

Identifying the Cause of Using Endosulfan in Agriculture by Induced Fuzzy Cognitive Maps (IFCMs) Approach

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Abstract: *In this article we study to identify the cause of using Endosulfan in agriculture which leads to most dangerous side effects in human beings faced by the people of South Indian State of Kerala, Kasargode and Palakkad District using Induced Fuzzy Cognitive Maps (IFCMs). We have interviewed 101 Endosulfan victims in the area of Palakkad and Kasargod District of Kerala. This research investigates the most identifying, the cause of using Endosulfan in agriculture by using IFCMs. IFCMs are a fuzzy graph modeling approach based on experts opinion. This is non statistical approach to study the problems with imprecise information..*

Key words: Fuzzy Cognitive Maps, Induced FCMs, Pesticide Endosulfan.

1. Introduction

Endosulfan is a pesticide which is a leading chemical used against a broad spectrum of insects and mites in agricultural products like fruits, vegetables, rice, grains, tea, coffee, cotton, rice and grains. But Endosulfan is acutely toxic and is readily absorbed by the stomach and lungs, through skin. Symptoms of acute Endosulfan exposure include central nervous system disorders such as dizziness, vomiting, diarrhoea, breathing difficulties, convulsions, and loss of consciousness. In extreme cases, death can result. The Stockholm Convention, a global treaty to protect human health and environment from such compounds, has declared Endosulfan a persistent organic pollutant and 73 countries have banned its use. Endosulfan was banned in Kerala in 2005 after the Centre issued a gazette notification withholding the use of Endosulfan in the state, on the basis of reports of National Institute of Occupational Health and other committees. But the ban has been ineffective. Nearly 300 landholders of Palakkad who own big plantations in the region use Endosulfan and other pesticides extensively during the flowering seasons to kill pests, leaf miners and leaf hoppers. The aerial spraying of Endosulfan over the cashew plantations in Kasargod district in Kerala was started in 1978. In this study we have interviewed 101 Endosulfan victims in Palakkad and Kasargod District Of Kerala. These people are affected with the diseases like skin diseases, mentally retardation, epilepsy, autism, etc. Our aim is to identify the cause of using Endosulfan in agriculture and find out the remedial measures for it.

Fuzzy Cognitive Maps (FCMs) is a well established technique for prediction and decision making especially for situations where fuzziness and uncertainty exists. Lofti A. Zadeh in 1965 introduced the notion of fuzziness. In 1986, Kosko, the guru of fuzzy Cognitive Map introduced the Fuzzy Cognitive Maps. It was a fuzzy extension of the Cognitive Map pioneered in 1976 by Polical Scientists Robert Axelord. Who used it to represent knowledge as an interconnected, directed bilevel logic graph FCMs have a major role to play mainly when the data concerned is an unsupervised one

This method is most simple and an effective one as it can analyze the data by directed graphs and connection matrices. Even though IFCM is an advancement of FCM it follows the foundation of FCM. It has slight moderation only in algorithm approach. Our work is based on the field work conducted at Palakkad and Kasargod District of Kerala. The data collected from the victims of Endosulfan is studied using fuzzy model. The data collected from these people using linguistic questionnaire and is transformed in to fuzzy data. We analyze this using IFCMs model.

2. Fuzzy Cognitive Maps

Fuzzy Cognitive maps (FCMs) are fuzzy graphs structures for representing casual reasoning. Their fuzziness allows hazy degrees of causality between hazy casual objects (concepts). Their graph structure allows systematic casual propagation, in particular forward and backward chaining, and it allows knowledge bases to be grown by connecting different FCMs. Thus FCM is a directed graph with concepts like policies, events etc. as nodes and causalities as edges. It represents causal relationship between concepts. When the nodes of the FCM are fuzzy sets then they are called as fuzzy nodes. FCMs with edge weights or causalities from the set $\{-1, 0, 1\}$, are called simple FCMs. Consider the nodes or concepts $C_1, \dots, C_n$ of the FCM. Suppose the directed graph is drawn using edge weight $e_{ij} \in \{0, 1, -1\}$. The matrix E be defined by $E = (e_{ij})$, where e_{ij} is the weight of the directed edge $C_i C_j$. E is called the adjacency matrix of the FCM, also known as the connection matrix of the FCM. It is important to note that all matrices associated with an FCM are always square matrices with diagonal entries as zero. Let $C_1, C_2, \dots, C_n$ be the nodes of an FCM. $A = (a_1, a_2, \dots, a_n)$, where $e_{ij} \in \{0, 1\}$. A is called the instantaneous state vector and it denotes the on-off position of the node at an instant.

$a_i = 0$ if a_i is off
 $= 1$ if a_i is on, where $i = 1, 2, \dots, n$.

Let $C_1, C_2, \dots, C_n$ be the nodes of an FCM. Let $C_1 C_2, C_2 C_3, \dots, C_i C_j$ be the edges of the FCM ($i \neq j$). Then, the edges form a directed cycle. An FCM is said to be cyclic if it

possesses a directed cycle. An FCM is said to be acyclic if it does not possess any directed cycle. When there is a feedback in an FCM, i.e., when the causal relations flow through a cycle in a revolutionary way, the FCM is called a dynamical system. Let $C_1C_2C_2C_3, \dots, C_iC_j$ be a cycle. When C_i is switched on and if the causality flows through the edges of a cycle and if it again causes C_i , we say that the dynamical system goes round and round. This is true for any node C_i , for $i = 1, 2, \dots, n$. The equilibrium state for this dynamical system is called the hidden pattern. If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point. If the equilibrium state of a dynamical state is a unique state vector it is called a fixed point or limit cycle. Inference from the hidden pattern summarizes the joint effects of all interacting fuzzy knowledge.

3. Algorithmic Approach in Induced Fuzzy Cognitive Maps(IFCMs)

IFCM is an advancement of FCM it follows the foundation of FCM; it has a slight modification only in algorithm approaches. The following steps are used for finding IFCM.

Step 1: For the given model (problem) collect the unsupervised data that is in. Determinant factors called nodes

Step 2: According to the expert opinion, draw the directed graph.

Step 3: Obtain the connection matrix, M , from the directed graph (FCM). Here the Number of rows in the given matrix = number of steps to be performed.

Step 4: Consider the state vector C_1 which is in ON position. Find $C_1 \times M$. The state Vector is updated and threshold at each stage.

Step 5: Threshold values are calculated by assigning 1 for the values >1 and 0 for the values <0 . The symbol represents the threshold value for the product of the result.

Step 6: Now each component in the C_1 vector is taken separately and product of the given. Matrix is calculated. The vector which has maximum number of one's is found. The vector which has the maximum number of one's which occurs first considered as C_2

Step 7: When the same threshold value occurs twice. The value is considered as the. Fixed point. The iteration gets terminated.

Step 8: Consider the state vector C_1 by setting C_2 ON state that is assigning the Second component of the vector to be 1 and the rest of the components as 0. Precede the Calculations discussed in step 4 to 6

Step 9: Continue Step 9 for all the state vectors and find hidden pattern.

4. Identifying the cause of using Endosulfan – Undetermined factors

We have made a sample survey of 101 people of Kerala (Palakkad and Kasrgode). They were interviewed using a questionnaire relevant to the topic. According to their views some of the factors as indicators are considered for our studies are given as follows. The following are the eleven nodes taken by the experts

P_1 –Population Increase

P_2 –To increase food productivity

P_3 –Cheap cost

P_4 –Easy availability of Endosulfan

P_5 – Need better yield

P_6 – Need for pest control

P_7 –Illiteracy

P_8 –No awareness on ill effects of Endosulfan

P_9 –No knowledge of any other non chemical alternative

P_{10} –Non involvement of social organization

P_{11} –Govt. indifference or negligence in farmers

The following represents the connection graph of the above eleven concepts and its connection matrix

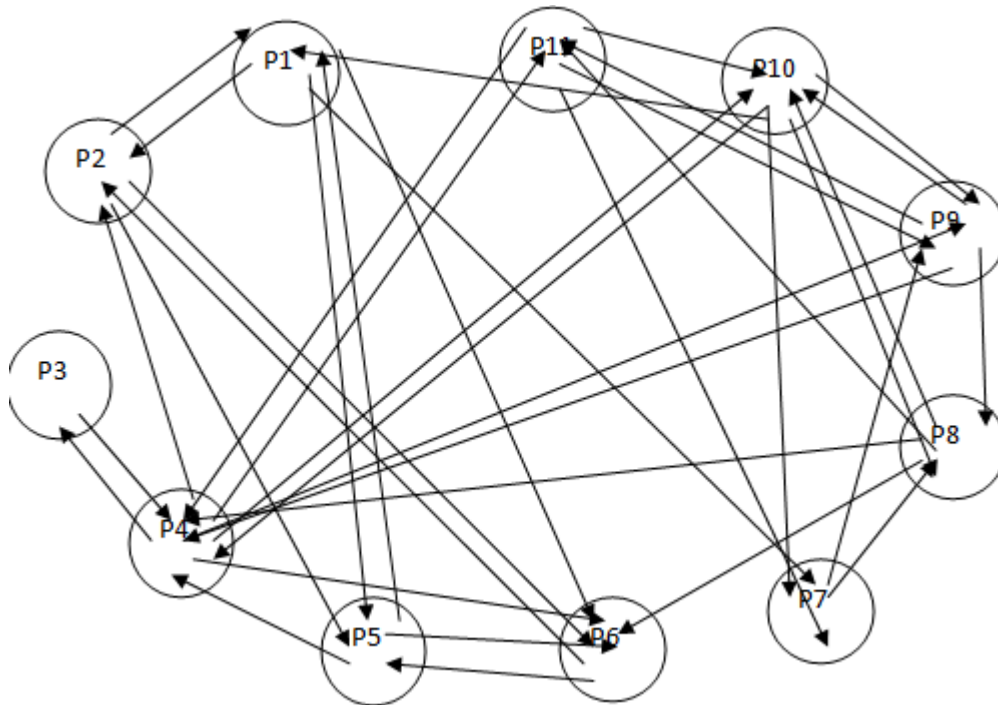


Figure 4.1: Directed graph

	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	P ₁₁	
P ₁	0	1	0	0	1	1	1	0	0	0	0	Threshold value is calculated by assigning 1 for values greater than 1 and 0 for the values less than 0. The symbol $\hookrightarrow$ represents the threshold value for the product of the result.
P ₂	1	0	0	0	1	1	0	0	0	0	0	
P ₃	0	0	0	1	0	0	0	0	0	0	0	Now $C_1^1 = (0\ 0\ 0\ 1\ 0\ 1\ 0\ 1\ 0\ 1\ 1)$ $C_1^1 M = (0\ 0\ 0\ 1\ 0\ 1\ 0\ 1\ 0\ 1\ 1)M$
P ₄	0	1	1	0	0	1	0	0	1	1	1	
P ₅	1	0	0	1	0	1	0	0	0	0	0	Now as per Induced Fuzzy Cognitive Map methodology, each component in the C_1^1 vector is taken separately and product of the given matrix is calculated. The vector which has the maximum number of one's which occurs first is considered as C_2 .
P ₆	0	1	0	0	1	0	0	0	0	0	0	
P ₇	0	0	0	0	0	0	0	1	1	0	0	The symbol $\sim$ denotes the calculation performed with the respective vector,
P ₈	0	0	0	1	0	1	0	0	0	1	1	
P ₉	0	0	0	1	0	0	0	1	0	1	1	$C_1^1 M \sim (0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M \hookrightarrow (0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$ $C_1^1 M \sim (0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)M \hookrightarrow (0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$ $C_1^1 M \sim (0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M \hookrightarrow (0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 1\ 1)$ $C_1^1 M \sim (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)M \hookrightarrow (1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$ $C_1^1 M \sim (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M \hookrightarrow (0\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$ $C_2 = (0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$ $C_2 M = (0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)M = (2\ 1\ 0\ 4\ 2\ 1\ 2\ 2\ 2\ 1\ 1)$
P ₁₀	1	0	0	1	0	0	1	1	1	0	0	
P ₁₁	0	0	0	1	0	0	1	1	1	0	0	

4.2 Connection Matrix

Trial 1:

Let us consider C_1 in the trial 1, by setting the concept C_8 to ON state, that is the eight component of the vector is set to be 1 and the rest are assigned to 0.

Let $C_1 = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0)$

Product of C_1 and M is calculated.

$$C_1 M = (0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 1\ 1) \hookrightarrow (0\ 0\ 0\ 1\ 0\ 1\ 0\ 1\ 0\ 1\ 1) = C_1^1$$

$$C_1^1 = (0\ 0\ 0\ 1\ 0\ 1\ 0\ 1\ 0\ 1\ 1)$$

Product of C_2 and M is calculated.

$$\hookrightarrow (1\ 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) = C_2^1$$

$$(1\ 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) = C_2^1$$

Similar to the above computation, the vector which has the maximum number of one's is found and left it be C_3 .
 $C_3 = (0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1) = C_2$

The fixed point is $C_3 = (0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$

When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated

and the calculation gets terminated and the calculation for Trial 2 is performed. Similar to the Trial 1, consider C_1 by setting C_9 in ON state that is, assigning the ninth component of the vector to be 1 and the rest of the component as 0.

The fixed point $C_3=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$

When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated and the calculation gets terminated and the calculation for Step 2 is performed. Similar to the Step 1, consider C_1 by setting C_9 in ON state that is, assigning the ninth component of the vector to be 1 and the rest of the component as 0.

Trial 2:

Let C_1 be

$$C_1=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)$$

$$C_1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 1\ 1)$$

Product of C_1 and M is calculated.

$$\rightarrow(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1)=C_1^1$$

$$C_1^1=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1)$$

$$C_1^1M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)M\rightarrow(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$$

$$C_1^1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M\rightarrow(0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 1\ 1)$$

$$C_1^1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)M\rightarrow(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 1\ 1)$$

$$C_1^1M(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M\rightarrow(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

$$C_1^1M(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M\rightarrow(0\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

Now the vector with maximum number of 1's be C_2 .

$$C_2=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$$

$$C_2M=(2\ 1\ 0\ 4\ 2\ 1\ 2\ 2\ 2\ 1\ 1)\rightarrow(1\ 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1)$$

$$C_2^1=\rightarrow(1\ 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1)$$

Now the vector with maximum number of 1's be C_3 .

$$C_3=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=$$

$$C_2^1M=(1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M$$

$$\rightarrow(0\ 1\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0)$$

$$C_2^1M=(0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M$$

$$\rightarrow(1\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0)$$

$$C_2^1M=(0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M$$

$$\rightarrow(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$C_2^1M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)M$$

$$\rightarrow(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 1)$$

$$C_2^1M=(0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0)M$$

$$\rightarrow(0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)$$

$$C_2^1M=(0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M$$

$$\rightarrow(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0)$$

$$C_2^1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M$$

$$\rightarrow(0\ 0\ 0\ 1\ 0\ 0\ 1\ 0\ 1\ 1)$$

$$C_2^1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)M$$

$$\rightarrow(0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 1)$$

$$C_2^1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M$$

$$\rightarrow(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0)$$

$$C_2^1M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M$$

$$\rightarrow(0\ 0\ 1\ 0\ 0\ 0\ 1\ 1\ 0\ 0)$$

Now the vector with maximum number of 1's be C_3 .

$$C_3=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$$

That is,

$$C_3=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=C_2, \text{ the fixed point is } C_3.$$

In the above manner, the other trials to be performed. By keeping each vector in ON position, the various fixed points are found.

5. Conclusion

In this study, we have performed two trials. Result of trials 1 suggests, by keeping concept P_8 in ON state, suggests C_4 as the hidden pattern. That is, all the 1's in C_4 are the possible factors revealed from the first factor. More precisely, the factors viz, to increase the food productivity(P_2), cheap cost(P_3), need for pest control(P_6), P_9 -No knowledge of any other non chemical alternative(P_9) non involvement of social organization(P_{10}) and Govt. indifference or negligence in farmers(P_{11}) are ON state.

In a similar manner, we can discuss the result of trials 2. In trials 2, we kept P_9 in ON position and we have derived C_4 as the hidden pattern. C_4 contains the factors in ON state are nothing but the factors which are discussed in trials 1. So by taking 'No knowledge of any other non chemical alternative' factors also we obtain the same implications. Likewise if we choose other factors in ON position, we derive corresponding implication factors.

Two further results are worthy of consideration in the present study. First, by observing the above calculation of IFCM done in trials 1 and 2, it is explicitly shown that the fixed point vector is taken as the vector which has the maximum number of 1's. In both the steps we obtain the fixed point vector as $(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$. That is, the factors such as 2,3,6,9,10 and 11 are the main implicated factors so for any common factors as we have taken as attributes 1 to 11, the above are the casualties.

The second interesting result we can see that the above fixed point vector is nothing but the 4th factor in the casual connection matrix M , 'Easy availability of Endosulfan'. So we can conclude that this factor as the most impactful factor in this study, even though many attribute present.

Earlier studies in this field, revealed results by concentrating one or two factors alone. But the unique contribution of this study is that various interpersonal, social, intrapersonal and empirical factors for identifying the cause of using Endosulfan have been taken and among them the most impactful factor also found. Although this research is unique, it has a couple of limitations also. First the limitation of IFCM. This model consists of lengthy procedure of calculation which is not suitable for calculation with matrices which has higher number of rows and columns. Second, this manual calculation is fully based on expert's opinion. So, it may lead to personal bias. But to deal with unsupervised data, the IFCM model predicates the accurate results when comparing the FCM model. The reason is, the vector yields more number of concepts is considered to be the most vector that is, the fixed point which is not the case of FCM. The present

study is the first that examining the effects and causalities of each attribute taken for the study. Also it yields the most impactful factors for identifying the cause of using Endosulfan in agriculture fields.

6. Remedial Measures

An immediate remedial measure is to bring the awareness on the effects of Endosulfan among the farmers by the Govt. or NGO's by the following methods.

1. By supplying organic pesticides to the farmers freely.
2. Giving information of alternative pesticides through media's like newspaper, T.V., and radio.
3. By inaction road shows the most dangerous effects of Endosulfan in villages by social organizations.
4. Regular medical checkup by Govt. doctors and their advances to the farmers in not using the dangerous pesticides.

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