1/5	1/3	1	5	1.66667	1.10757	0.14273
Electronics Lab	3	1/9	1/7	1/5	1	0.00952	0.39424	0.05080
Sum of Column	21.0000	1.7873	4.6762	9.4000	22.3333		7.76000	
Sum x NW	0.7733	0.9066	1.2270	1.3416	1.13462964		5.38314	

Table 8: Criteria C3 Results

Lmax	5.38314
CI	0.095786
RI	1.21
CR	0.079162

Table 9: Fuzzy paired-wise comparisons matrix according to Electrical equipment (C4)

	Thermal Lab	Electrical lab	Cad Lab	Cam Lab	Electronics Lab	Product	5th root of product	Normalized weights (NW)
Thermal Lab	1	1/5	1/3	1/7	1/9	0.00106	0.25405	0.04898
Electrical lab	5	1	3	1/3	1/5	1.00000	1.00000	0.19279
Cad Lab	3	1/3	1	1/5	1/7	0.02857	0.49112	0.09468
Cam Lab	7	3	1/3	5	1/3	11.66667	1.63452	0.31511
Electronics Lab	9	5	1/7	3	1	19.28571	1.80737	0.34844
Sum of Column	25.0000	9.5333	4.8095	8.6762	1.7873		5.18705	
Sum x NW	1.2244	1.8379	0.4554	2.7340	0.622765227		6.87447	

Table 10: Criteria C4 Results

Lmax	6.87447
CI	0.468618
RI	1.21
CR	0.387287

Table 11: Fuzzy paired-wise comparisons matrix according to Utilization (C5)

	Thermal Lab	Electrical lab	Cad Lab	Cam Lab	Electronics Lab	Product	5th root of product	Normalized weights (NW)
Thermal Lab	1	5	7	5	1	175.00000	2.80936	0.36515
Electrical lab	1/5	1	3	1	1/5	0.12000	0.65439	0.08505
Cad Lab	1/7	1/3	1	1/3	1/7	0.00227	0.29588	0.03846
Cam Lab	1/5	3	3	5	1/5	1.80000	1.12475	0.14619
Electronics Lab	1	5	7	5	1	175.00000	2.80936	0.36515
Sum of Column	2.5429	14.3333	21.0000	16.3333	2.5429		7.69374	
Sum x NW	0.9285	1.2191	0.8076	2.3878	0.928522198		6.27153	

Table 12: Criteria C5 Results

Lmax	6.27153
CI	0.317882
RI	1.21
CR	0.262712

Table 13: Fuzzy paired-wise comparisons for total criteria together

COMPANY	Heat source	Design	Ventilation	Electrical equip	Utilization	Priority Weights (Pwi)
NWj	0.59769	0.1493	0.15186	0.05314	0.04805	
Thermal Lab	0.03791973	0.0314689	0.036821932	0.048977093	0.3651492	0.05310239
Electrical lab	0.44852314	0.5127232	0.507253203	0.19278772	0.0850548	0.092320634
Cad Lab	0.28902563	0.2697783	0.262392879	0.094681637	0.038457	0.422580307
Cam Lab	0.14194586	0.1371948	0.142727673	0.315114746	0.1461898	0.150946478
Electronics Lab	0.08258563	0.0488349	0.050804312	0.348438804	0.3651492	0.188853064

Table 14: Final results of ranking indexes using FAHP

Sl No	Evaluation of Green concept "HOWs"	Crisp Weights	Evaluation of Green concept					C.I.	R.I.	Inconsistency (%)
			Thermal Lab	Electrical lab	Cad Lab	Cam Lab	Electronics Lab			
1	Heat source	0.59769	0.03792	0.44852	0.28903	0.14195	0.08259	0.202849	1.12	18.11%
2	Design	0.1493	0.03147	0.51272	0.26978	0.13719	0.04883	0.078308	1.12	6.99%
3	Ventilation	0.15186	0.03682	0.50725	0.26239	0.14273	0.05080	0.095786	1.12	8.55%
4	Electrical equip	0.05314	0.04898	0.19279	0.09468	0.31511	0.34844	0.468618	1.12	41.84%
5	Utilization	0.04805	0.36515	0.08505	0.03846	0.14619	0.36515	0.317882	1.12	28.38%
	Overall Score		0.05310	0.09232	0.42258	0.15095	0.18885			
	Rank		**5**	**4**	**1**	**3**	**2**			

4. CONCLUSIONS

Nowadays, succeeding to increase of laboratory usage activities and the importance of heat emission level by various activities like using of equipment's , power panels, co2 emission etc, the educational institutions has become more facilitate the laboratory operations and reduces the time by purchasing modern equipment's. The purpose of this study is to identify and select best green conditional laboratory based on FAHP calculations. In this paper the five alternative laboratories in an educational institution were selected. For calculation and ranking the five criteria of heat source, ventilation, design, electrical equipment's and utilization were considered. Due to the uneven scale of judgments and failure to adequate handle the inherent vagueness and carelessness in pairwise comparison process by AHP is criticized. So Fuzzy AHP method is developed to overcome all the shortcomings and respect to ambiguity and complexity of human decision making process.

The research results can be summarized as following items: cad lab with (0.4226) and electronics lab with (0.05310) have the most priority weights and thermal lab (0.05310) has the lowest weight. The most important criteria based on experts judgments in selecting the green conditional laboratory are respectively the heat source (0.597) and ventilation (0.15186), design (0.1493), electrical equipment (0.05314) and utilization (0.1493). Table 8 results shows that cad lab has the highest ranking in heat source, ventilation, and design criteriawith thermal lab has the lowest rating between all the criteria. Future research can be used more comprehensive criteria for evaluating the green conditional laboratory. Other laboratories which haven't referred in this article can be cited for more accurate ranking. For subsequent studies, using other multi criteria decision making methods can be proposed to rank the institutional laboratories more properly.

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