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Ranking of Locations Based on Ambient Air Quality Pollution in Hyderabad City by Using MADM Technique

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Abstract: **While large-scale industrialization increases the production of material goods and urbanization creates mega cities, the ill effects of these activities are reflected in the form of various environmental problems. One such problem is the deterioration of urban air quality in India and other developing countries. The main contributing factors to air pollution are the overwhelming concentration of vehicles, poor transport infrastructure and the establishment of industries in urban agglomerations. Due to constantly rising air pollution levels as well as an increasing awareness of the hazardousness of air pollutants, new laws and rules have been passed. Adverse health effects of air pollution, even at relatively low levels, remain a public concern. In the present study, the various locations in Hyderabad city are ranked based on ambient air quality by using multi attribute decision making technique. The locations are ranked based on pollutant load. The results of the study will be useful to Government to implement measures to minimize the air pollution effects on health of public.**

Index Terms— Multiple attribute decision making (MADM), air pollution, pollutants, attributes

1. INTRODUCTION

Air pollution is a major environmental health problem affecting the developing and the developed countries alike. Rapid economic growth has brought many benefits to India; the environment has suffered, exposing the population serious air pollution [1]. The consequences of pollution have led to poor urban air quality in many Indian cities. The air pollution and the resultant air quality can be attributed to emissions from transportation, industrial and domestic activities. The air quality has been, therefore, an issue of social concern in the backdrop of various developmental activities. Though the measurement of air quality is complicated, there are a few pollutants which regulators keep a watchful eye on through regular monitoring. The concentrations of air pollutants include particular matter (PM), nitrogen dioxide (NO2), sulphur dioxide (SO2) and carbon dioxide (CO2) are monitored regularly[2]. The annual average concentration of suspended particulate matter (PM10) is very high in Indian cities. The effects of air pollution on health are very complex as there are many different sources and their individual effects vary from one to the other. Air pollutants cause seriousimpact on human health affecting the lungs and the respiratory system.Some of these gases can seriously and adversely affect the health of the population and should be given due attention by the concerned authority. The gases mentioned below are mainly outdoor air pollutants but some of them can and do occur indoor depending on the source and the circumstances.

Respirable suspended particulate matter accounts for a substantial impact on human health and environment with respect to airborne particle threat. Owing to fine size, dust penetrates deep into respiratory system during breathing resulting into health problems such as aggravated asthma, painful breathing, wheezing, chronic bronchitis, and decreased lung function. Past studies show that adverse impact of elevated levels of particulate matter in air on human health [3].

Increase in technological, industrial and agricultural advancement, coupled with increases in population growth, has triggered the deterioration of environmental quality throughout the world. Rapidly growing cities, more traffic on roads, growing energy consumption and waste production, and lack of strict implementation of environmental regulation are increasing the discharge of pollutants into air, water, and soil [4].Urban ambient air pollution is the result of emissions from a multiple, mainly stationary, industrial and domestic fossil fuel combustion; petrol and diesel vehicle emissions [5,6]. Fossil fuels, the primary source of energy consumption, are the greatest source of ambient air pollution, producing nitrogen oxides, sulfur oxides, dust, soot, smoke, and other suspended particulate matter. These pollutants can lead to serious public health problems, including asthma, irritation of the lungs, bronchitis, pneumonia, decreased resistance to respiratory infections, and premature death. The burning of fossil fuels is also the major source of carbon dioxide emissions, a primary contributor to global warming [6].The

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levels of air pollutants are rapidly increasing in urban and rural areas in megacities (urban population greater than 10 million) of the developing world [7]. The air pollutants so generated are detrimental to human health. In addition, they cause negative impacts directly or indirectly, if at elevated concentrations, on vegetation, animal life, buildings and monuments, weather and climate, and on the aesthetic quality of the environment.

Developing nations are particularly affected by air pollution; as many as two thirds of the deaths and lost life years associated with air pollution on a global scale occur in Asia[8]. To date, estimates of the health effects resulting from exposure to air pollution in Asia have relied largely on the extrapolation of results from research conducted outside Asia primarily in Europe and North America [9]. India need to generate regular information on the ambient concentration levels of small particulates of diameter less than 10 micron and/or 2.5 micron and take urgent steps to control emissions of these particles [10]. The World Health Organization estimates that air pollution contributes to approximately 800,000 deaths and 4.6 million lost life years annually [8].

The purpose of the study is to ascertain the priority locations in Hyderabad city based on the air pollutants load by using multiple attribute decision making approach. To prioritize the various locations, multiple attribute decision-making (MADM) method has been applied. Prioritization of locations based on air pollution load is based on certain attributes which influence decision making process. The attributes are PM10,sulphur dioxide,Nox,Ammonia and carbon monoxide.

2. MATERIALS AND METHODS

Multiple attribute decision making helps to arrive at a decision based on either the objective weights of importance of the attributes or subjective preferences or considering both the objective weights and the subjective preferences. The proposed method suggested by the researchers has applied in the different field's viz. material selection for a high-speed naval craft, material selection of a flywheel and materials for cryogenic storage tank [12].In multiple attribute decision making, selection among decision alternatives is based on their attributes.

The flow chart of research methodology is shown in the Figure 1.

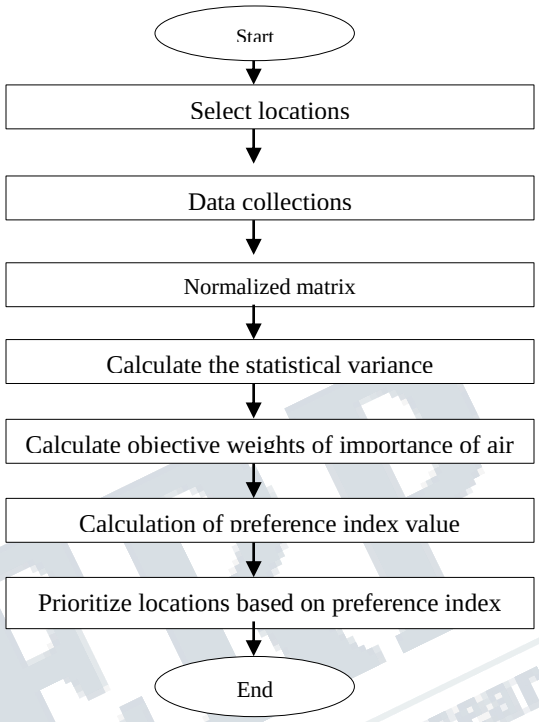

Fig1. Flow chart of methodology

The methodology adopted in the study for prioritizing metro corridors is described below[13].

Step 1: Normalized matrix
Identify the attributes for the prioritizing locations and short-list the locations on the basis of the identified attributes satisfying the requirements. The attributes are of two types, beneficial (i.e. higher values are desired) and non-beneficial (i.e. lower values are desired). The values associated with the attributes that is air pollutant concentrations is represented by (Eij) and the attributes may be in different units (e.g., PM10 in ug per m3, Nox in ug/m3 etc.). The tabulated values of attributes are to be normalized and the following equation can be used for normalization for different locations.

$$E_{ij}^{*} = E_{ij} / \sum_{i=1}^{n} E_{ij} \quad \text{---------- (1)}$$

Step 2: Calculate the Statistical variance value
The statistical variance for determining the objective weights of importance of the attributes the following equation and is represented by Sj.

$$S_j = (1/n) / \sum_{i=1}^{n} \{ E_{ij} - (E_{ij})_{\mathbf{mean}} \}^2 \quad \text{---------- (2)}$$

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Step 3: Determine objective weights of importance of the attributes

The objective weight of the jth attribute Wj is computed by dividing the statistical variance of jth attribute with the total value of the statistical variances of 'm' number of attributes. The objective weights have been computed by using formula as shown in equation (3).

$$W_j = S_j / \sum_{i=1}^{n} S_j \quad \ldots\ldots\ldots (3)$$

Step 4:- Calculation of preference index

Each attribute (air pollutant concentrations) is given a weight and each alternative (locations) is assessed to data corresponding to every attribute. The overall performance score of an alternative is the weighted sum, called preference index. The preference index for each alternative indicates the score or merit of the alternative with respect to the other alternatives.

The preference index (Ii) can be calculated using the following equations:

$$I_i = \sum_{j=1}^{n} W_j E_{ij}^{**} \quad \ldots\ldots\ldots (4)$$

where, $E_{ij}^{**} = [\ E_{ij}^{*b} / (\ E_{ij}^{*b}\ )_{max}\ ]$ for beneficial attributes and $[(E_{ij}^{*nb})_{min} / E_{ij}^{*nb}]$ for non-beneficial attributes . E_{ij}^{*b} and E_{ij}^{*nb} indicate the normalized values of the beneficial and non-beneficial attributes, respectively.

3. DATA COLLECTION

The environmental parameters PM10, sulphur dioxide,Nox,Ammonia and carbon monoxide at ambient air have direct effect on environment is considered. Ambient Air Quality Management AAQM data of Hyderabad during the year 2013 and 2014 is considered[14].

S.No	Station Name	2013					2014				
		PM_{10} ug/m^3	SO_2 ug/m^3	No_x ug/m3	NH_3 ug/m^3	CO mg/m^3	PM_{10} ug/m^3	SO_2 ug/m^3	No_x ug/m3	NH_3 ug/m^3	CO mg/m^3
1	Balanagar	144	5.0	28.6	100	1	135	5.1	32.0	131	1
2	Uppal	90	4.8	24.3	105	-	99	5.0	26.5	122	
3	Jubilee Hills	72	4.3	17.4	87	1	80	4.5	19.6	127	2
4	Jeedimetla	92	4.9	25.0	110	-	107	5.1	29.5	144	-
5	Paradise	84	4.8	23.9	74	-	120	5.0	28.3	120	-
6	Charminar	95	4.8	24.2	100	3	112	5.0	27.7	125	4
7	Zoopark	73	4.3	13.6	92	4	73	4.3	16.6	105	1
Standards		60	50	40	100	4	60	50	40	100	4

Table 1.Environmental parameters

3.1Hierarchy diagram

Three level hierarchy diagram shown in Fig. 2 has been used to evaluate the locations. It shows that level 1refers to the goal, level 2 comprises of five objectives such as PM10,sulphurdioxide,Nox,Ammonia and carbon monoxide and level 3 refers to different alternatives such as locations 1, 2, 3, 4, 5,6 and 7. The objective of this research work is to find out the best alternative on the basis of air pollutants load.

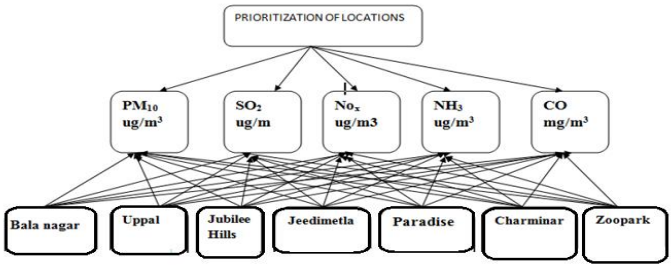

Fig 2. Three level hierarchy diagram

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4. RESULTS AND DISCUSSION

To obtain the values of relative weights, divide each entry in column by the sum of entries in column and values are shown in Table 2.

Year	2013					2014				
Locations	PM_{10} ug/m^3	SO_2 ug/m^3	No_x ug/m3	NH_3 ug/m^3	CO mg/m^3	PM_{10} ug/m^3	SO_2 ug/m^3	No_x ug/m3	NH_3 ug/m^3	CO mg/m^3
Balanagar	0.2215	0.1519	0.1821	0.1497	0.111	0.185	0.15	0.1720	0.1499	0.125
Uppal	0.1384	0.1458	0.1547	0.1571	0	0.136	0.147	0.1470	0.1395	0
Jubilee Hills	0.1107	0.1306	0.1108	0.1302	0.111	0.110	0.132	0.1088	0.1453	0.25
Jeedimetla	0.1415	0.1489	0.1592	0.1647	0	0.147	0.150	0.1637	0.1647	0
Paradise	0.1292	0.1458	0.1522	0.1108	0	0.1652	0.147	0.1570	0.1373	0
Charminar	0.1461	0.1458	0.1541	0.1497	0.33	0.1542	0.147	0.1537	0.1430	0.5
Zoopark	0.1123	0.1306	0.086	0.1377	0.44	0.1005	0.126	0.092	0.1201	0.125

Table 2.Normalized matrix

Statistical variance is a measure of the dispersion of a set of data points around their mean value; the variance looks at all the data points and then determines their distribution. The statistical variance values are shown in Table 3.

Year		2013	2014
S.No	Parameters	Variance	Variance
1	PM10	0.00090	0.00139
2	SO_2	0.00008	0.00007
3	No_x	0.00089	0.00107
4	NH_3	0.00018	0.00033
5	CO	0.03348	0.03109

Table 3.Variance of attributes

The objective weights have been computed by using below mentioned formula and the values of objective weights are shown in Table 4

Year		2013	2014
S.No	Parameters	Objective weight	Objective weight
1	PM10	0.02541	0.04107
2	SO_2	0.00249	0.00218
3	No_x	0.02512	0.03150
4	NH_3	0.00512	0.00975
5	CO	0.94185	0.91549

Table 4.Objective weights of attributes

The preference index for each location indicates the score or merit of the locations with respect to the other locations. The values of the preference index values and ranking of locations are shown in Table 5. The locations whose value is closest to unity is treated as last among other locations based on air pollutant load. In the present study, location 4 has lowest preference index value placed at first position, followed by locations 5, 2, 4, 6,3,1 and 8 for the year 2013.

Year	2013		2014	
Locations	Preference Index	Rank	Preference Index	Rank
Balanagar	0.3170	2	0.29316	3
Uppal	0.0677	5	0.04622	7
Jubilee Hills	0.2809	3	0.50809	2
Jeedimetla	0.0620	7	0.05092	6
Paradise	0.0627	6	0.05151	5
Charminar	0.0685	4	0.99158	1
Zoopark	0.9638	1	0.26808	4

Table.5 Preference index values and ranking of Locations

Crucial steps involved in the study are identifying the attributes and ranking the locations based on their impact on environment. The purpose of identification of attributes is to narrow down the choices to a manageable number for subsequent detailed evaluation. In the present study, the air pollutants impacts which have direct effect on environment to prioritize the locations. The multiple attribute decision making method simultaneously consider any number of quantitative and qualitative selection attributes like PM10,sulphurdioxide,Nox,Ammonia and carbon monoxide and helps to obtain the preference index which evaluates and ranks the locations.

5. CONCLUSION

The study mainly focuses on ranking of locations to ascertain adverse health effects due to air pollution. The first ranked location cannot be considered as benchmark to other location but it gives relative importance. As the air pollutant concentration increases causes adverse impact in urban environment and the relative importance create awareness among municipalities of the respective locations to take steps improve pollution control measures. It is also useful tool to monitor the impact of air pollution at various locations in the

Hyderabad. It is helpful to Government to incorporate/amend in the legislations relating to air pollution control in the urban environment.

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