Intervention of Environmental Engineering Principles in the Investigation of the Viable Air Pollution Mitigation Methods with IFS Tool

F.X.Edwin Deepak, A.Aleeswari, W.Lilly Merline, Nivetha Martin

Abstract: ***Air is the most indispensable need of the human to live in this world, but in the past decades the quality of air we inhale is being polluted by the emission of pollutants from industries which contributes highly in comparison with the other dynamic and area sources of pollutants. Air pollution is not just the contamination of the air alone, rather it is the destruction of the life of living organisms. Quality of an individual's health depends on the quality of the air he breathes. The legal warnings from the government and welfare alarms from voluntary associations in failing to promote the quality of air have propelled the industrial sectors to practice robust air pollution mitigation (APM) methods. The challenging task of the industries is the selection of appropriate APM method from the existing numerous methods after evaluating each method's degree of fulfilling the essential criteria. This research work presents four major APM methods cum ten vital criteria by considering the intervention of environmental engineering principles of monitoring the quality of APM methods. To make the decision making process more consistent, intutionistic fuzzy sets (IFS) are used which are highly compatible than other fuzzy representations. The ranking results of APM methods are made by using various significant measures of IFS to find the viable APM method of condensing the hurdles of industrial sectors in upholding environmental sustainability.***

Keywords: APM, intutionistic fuzzy sets, similarity measure, environmental engineering, environmental sustainability.

I. INTRODUCTION

Industrialization and urbanization is playing a decisive role in transforming the society's patterns of culture, social and economic aspects. The industrial sectors lessen the burden of production time and energy by practicing robust manufacturing techniques. The prime functioning principle of these production sectors is maximum profit with minimum input. But in reality these industries are bearing high economic risks to maintain marginal turnover of monetary values. The major reason for these financial crises is the oblige of stringent environmental regulations, which have made the industries to have an eye over the production mechanism and the expulsion of pollutants to the environment, for which additional expenses are incurred.

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F.X.Edwin Deepak, Department of Electrical & Electronics Engineering,PSNA CET, Dindigul

A.Aleeswari, Department of MBA, PSNACET, Dindigul

W.Lilly Merline, PG & Research centre of Mathematics, Periyar EVR College, Tirchy

Nivetha Martin, Department of Mathematics, Arul Anandar College (Autonomous), Karumathur

Presently the check on air quality index is taking place in major Indian industrial cities such as Delhi, Mumbai, Bangalore, Kolkatta to alleviate the level of pollutants in atmosphere and averting the chances of air turning poisonous. As the concern for environmental sustainability is increasing day after day, the eviction of pollutants should be controlled by implementing APM methods in industrial sectors. The four major methods of APM are method of employing equipment, pollutant diffusion method, source rectification method and vegetation. The description of these methods is presented below.[20]

Methods	Description
Method of employing equipment	Utilization of special devices to control the emission of pollutants.
Pollutant diffusion method	Dilution of pollutants in the atmosphere
Source rectification method	Prevents pollutants at the source level.
Vegetation	Use of plant species for pollutant absorption

All the four APM methods are good in mitigating air pollution with its own merits and limitations. But finding the viable APM method is indeed highly difficult. To settle on such crisis, the environmental experts are made to represent each method's degree of fulfilling the criteria of APM in terms of IFS. The pioneer of IFS is Atanassov [1] which considers the membership and non membership values and later the inclusion of hesitation margin. IFS is more consistent than ordinary fuzzy sets as the former takes into account of the degree of belongingness and non-belongingness, where the latter take only belongingness into consideration. IFS has been extensively applied by many researchers such as [4] De.et.al, Shinoj.et.al [9],Szmidt et.al [10] in medical diagnosis, Ejegwa.et.al [5] have applied the notion of IFS in career administration, setting research questionnaire, electoral system and also in the diagnosis of viral hepatitis. The concept of IFS is also used by Xiumei Zhang [17] in multi attribute decision making to rank the alternatives using similarity measures (SM). A means to find out the extent of likeness between two or more entity is known as similarity measure. The aspect of SM for fuzzy sets was established and extended by researchers like Kaufman [7], Fan [6], Zadeh [18], Zwick [19], Wang [15], Li [8].

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The same similarity measures were modified to IFS by Wen-Liang Hung and Min-Shen Hang [16]. Followed by them many scholars have contributed various similarity measures. This paper aims in uncovering the most viable pollution control method with the intrusion of the principles of environmental engineering.

This research work involves four prime similarity measures of IFS proposed by Burillo & Bustinence [3],Hung & Hang [16] to rank APM methods. It is distinct from the earlier researches as; this work presents the comparative analysis of the results of similarity measures in the context of making decisions for sustaining the environment. The methodology used is based on the work of Bapat.et.al [2] in which the fuzzy relations are used in determining the pattern of crop selection and the expert's opinion are represented by fuzzy values, but in this article expert's opinion are represented by intutionistic fuzzy values which represents each APM method's degree of fulfilling and not fulfilling the criteria considered for study. This will indeed support the decision makers to take into account of the pros and cons.

The outline of the paper is as follows: section 2 presents the preliminaries; section 3 encompasses the methodology; section 4 contains the application of the suggested method to the decision making problem; section 5 discusses the results and the last section concludes the paper.

II. PRELIMINARIES

This section contains the basic definitions pertaining to the study.

Fuzzy set

Let X be a universal set. A fuzzy set A is of the form $\tilde{A}$ = { (x, μ_A (x)) / x ∈ X}, where
μ_A (x) : X → [0,1], the membership function of the fuzzy set $\tilde{A}$.

Intutionistic Fuzzy set

An intutionistic fuzzy set is of the form $\tilde{A} = \{(x, \mu_A(x), \nu_A)(x) : x \in X\}$, where $\mu_A(x), \nu_A(x)$ are the membership and non-membership function respectively, $\mu_A(x), \nu_A(x)$ are functions from X to [0,1] and X is a universal set.

Similarity Measure

A real function S from IFS × IFS → R^+ is a similarity measure if the below conditions are fulfilled:

1. $S(\tilde{A}, \tilde{B}) = S(\tilde{B}, \tilde{A}), \forall \tilde{A}, \tilde{B} \in IFS$
2. $S(E, E^c) = 0$, if E is a crisp set.
3. $S(\tilde{F}, \tilde{F}) = max_{\tilde{A},\tilde{B} \in IFS} S(\tilde{A}, \tilde{B}), \forall \tilde{F} \in IFS$
4. $\forall \tilde{A}, \tilde{B}, \tilde{C} \in IFS, if\ \tilde{A} \subset \tilde{B} \subset \tilde{C}, then\ S(\tilde{A}, \tilde{B}) \geq S(\tilde{A}, \tilde{C})$ and $S(\tilde{B}, \tilde{C}) \geq S(\tilde{A}, \tilde{C})$

Similarity Measure I (By Burillo and Bustince) [3]

Let $\tilde{A}, \tilde{B}$ *be IFS*, then the hamming distance similarity measure is defined as

$$SM_1(\tilde{A}, \tilde{B}) = \frac{\sum_{i=1}^{n} \left|\mu_{\tilde{A}}(x_i) - \mu_{\tilde{B}}(x_i)\right| + \left|\nu_{\tilde{A}}(x_i) - \nu_{\tilde{B}}(x_i)\right|}{2}$$

Similarity Measure II (By Burillo and Bustince) [3]

Let $\tilde{A}, \tilde{B}$ *be IFS*, then the Euclidean similarity measure is defined as

$$SM_2(\tilde{A}, \tilde{B}) = \left(\frac{\sum_{i=1}^{n} ((\mu_{\tilde{A}}(x_i) - \mu_{\tilde{B}}(x_i))^2 + ((\nu_{\tilde{A}}(x_i) - \nu_{\tilde{B}}(x_i))^2}{2} \right)^{1/2}$$

Similarity Measure III (By Hung and Yang) [16]

$$SM_3(\tilde{A}, \tilde{B}) = \frac{1}{n} \sum_{i=1}^{n} \frac{\min(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i)) + \min(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i))}{\max(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i)) + \max(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i))}$$

Where $\tilde{A}, \tilde{B}$ *be IFS*

Similarity Measure III (By Hung and Yang) [16]

$$SM_4(\tilde{A}, \tilde{B}) = \frac{\sum_{i=1}^{n} \min(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i)) + \min(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i))}{\sum_{i=1}^{n} \max(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i)) + \max(\mu_{\tilde{A}}(x_i), \mu_{\tilde{B}}(x_i))}$$

Where $\tilde{A}, \tilde{B}$ *be IFS*

III. METHODOLOGY

The modified steps based on Bapet.et.al [2] followed in decision making are as follows

i. The various methods of APM and its attributes or criteria related to the problem are considered.
ii. The degree of APM methods fulfilling each criterion is represented by intutionistic fuzzy set.
iii. The similarity measures of Mi over Mj for criterion Ck are determined.
iv. The ranking (R) of the methods is made from the average matrix P_A.

$$P_A = \frac{1}{10} \sum_{i=1,j=1}^{4,10} a_{ij}\ ,\quad R = \frac{1}{3} \sum_{j}^{4} a_{ij}$$

IV. ADAPTATION TO THE PROPOSED PROBLEM

The criteria (C) and the methods (M) which are considered for this research work are based on the analytic study undertaken by the environmental engineers.

C1 Economically Feasible C2 Durability C3 Compatibility C4 Flexibility C5 Consistency C6 Efficiency in reducing pollutants C7 Commercially beneficial C8 Eco-friendly C9 Abatement of toxins C10 Prevention of secondary pollution	M1 Method of employing equipment M2 Pollutant Diffusion Method M3 Source rectification Method M4 Vegetation

Table. 4.1The intutionistic representation of the degree satisfaction of criteria by APM methods

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
M1	(0.6,0.3)	(0.5,0.4)	(0.6,0.2)	(0.7,0.1)	(0.6,0.2)	(0.8,0.1)	(0.7,0.3)	(0.6,0.2)	(0.7,0.2)	(0.8,0.1)
M2	(0.2,0.7)	(0.6,0.2)	(0.5,0.3)	(0.6,0.3)	(0.7,0.2)	(0.7,0.2)	(0.6,0.2)	(0.4,0.5)	(0.6,0.2)	(0.7,0.2)
M3	(0.1,0.8)	(0.4,0.5)	(0.6,0.3)	(0.7,0.2)	(0.5,0.3)	(0.6,0.2)	(0.5,0.4)	(0.5,0.3)	(0.8,0.1)	(0.3,0.6)
M4	(0.7,0.2)	(0.3,0.6)	(0.4,0.5)	(0.5,0.4)	(0.5,0.2)	(0.4.0.3)	(0.4,0.5)	(0.8,0.1)	(0.5,0.4)	(0.4,0.5)

The matrix (P) representation of the similarity measure of one method over another for each criterion using Hamming distance is presented below

P1	-	0.4	0.5	0.1	P2	-	0.15	0.1	0.2
	0.4	-	0.1	0.5		0.15	-	0.25	0.2
	0.5	0.1	-	0.6		0.2	0.25	-	0.2
	0.1	.5	0.6	-		0.2	0.35	0.2	-
P3	-	0.1	0.05	0.25	P4	-	0.15	0.05	0.25
	0.1	-	0.05	0.15		0.15	-	0.1	0.1
	0.05	0.05	-	0.2		0.05	0.1	-	0.2
	0.25	0.15	0.2	-		0.25	0.1	0.2	-
P5	-	0.05	0.1	0.05	P6	-	0.1	0.15	0.3
	0.05	-	0.15	0.1		0.1	-	0.05	0.1
	0.1	0.15	-	0.05		0.15	0.05	-	0.15
	0.05	0.1	0.05	-		0.3	0.1	0.15	-
P7	-	0.1	0.15	0.25	P8	-	0.15	0.1	0.15
	0.1	-	0.15	0.25		0.15	-	0.1	0.4
	0.15	0.15	-	0.1		0.1	0.15	-	0.25
	0.25	0.25	0.1	-		0.15	0.4	0.25	-
P9	-	0.05	0.1	0.2	P10	-	0.1	0.5	0.4
	0.05	-	0.15	0.15		0.1	-	0.4	0.3
	0.1	0.15	-	0.3		0.5	0.4	-	0.1
	0.2	0.15	0.3	-		0.4	0.3	0.1	-

The average matrix P_A is

-	0.135	0.18	0.215
0.135	-	0.15	0.225
0.9	0.155	-	0.215
0.215	0.24	0.215	-

The final ranking of the APM methods

M1	M2	M3	M4
0.18	0.17	0.42	0.22
3	4	1	2

The same procedure is repeated with other similarity measures and the respective ranking is presented in the Table.

Similarity Measures & Ranking	M1	M2	M3	M4
SM2	0.133	0.128	0.165	0.138
Rank	3	4	1	2
SM3	0.183	0.174	0.45	0.23
Rank	3	4	1	2
SM4	0.145	0.126	0.189	0.172
Rank	3	4	1	2

V. RESULTS AND DISCUSSION

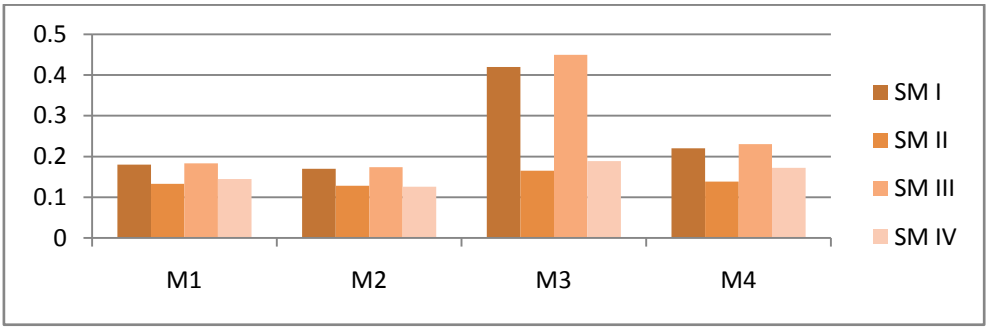

Fig. 5.1 Ranking of APM methods

Fig 5.1 clearly explicates that M3 is the most feasible APM method when compared to M4, M1 and M2. Also the proximity between M2 and M1 is high. The graphical representation strongly emphasizes that M3 method of mitigating air pollution fulfills the essential attributes of APM methods in the implication of all the four similarity measures.

VI. CONCLUSION

This research work has presented the major APM methods and its necessary criteria based on the principles of environmental engineering. The results of ranking are obtained by using intutionistic fuzzy sets, which is a well-suited form of representing one's opinion. The results obtained will be useful to the decision makers of the industrial sectors in selecting the feasible method. This work can also be extended by using other significant measures.

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