S. Jackson et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Special Issue: Conscientious Computing Technologies, April 2018, pp. 418-423

An Analysis of Water Quality Using Fuzzy Matrices

S. Jackson[1], S.Nivedha[2], P.Amutha[3], T.Anny[4]

[1] Assistant Professor, [2] PG student

[1,2,3,4] P.G&.Research Department of Mathematics, V.O.Chidambaram College, Thoothukudi, India.

Abstract- **The classical set theory is built on the fundamental concept of set of which an individual is either a member or not a member. Thus, many real-world problems cannot be described and handled by the classical set theory, including all whose involving elements with only partial membership of a set. To overcome this problem In the year 1965 Lofti A. Zadeh[8] coined Fuzzy set theory. In 1998 W.B.Vasantha Kandsamy[7] cleared a pathway by establishing Fuzzy matrix theory. A fuzzy matrix is a matrix with elements having values in the fuzzy interval. In this Paper We Introduced Four new types of Fuzzy Matrices Called Initial Raw quantity Matrix(IRQ Matrix),Average Quantity Dependent Matrix(AQD matrix),Redefined Quantity Dependent Matrix(RQD Matrix),Combined Effect Quantity Dependent Matrix(CEQD Matrix) to know the level of chemicals mixed in the water samples from various places in the Kancheepuram District .**

AMS Mathematics Subject Classification: 15B15.

Keywords: AQD, RQD, CEQD, Decision making, Chemicals , Water Quality

1. INTRODUCTION

Many complicated problems in Economics, Science, Engineering, technology, medical sciences, social sciences and many other fields involve uncertain data. All the problems cannot be solved using classical mathematical methods. In classical mathematics, a mathematical tool of an object is formulated and the notion of the accurate solution of this model is determined. Because of that, the mathematical model is very difficult and the exact solution cannot be found. Fuzzy set theory, which was first proposed by the researcher Zadeh (1965)[8], has become a very important tool to solve problems and it provides an appropriate framework for representing vague concepts by allowing partial membership. In the year 1998 Fuzzy matrix theory was developed by W.B.Vasantha[7] and V.Indira to study the passenger transportation problem. To study this problem they divided and defined four types of new matrices called Initial Raw Matrix, Average Time Dependent Data matrix (ATD), Refined Time Dependent Data matrix (RTD matrix) and Combined Effect Time Dependent Data matrix (CETD matrix). Dr.A.Kalaichelvi & S.Gnanamalar(2013)[2] used to analyze the problems encountered by the coffee cultivators in Kodai hills.Using Fuzzy Technique the problems faced by the farmers in Sriperumbudur taluk, Kanchi district was analyzed by T.Pathinathan and M.Peter[4]. In 2017, Dr.D.Radhika et.al[5,6] used fuzzy matrix in the field of aqua culture by choosing the appropriate feed, in which the uncertain information gathered by experimentally using Azolla microphyla as a feed to the fishes Cyprinus Carpio. The application of Fuzzy matrix to the prediction of biological values has been attempted previously in many cases of health care issues like cancer and also nutrition is investigated by R.Umarani and H.Lokman Sithic[3].

In this Paper We initiate Four new types of Fuzzy Matrices Called Initial Raw quantity Matrix(IRQ Matrix),Average Quantity Dependent Matrix(AQD matrix),Redefined Quantity Dependent Matrix(RQD Matrix),Combined Effect Quantity Dependent Matrix(CEQD Matrix) to know the level of chemicals mixed in the water samples from various places in the Kancheepuram District .

2. BASIC CONCEPT OF FUZZY MATRIX THEORY:

We say [0, 1] denotes the unit interval. We say $x \in [0, 1]$ if $0 \leq x \leq 1$. We also call unit interval as a Fuzzy interval. We say [a, b] is a Fuzzy sub interval of the Fuzzy interval [0, 1] if $0 \leq a \leq b \leq 1$: we denote this by [a, b] sub-section of [0, 1]. We also use the convention of calling [-1, 1] to be also a Fuzzy interval, $x \in [-1, 1]$ if $-1 \leq x \leq 1$. Thus we have $\{x/ x \in [0, 1]$ i.e.$0 \leq x \leq 1\}$ is uncountable; hence [0, 1] is an infinite set as [0, 1] is an uncountable set. Let X be any universal set. The characteristic function maps elements of X to elements of the set to elements of the set {0, 1}, which is formally expressed by XA: X [0, 1]. Set A is defined by its characteristics function XA. To be more non-technical a Fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse a value representing its grade of membership in the Fuzzy set.

For Zadeh introduced a theory whose objects Fuzzy sets are set with boundaries that are not precise. The membership in a Fuzzy set is not a matter of affixation or denial but rather a matter of a degree. The significance of Zadeh's contribution was that it challenged not only probability theory as a sole

agent for uncertainty; but the very foundations upon which the probability theory is based Aristotelian two-valued logic.

For when A is a Fuzzy set and x is a relevant object the proposition x is a member of A is not necessarily either true or false as required by two valued logic, but it may be true only to some degree the degree to which x is actually a member of A. It is most common, but not required to express degrees of membership in the Fuzzy sets as well as degrees of truth of the associated propositions by numbers in the closed unit intervals [0, 1]. The extreme values in this interval 0 and 1, then represent respectively, the total denial and affirmation of the membership in a given Fuzzy set as well as the falsity or truth of the associated proposition.

The capability of Fuzzy sets to express gradual transitions to membership to non-membership and vice versa has a broad utility. This not only helps in the representation of measurement of uncertainties but also gives a meaningful representation of vague concepts in a simple natural language.

3. NEW FORMS OF FUZZY MATRIX:

Initial Raw Quantity Matrix (IRQ Matrix)
This matrix contains the values of given data.

Average Quantity Dependent Matrix (AQD Matrix)
Raw data is transformed into Initial raw quantity dependent data matrix by taking along the rows the experimental values of the chemical parameters and along the columns. We may it into the Average Quantity Dependent Data (AQD) matrix by dividing each entry of the raw data matrix by the percentage difference in given water chemicals. This matrix represents a data, which is totally uniform.

Refined Quantity Dependent Matrix (RQD Matrix)
Using the average μ_j and the standard deviation σ_j of each j^{th} column and by choosing a parameter α from the interval [0, 1]. We can form the Refined Quantity Dependent Matrix using the conditions,

If
$$\begin{cases} a_{ij} \le (\mu_i - \alpha*\sigma_j) & ; \ e_{ij} = -1 \\ a_{ij} \in (\mu_i - \alpha*\sigma_j,\ \mu_i + \alpha*\sigma_j) & ; \ e_{ij} = 0 \\ a_{ij} \ge (\mu_i - \alpha*\sigma_j) & ; \ e_{ij} = 1, \end{cases}$$

Where e_{ij} 's are entries of Average Quantity Dependent Matrix. This matrix is also at times turned as a the Fuzzy Matrix as the entries 1, 0 & -1

Combined Effect Quantity Matrix (CEQD Matrix)
It is the matrix whose entries are the cumulative values of the corresponding entries of the RQD Fuzzy matrix for different values of α choses in [0, 1].

Fuzzy Matrix Model:
This is a five stage process.
In first stage, the raw data of the problem at hand is converted or transformed into a Average Quantity Dependent Matrix [AQD Matrix].

In the second stage, after obtaining the Average Quantity Dependent Matrix, next have to find Average and Standard Deviation.

In the third stage, using the Average Technique, to convert the AQD Matrix into a Fuzzy Matrix with entries eij , where eij ∈ {-1,0,1}. We call this matrix as the Fuzzy Matrix or Refined Quantity Data Matrix (RQD-Matrix). At the same time we calculate Row sum matrix for RQD Matrices.

At the fourth stage, we get the Combined Effect Quantity Dependent Data Matrix (CEQD-Matrix), which was the cumulative effect of the all these entries of RQD Matrices.

In the Final stage we obtain the Row sum of the CEQD Matrix along the Y-axis and time scale along X-axis. These graphs are understandable even by a simple man. Hence this method is very effective.

4.APPLICATIONS OF FUZZY MATRICES

In order to analyse chemicals in the water, an interview schedule was administered to 10 chemicals in the 10 different areas in Tamilnadu (i) Voyalur, (ii) Sadras, (iii) Elumichampet, (iv)Pallikaranai, (v) Madambakkam, (vi) Injambakkam, (vii) Muttukkadu, (viii) Vengaivasal, (ix) Tambaram, (x) Thiruneermalai

The list of the chemicals in the water encountered by them is as follows

No3 – Nitrate ,CA – Calcium, Mg – Magnesium, Na – Sodium, K – Potassium, CL – Chlorine,
So4 – Sulphate, Co3 – Carbonate, HCo3- Hydrogen carbonate, F – Fluorine

Initial Raw Quantity Matrix

	No_3	CA	Mg	Na	K	CL	So_4	Co_3	HCo_3	F
Voyalur	17	70	34	115	28	156	53	36	238	0.1
Sadras	13	36	49	152	3	248	70	18	153	0.18
Elumichampet	13	96	75	230	2	440	154	0	293	0.19
Pallikaranai	5	96	33	138	26	220	83	0	378	0.18

Mdambakkam	4	44	23	71	8	92	60	0	183	0.05
Injambakkam	1	26	7	21	2	25	35	15	55	0.02
Muttukkadu	3	24	16	71	26	103	40	18	110	0.24
Vengaivasal	1	52	51	161	32	177	26	60	427	0.55
Tambaram	29	100	34	115	176	163	48	0	561	0.22
Thiruneermalai	11	96	39	94	74	206	65	36	329	0.32

Stage 1:

In the this stage the initial raw quantity matrix has been converted into the Average Quantity Dependent Matrix (AQD Matrix)

To convert into AQD Matrix, every row of the raw quantity matrix is divided by 100.

AQD Matrix

	No3	CA	Mg	Na	K	CL	So4	Co3	HCo3	F
Voyalur	0.17	0.70	0.34	1.15	0.28	1.56	0.53	0.36	2.38	0.001
Sadras	0.13	0.36	0.49	1.52	0.03	2.48	0.70	0.18	1.53	0.0018
Elumichampet	0.13	0.96	0.75	2.30	0.o2	4.40	1.54	0	2.93	0.0019
Pallikaranai	0.05	0.96	0.33	1.38	0.26	2.20	0.83	0	3.78	0.0018
Mdambakkam	0.04	0.44	0.23	0.71	0.08	0.92	0.60	0	1.83	0.0005
Injambakkams	0.01	0.26	0.07	0.21	0.02	0.25	0.35	0.15	0.55	0.0002
Muttukkadu	0.03	0.24	0.16	0.71	0.26	1.03	0.40	0.18	1.10	0.0024
Vengaivasal	0.01	0.52	0.51	1.61	0.32	1.77	0.26	0.60	4.27	0.0055
Tambaram	0.29	1	0.34	1.15	1.76	1.63	0.48	0	5.61	0.0022
Thiruneermalai	0.11	0.96	0.39	0.94	0.74	2.06	0.65	0.36	3.29	0.0032

Stage 2: The average (μ_j) and the standard deviation (σ_j) of every column were worked out as follows

Average	0.097	0.64	0.361	1.168	0.377	1.83	0.634	0.183	2.727	0.00205
Standard deviation	0.0882	0.3123	0.193	0.581	0.5321	1.1204	0.3613	0.2032	1.5601	0.00151

Stage 3: At the third stage, the Average and the Standard Deviation(SD) of every column in the AQD Matrix are determined using the average (μ_j) of each j^{th} column, standard deviation (σ_j) for each j^{th} column and a parameter α from the interval [0, 1], a fuzzy matrices called the Refined quantity Dependent Matrix (RQD Matrix) was formed. The RQD matrix with the entries e_{ij}, where $e_{ij} \epsilon \{-1,0,1\}$, was formed using the formula in the definition.

Stage 4: Calculate RQD Fuzzy Matrix for different α – values that is randomly chosen between [0, 1] based on the values Average and Standard Deviation tables and also Row Sum Matrix. i.e., sum of the row values of the founded Fuzzy matrix.

RQD MATRIX for α=0.3 **Sum of matrix**

1	0	0	0	0	0	0	1	0	-1
0	-1	1	1	-1	0	0	0	-1	0
0	1	1	1	-1	1	1	-1	0	0
0	1	0	0	0	0	0	-1	1	0
-1	-1	-1	-1	0	-1	0	-1	0	-1
-1	-1	-1	-1	-1	-1	-1	0	-1	-1
-1	-1	-1	-1	0	-1	-1	0	-1	0
-1	0	1	1	0	0	-1	1	1	1
1	1	0	0	1	0	0	-1	1	0
0	1	0	0	1	0	0	1	0	1

1
-1
3
1
-7
-9
-7
3
3
4

0	0	0	0	0	0	0	0	0	0
0	-1	0	0	0	0	0	0	0	0
0	1	1	1	0	1	1	-1	0	0
0	1	0	0	0	0	0	-1	0	0
0	0	0	0	0	0	0	-1	0	-1
-1	-1	-1	-1	0	-1	0	0	-1	-1
0	-1	-1	0	0	0	0	0	-1	0
-1	0	0	0	0	0	-1	1	1	1
1	1	0	0	1	0	0	-1	1	0
0	1	0	0	0	0	0	0	0	0

Sum of

0
-1
4
0
-2
-7
-3
1
3
1

α=0.6 matrix

1	0	0	0	0	0	-1	1	0	-1
1	-1	1	1	-1	1	0	0	-1	0
1	1	1	1	-1	1	1	-1	0	0
-1	1	0	1	0	1	1	-1	1	0
-1	-1	-1	-1	-1	-1	0	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	0	-1	-1
-1	-1	-1	-1	0	-1	-1	0	-1	0
-1	-1	1	1	0	0	-1	1	1	1
1	1	0	0	1	0	-1	-1	1	0
0	1	0	-1	1	0	0	1	1	1

Sum of

0
1
4
3
-9
-9
-7
2
2
4

α=0.9 matrix

Stage 5

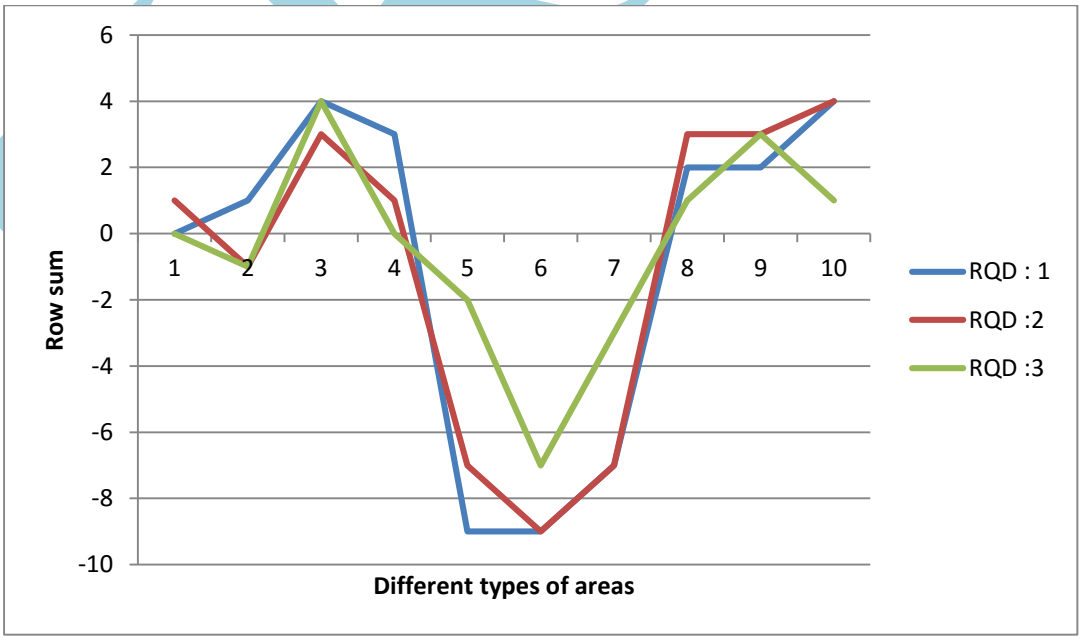
At the final stage by combining all these three matrices, the Combined Effect Quantity Dependent Data Matrix (CEQD – Matrix) which gives the Cumulative effect of all these entries. This gives the following CEQD-Matrix and also CEQD Row matrix.

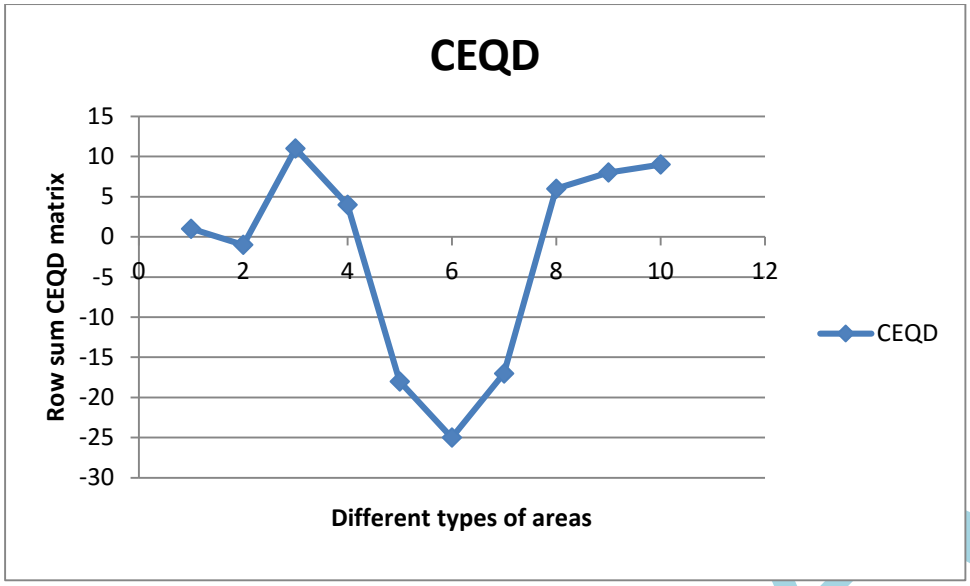
CEQD Matrix **Sum of matrix**

$$\begin{bmatrix} 2 & 0 & 0 & 0 & 0 & 0 & -1 & 2 & 0 & -2 \\ 1 & -3 & 2 & 2 & -2 & 1 & 0 & 0 & -2 & 0 \\ 1 & 3 & 3 & 3 & -2 & 3 & 3 & -3 & 0 & 0 \\ -1 & 3 & 0 & 1 & 0 & 1 & 1 & -3 & 2 & 0 \\ -2 & -2 & -2 & -2 & -1 & -2 & 0 & -3 & -1 & -3 \\ -3 & -3 & -3 & -3 & -2 & -3 & -2 & 0 & -3 & -3 \\ -2 & -3 & -3 & -2 & 0 & -2 & -2 & 0 & -3 & 0 \\ -3 & -1 & 2 & 2 & 0 & 0 & -3 & 3 & 3 & 3 \\ 3 & 3 & 0 & 0 & 3 & 0 & -1 & -3 & 3 & 0 \\ 0 & 3 & 0 & -1 & 2 & 0 & 0 & 2 & 1 & 2 \end{bmatrix} \quad \begin{bmatrix} 1 \\ -1 \\ 11 \\ 4 \\ -18 \\ -25 \\ -17 \\ 6 \\ 8 \\ 9 \end{bmatrix}$$

5.RESULT :

Next the chart has been drawn using the above matrix values. the plot of graphical charts displays between the chemicals and Row matrix of Fuzzies of different α-values, that gives the result of which area has the impure water





5.RESULT :

Next the chart has been drawn using the above matrix values. the plot of graphical charts displays between the chemicals and Row matrix of Fuzzies of different α-values, that gives the result of which area has the impure water. The RQD matrix and CEQD matrix are formed using Microsoft Excel and the charts are prepared using Microsoft Excel Sheet. From the graphical representation of CEQD matrix, ELUMICHAMPET has more chemicals in the water.

6.CONCLUSION :

The above experiment was concluded using the experimental data of parameters of the place which carries chemical in water. In this paper the fuzzy AQD, RQD and CEQD matrix concepts are adopted to determine the water quality in the given set of places. The fuzzy logic used to transform the data into Quantity Dependent Matrix. With these matrixes we are able to identify the place with chemicals contained in water. The result of the fuzzy matrix model; gave the exact result as that obtained experimentally.

REFERENCES

1. Geethalakshmi, M., Jose Praveena, N. and Rajkumar, A. (2012), "Result analysis of students using fuzzy matrices", International Journal of Scientific and Research Publications, 2, no. 4, pp. 1-4.
2. Kalaichelvi, A. and Gnamalar, S. (2011), "Application of fuzzy matrices in the analysis of encountered by the coffee cultivators in kodaihillls", International Journal of Mathematical Sciences and Applications, 1, no. 2, pp. 651-657.
3. Lokman Sithic ,H., and Umarani,R., Fuzzy matrix theory as a knowledge discovery in health care domain Procedia computer science (47),PP 282-291(2015).
4. Pathinathan, T. and Peter.M. (2014), "Adaptation of induced fuzzy cognitive maps to the problems faced by the farmers in Sriperumbudur taluk, Kanchi district",

International Journal of Computing Algorithm, 3, pp. 578-582.
5. Radhika.D, Piousmissier.S, and Jackson.S" Fuzziness in Aqua Culture Decision Making", International Journal of Mathematical Archive-8(10), 2017, pp 23-28.
6. Radhika.D, Piousmissier.S, and Jackson.S," Fuzzy Matrix Analysis in Aqua Culture", International Journal of Mathematics and its Applications, Volume 5, Issue 4–F (2017), pp 999–1005.
7. Vasantha Kandasamy W.B,"Elementary fuzzy matrix theory and fuzzy model for social scientists,(Automation Losangels 2007)",PP 94-110
8. Zadeh ,L.A., "Fuzzy sets information and control."(1965).

