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DETERMINING THE RISK FACTORS OF WASTES GENERATED FROM DYEING INDUSTRY USING BIPOLAR FUZZY SOFT MATRICES

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ABSTRACT

The rise in number of industries in our country has paved way for many health hazards among people. These wastes are generated in the form of chemicals and pollutants. In this paper has been collected from people residing near a dyeing industry about the health issues they are suffering due to the large number of industrial wastes. People of all age group have considered and using the concept of bipolar fuzzy soft matrices, it is found that which age group has been affected to the most by a particular disease due to the wastes emitted from these industries.

Key Words: *Soft Set, Bipolar Fuzzy Set, Fuzzy Soft Set, Bipolar Fuzzy Soft Set.*

AMS Subject Classification: *03E02, 03E72, 62C86, 26E50.*

INTRODUCTION

The notion of uncertainties has been studied for a long time by mathematicians. Many theories has been developed so far for study these uncertainties. The widely used mathematical tools for studying these uncertainties are fuzzy sets, soft sets, rough sets and so on. The concept of soft sets was first proposed by Molodstov [7]. Arindam Choudhure *et al.* [1] defined the concepts of soft relation and fuzzy soft relation and then applied them to solve a number of decision-making problems. Now a days much importance is given to the development of fuzzy soft theory which was initially introduced by Maji *et al.* [5]. The most important of applications of these sets on decision-making problems was given by F. Feng *et al.* [3]. The notion of soft matrices in theoretical study was studied by Cagman N. and Enginoglu S [2]. The concept of fuzzy matrices was also studied by Meenakshi A.R. and Kaliraja M. [6]. Tridiv Jyoti Neog *et al.* [10], Yong yang and Chenli Ji [11].

The theory of fuzzy sets was proposed by Zadeh L.A. [12]. Fuzzy set is an important structure to represent a collection of objects whose boundaries are imprecise or in other words vague. The most important extension of fuzzy sets is the bipolar valued fuzzy set whose membership degree range is different from the above extensions.

Lee [4] initiated the study of Bipolar valued fuzzy set which extends the interval [0, 1] to [-1, 1]. In a bipolar valued fuzzy sets, the membership degree 0 indicate the elements are irrelevant to the corresponding property, the membership degrees on (0, 1] assigned that elements somewhat satisfy the property, and the membership degrees on [-1, 0) assign that elements somewhat satisfy the implicit counter-property.

In this paper data has been collected from people residing near a dyeing industry about the health issues they are suffering due to the large amount of industrial wastes. People of all age group have been considered for collecting the data required to this paper and the data are fuzzified by using the concept of bipolar fuzzy soft matrices, it is found that which age group of people has been affected to the most by a particular disease due to the wastes emitted from these industries.

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PRELIMINARIES

In this section the important concepts are required for the study are discussed.

Definition 2.1: [12] If X is a collection of objects denoted generally x, then a fuzzy set A in X is defined as a set of ordered pairs $\tilde{A} = \{(x,\ \mu_{\tilde{A}}(x))/\ x \in X\}$. Where $\mu_{\tilde{A}}(x)$ is called the membership function (or grade membership of x) for the fuzzy set $\tilde{A}$. The membership function which maps each element of X to a membership value between 0 and 1.

Definition 2.2: [4] A bipolar fuzzy set A in the universe U is an object having the form,
A= $\{(x,\ A^{+}(x);\ A^{-}(x)) : x \in U\}$ where $\mu_A^{+}: U \to [0,1]$, $\mu_A^{-}: U \to [-1,0]$. So μ_A^{+} denote for positive information, μ_A^{-} denote the negative information.

Definition 2.3: [7] Let U be an initial universe, E be the set of parameters, A ⊂ E and P(U) is the power set of U. Then (F,A) is called a soft set, where F : A→ P(U).

Definition 2.4: [8] Let U be an universe, E be the set of parameters and A ⊂ E. Define F : A→ BF^U is the collection of all bipolar fuzzy subsets of U. Then (F, A) is said to be a bipolar fuzzy soft set over a universe U. It is defined by

$$(F, A) = F(e_i)$$
$$F(e_i) = \{(c_i,\ \mu^{+}(c_i);\ \mu^{-}(c_i)) : \forall c_i \in U,\ \forall e_i \in A\}$$

Definition 2.5: [8] The complement of a bipolar fuzzy soft set (F, A) is denoted $(F, A)^c$ and is defined by

$$(F, A)^c = \{(x, 1-\mu_A^{+}(x), -1-\mu_A^{-}(x))\ ;\ x \in U\}$$

Application of Bipolar Fuzzy Soft Matrices

With the Aid of [8, 9], we have constructed novel approach to fuzzy soft set via bipolarity.

Definition 2.6: Let $\tilde{A} = [a_{ij}^{\tilde{A}}]_{m\times n}$, $a_{ij}^{\tilde{A}} = \{(x,\ \mu_A^{+}(x),\ \mu_A^{-}(x))\ ;\ x \in U\}$; Also let $\tilde{B} = [b_{jk}^{\tilde{B}}]_{n\times p}$, $b_{jk}^{\tilde{B}} = \{(x, \mu_B^{+}(x), \mu_B^{-}(x))\ ;\ x \in U\}$; We now define $\tilde{A}.\tilde{B}$ the product of $\tilde{A}$ and $\tilde{B}$ as $\tilde{A}.\tilde{B} = [d_{ik}^{\tilde{A}\tilde{B}}]_{m\times p}$ = [max min $(\mu_A^{+}(x), \mu_B^{+}(x))$, min max $(\mu_A^{-}(x), \mu_B^{-}(x))]_{m\times p}$, $1 \le i \le m$, $1 \le k \le p$ for j = 1, 2, 3, …, n.

Definition 2.7: The membership value matrix corresponding to the matrix $\tilde{A}$ is given by MV($\tilde{A}$) = $[\delta_{ij}^{\tilde{A}}]_{m\times n}$, where $\delta_{ij}^{\tilde{A}} = \mu_{ij}^{+}(x) + \mu_{ij}^{-}(x)\ \forall i = 1,2,3,\dots,m \text{ and } j = 1,2,3,\dots,n$.

In this connection, the application of bipolar fuzzy soft matrices based on the data collected from people residing near a dyeing factory at Erode.

Let A be the collection of age group of people near a dyeing factory, A = $\{A_1, A_2, A_3\}$ where A_1 denotes age group from 1-35, A_2 denotes age group from 36-50 and A_3 denotes age group from above 50.We consider the set S = $\{e_1, e_2, e_3\}$ as an universal set where e_1, e_2 and e_3 represents the people affected by the diseases like Skin Disease, Asthma, Eye Problems respectively. Let the set W = $\{w_1, w_2, w_3\}$ represents the types of wastes from the dyeing factory where w_1, w_2 and w_3 BOD, COD and PH factor respectively. The following tables gives the number of people who are affected by various diseases and the amount of wastes emitted from the dyeing factory.

Table-1: Age wise data of people affected by diseases

Ages \ Diseases	Skin Disease	Asthma	Eye Problems
1-35 yrs	38	38	57
36-50 yrs	32	19	29
51 and above	19	33	27

Table-2: Amount of wastes emitted from these factories

Type of waste	Emitted values
Biological Oxygen Demand(BOD)	300-500 mg/L
Chemical Oxygen Demand(COD)	1000-2000 mg/L
PH factor	6-10

We construct a bipolar fuzzy soft set ($\widetilde{F}$, W) = {($W_{i,}$ $\mu^{+}(w_i)$; $\mu^{-}(w_i)$)} over S, where W_i is the total amount of wastes emitted from the factor, $\mu^{+}(W_i)$ denotes the range to which the waste has totally affected a person with a particular disease and $\mu^{-}(W_i)$ denotes the range to which the waste has caused a person to get a susceptible to a particular disease.

This bipolar fuzzy soft set gives a relation between the wastes emitted and the diseases, the complement of the bipolar fuzzy soft set is denoted by $(\widetilde{F},\ W)^{c}$. Also, we construct another bipolar fuzzy soft set ($\widetilde{F}$, S) = {($S_{i,}$ $\mu^{+}(s_i)$, $\mu^{-}(s_i)$)} where S_i are the diseases affecting different age groups of people, $\mu^{+}(s_i)$ denotes the range of people who are totally affected by a disease in a particular age group and $\mu^{-}(s_i)$ denotes the range of people who show signs of getting affected in that age group. The complement of ($\widetilde{F}$, S) is denoted by $(\widetilde{F}, S)^{c}$.

The method of computation is as follows:

1. Convert the numerical data into the bipolar fuzzy soft set of the form ($\widetilde{F}$, W) and compute $(\widetilde{F},\ W)^{c}$.
2. Convert the numerical data into the bipolar fuzzy soft set of the form ($\widetilde{F}$, S) and compute $(\widetilde{F},\ S)^{c}$.
3. Compute $\tilde{T}_1 = (\widetilde{F}, S) \cdot (\widetilde{F}, W)$, $\tilde{T}_2 = (\widetilde{F}, S) \cdot (\widetilde{F}, W)^{c}$, $\tilde{T}_3 = (\widetilde{F}, S)^{c} \cdot (\widetilde{F}, W)$ and $\tilde{T}_4 = (\widetilde{F}, S)^{c} \cdot (\widetilde{F}, W)^{c}$.
4. Compute the corresponding membership value matrices MV($\tilde{T}_1$), MV($\tilde{T}_2$), MV($\tilde{T}_3$), MV($\tilde{T}_4$).
5. Compute the diagnosis score $C_{\tilde{T}_1} = [\gamma(\tilde{T}_1)_{ij}]_{m\times n}$ where $\gamma(\tilde{T}_1)_{ij} = \rho(\tilde{T}_3)_{ij} - \rho(\tilde{T}_1)_{ij}$ and $C_{\tilde{T}_2} = [\gamma(\tilde{T}_4)_{ij}]_{m\times n}$ where $\gamma(\tilde{T}_2)_{ij} = \rho(\tilde{T}_2)_{ij} - \rho(\tilde{T}_4)_{ij}$ and $\rho(\tilde{T}_k)_{ij} = \mu_{ij}^{+}(x) + \mu_{ij}^{-}(x)$ for all k = 1, 2, 3, …., r, i = 1, 2, 3, …., m, j = 1, 2, 3, …, n.
6. Find C_k = max ($C_{\tilde{T}_1}(a_{i,}\ w_j)$ and $C_{\tilde{T}_2}(a_{i,}\ w_j)$). We conclude that the age group of people a_i is suffering from physical inability due to the waste w_k.
7. If C_k has more than one value, then go to step (1) and repeat the process by reassessing the symptoms for the patient.

This is numerically computed as follows:

Step-1: Consider the bipolar fuzzy soft set ($\widetilde{F}$,W) over S, where $\tilde{F}$ is a mapping $\tilde{F} : W \to \tilde{F}(S)$ where $\tilde{F}(S)$ denotes the diseases due to which people are affected by the wastes emitted from the industry.

$(\widetilde{F}, W)$ ={ $\tilde{F}(w_1) = \{(e_1, 0.68, -0.21), (e_2, 0.76, -0.17), (e_3, 0.88, -0.05)\}$,
$\tilde{F}(w_2) = \{(e_1, 0.51, -0.36), (e_2, 0.67, -0.28), (e_3, 0.89, -0.03)\}$,
$\tilde{F}(w_3) = \{(e_1, 0.68, -0.26), (e_2, 0.74, -0.19), (e_3, 0.92, -0.05)\}$}.

The complement $(\widetilde{F}, W)^{c}$ is given by

$(\widetilde{F}, W)^{c}$ ={ $\tilde{F}^{c}(w_1) = \{(e_1, 0.32, -0.79), (e_2, 0.21, -0.83), (e_3, 0.12, -0.95)\}$,
$\tilde{F}^{c}(w_2) = \{(e_1, 0.49, -0.64), (e_2, 0.33, -0.72), (e_3, 0.11, -0.97)\}$,
$\tilde{F}^{c}(w_3) = \{(e_1, 0.32, -0.74), (e_2, 0.26, -0.81), (e_3, 0.08, -0.95)\}$}.

We represent the bipolar fuzzy soft sets ($\widetilde{F}$, W) and $(\widetilde{F}, W)^{c}$ by the following matrices $\widetilde{W}$ and $\widetilde{W}^{c}$ respectively.

$$\widetilde{W} = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \end{array}\!\!\begin{array}{c} \begin{array}{ccc} \quad w_1 \quad & \quad w_2 \quad & \quad w_3 \quad \end{array} \\ \begin{pmatrix} (0.68, -0.21) & (0.51, -0.36) & (0.68, -0.26) \\ (0.76, -0.17) & (0.67, -0.28) & (0.74, -0.19) \\ (0.88, -0.05) & (0.89, -0.03) & (0.92, -0.05) \end{pmatrix} \end{array}$$

and

$$\widetilde{W}^{c} = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \end{array}\!\!\begin{array}{c} \begin{array}{ccc} \quad w_1 \quad & \quad w_2 \quad & \quad w_3 \quad \end{array} \\ \begin{pmatrix} (0.32, -0.79) & (0.49, -0.64) & (0.32, -0.74) \\ (0.24, -0.83) & (0.33, -0.72) & (0.26, -0.81) \\ (0.12, -0.95) & (0.11, -0.97) & (0.08, -0.95) \end{pmatrix} \end{array}$$

Step-2: Again we take the group of ages A = {A_1, A_2, A_3} as an universal set where A_1, A_2 and A_3 represents the ages from 1-35 yrs, 36-50 yrs and 51 and above yrs respectively and S = {e_1, e_2, e_3} as an universal set where e_1, e_2 and e_3 represents the people affected by the diseases like Skin Disease, Asthma, Eye Problems respectively.

Let the bipolar fuzzy soft set ($\widetilde{F}$, S) over S, where $\tilde{F}$ is a mapping $\tilde{F} : S \to \tilde{F}(A)$ gives a collection of an approximate description of the group of ages of people affected by the diseases.

Let

$(\widetilde{F}, S)$ ={ $\tilde{F}(e_1) = \{(A_1, 0.28, -0.67), (A_2, 0.40, -0.45), (A_3, 0.24, -0.62)\}$,
$\tilde{F}(e_2) = \{(A_1, 0.28, -0.53), (A, 0.23, -0.58), (A_3, 0.41, -0.46)\}$,
$\tilde{F}(e_3) = \{(A_1, 0.43, -0.39), (A_2, 0.36, -0.54), (A_3, 0.34, -0.52)\}$}.

The complement $(\widetilde{F}, S)^c$ is given by

$$(\widetilde{F}, S)^c = \{ \widetilde{F}^c(e_1) = \{(A_1, 0.72, -0.33), (A_2, 0.6, -0.55), (A_3, 0.76, -0.38)\},$$
$$\widetilde{F}^c(e_2) = \{(A_1, 0.72, -0.47), (A_2, 0.77, -0.42), (A_3, 0.59, -0.54)\},$$
$$\widetilde{F}^c(e_3) = \{(A_1, 0.57, -0.61), (A_2, 0.64, -0.46), (A_3, 0.66, -0.48)\}\}.$$

We represent the bipolar fuzzy soft sets $(\widetilde{F}, S)$ and $(\widetilde{F}, S)^c$ by the following matrices $\tilde{S}$ and $\tilde{S}^c$ respectively.

$$\tilde{S} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array}\begin{array}{c} \begin{array}{ccc} e_1 & e_2 & e_3 \end{array} \\ \begin{pmatrix} (0.28, -0.67) & (0.28, -0.53) & (0.43, -0.39) \\ (0.40, -0.45) & (0.23, -0.58) & (0.36, -0.54) \\ (0.24, -0.62) & (0.41, -0.46) & (0.34, -0.52) \end{pmatrix} \end{array}$$

and

$$\tilde{S}^c = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array}\begin{array}{c} \begin{array}{ccc} e_1 & e_2 & e_3 \end{array} \\ \begin{pmatrix} (0.72, -0.33) & (0.72, -0.47) & (0.57, -0.61) \\ (0.60, -0.55) & (0.77, -0.42) & (0.64, -0.46) \\ (0.76, -0.38) & (0.59, -0.54) & (0.66, -0.48) \end{pmatrix} \end{array}$$

Step-3 and 4: Thus we have

$$\tilde{T}_1 = \tilde{S}\,.\,\widetilde{W} = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \end{array}\begin{array}{c} \begin{array}{ccc} w_1 & w_2 & w_3 \end{array} \\ \begin{pmatrix} (0.43, -0.21) & (0.43, -0.26) & (0.43, -0.26) \\ (0.40, -0.21) & (0.40, -0.36) & (0.40, -0.26) \\ (0.41, -0.21) & (0.41, -0.36) & (0.41, -0.26) \end{pmatrix} \end{array}$$

and

$$\tilde{T}_2 = \tilde{S}.\widetilde{W}^c = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \end{array}\begin{array}{c} \begin{array}{ccc} w_1 & w_2 & w_3 \end{array} \\ \begin{pmatrix} (0.28, -0.67) & (0.28, -0.64) & (0.28, -0.67) \\ (0.32, -0.58) & (0.40, -0.58) & (0.36, -0.58) \\ (0.24, -0.62) & (0.33, -0.62) & (0.26, -0.62) \end{pmatrix} \end{array}$$

and we have the following membership value matrices $MV(\tilde{T}_1)$, $MV(\tilde{T}_2)$.

$$MV(\tilde{T}_1) = \begin{bmatrix} 0.22 & 0.07 & 0.17 \\ 0.19 & 0.04 & 0.14 \\ 0.20 & 0.05 & 0.15 \end{bmatrix} \text{ and } MV(\tilde{T}_2) = \begin{bmatrix} -0.39 & -0.36 & -0.39 \\ -0.26 & -0.18 & -0.22 \\ -0.38 & -0.29 & -0.36 \end{bmatrix}$$

Again

$$\tilde{T}_3 = \tilde{S}^c.\widetilde{W} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array}\begin{array}{c} \begin{array}{ccc} w_1 & w_2 & w_3 \end{array} \\ \begin{pmatrix} (0.72, -0.21) & (0.67, -0.33) & (0.72, -0.26) \\ (0.76, -0.21) & (0.67, -0.36) & (0.74, -0.26) \\ (0.68, -0.21) & (0.66, -0.36) & (0.68, -0.26) \end{pmatrix} \end{array}$$

and

$$\tilde{T}_4 = \tilde{S}^c.\widetilde{W}^c = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array}\begin{array}{c} \begin{array}{ccc} w_1 & w_2 & w_3 \end{array} \\ \begin{pmatrix} (0.49, -0.61) & (0.33, -0.61) & (0.12, -0.61) \\ (0.49, -0.55) & (0.33, -0.55) & (0.12, -0.55) \\ (0.49, -0.54) & (0.33, -0.54) & (0.12, -0.54) \end{pmatrix} \end{array}$$

And we have the following membership value matrices $MV(\tilde{T}_3)$, $MV(\tilde{T}_4)$.

$$MV(\tilde{T}_3) = \begin{bmatrix} 0.51 & 0.34 & 0.46 \\ 0.55 & 0.31 & 0.48 \\ 0.47 & 0.30 & 0.42 \end{bmatrix} \text{ and } MV(\tilde{T}_4) = \begin{bmatrix} -0.12 & -0.28 & -0.49 \\ -0.06 & -0.22 & -0.43 \\ -0.05 & -0.21 & -0.42 \end{bmatrix}$$

Step-5: We now compute the diagnosis score $C_{\tilde{T}_1}$ and $C_{\tilde{T}_2}$ for and against the diseases as below

$$C_{\tilde{T}_1} = \begin{bmatrix} 0.29 & 0.27 & 0.29 \\ 0.36 & 0.27 & 0.34 \\ 0.27 & 0.25 & 0.27 \end{bmatrix} \text{ and } C_{\tilde{T}_2} = \begin{bmatrix} 0.27 & 0.08 & -0.10 \\ 0.20 & -0.04 & -0.21 \\ 0.33 & 0.08 & -0.06 \end{bmatrix}$$

Step-6: Now we have the difference for the diseases

$C_{\tilde{T}_1}$ - $C_{\tilde{T}_2}$	d_1	d_2	d_3
A_1	0.02	0.19	0.39
A_2	0.16	0.31	0.55
A_3	-0.06	0.17	0.33

Thus, we conclude that age group A_1, A_2 and A_3 (i. e: 36-50 yrs) are mostly affected due to the emission of waste w_3 (PH factor) . Also, the negative score for A_3 under w_1 indicates that people of that age group are on the verge of getting affected due to w_1 (Biochemical Oxygen Demand wastes) .

SUGGESTIONS

In order to safeguard the people residing around the industry the following measures can be taken:

- The pollutants present in discharged waters must be removed by effective filtering before its disposal.
- The fabrics must be made out of eco-friendly substances rather than using toxic chemicals.
- The industries that uses non-toxic substances must be endorsed financially by the concerned officials.
- Modern equipments that consumes less energy and water must be installed in all industries so that the amount of effulent water is reduced.
- People residing near the industries must filter the water more than once to protect themselves from harmful effects.
- Government has already set a range for emission for these chemicals from the industries. Hence, care must be taken that the emission is only below the prescribed range.

In order to avoid all the causes due to disposal of wastes from dyeing factory, it is strongly suggested

- To keep all such harmful industries far away from residential areas**.**

CONCLUSION

The above data were taken from people living near a dyeing industry and the resulting score gives us the details of how much the people are getting affected due to the emission of these wastes. The above mentioned points must always be considered by people, so that they can safeguard themselves against the impact of emitted wastes.

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