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OPTIMIZATION OF BIOMEDICAL WASTE DISPOSAL STRATEGY BY FUZZY TOPSIS METHOD

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ABSTRACT

Biomedical waste consists of hospital waste engendered during diagnosis, treatment or immunization of humans or animals like syringes, needles, infected organs, body fluids etc. or generated during any research activity like cultures, broken glasses etc. It is an important issue to be considered as biomedical waste cannot be disposed of like conventional waste and requires special attention for its disposal. The objective of this paper is to explore the best method to be used for disposal of biomedical waste with respect to its impact on environment. For this purpose, the 5 selected methods are assigned ranks using Fuzzy topsis method by taking opinion from decision makers and averaged for further analysis. On the basis of reviews 5 methods of disposal (incineration, autoclaving, microwave irradiation, chemical treatment and deep burial) are taken into considerations and 3 decision maker's opinion is taken on impact on environment (humans, air, soil, water, biodiversity). This survey was taken in Shirpur (Maharashtra). Fuzzy topsis method is a mathematical tool for optimization of results and selects the best method to be applied. In this paper the comparative studies show that incineration is the best method for disposal of biomedical waste followed by autoclaving, microwave irradiation, chemical treatment and deep burial.

Keywords: biomedical waste, hazardous, incineration, disposal, Fuzzy topsis.

INTRODUCTION

Biomedical Waste is mostly considered as any solid or liquid waste that is generated during the diagnosis, treatment or immunization of human beings and animals or may be during any research activity or during the production or testing of biological substantial. According to World Health Organization (WHO) 85% of biomedical waste is non-hazardous in nature and around 10% is infectious while the remaining 5% is non-infectious but contains of hazardous ¹. Biomedical waste includes used syringes and needles which possess very high risk to human health so it is very necessary to treat these types of waste properly. When the hospital waste is disposed it can be very hazardous if it gets mixed with municipal solid waste and this can lead to endanger the human health by various diseases like AIDS, Hepatitis, plague, cholera, etc. This paper studies about the biomedical waste generated in shirpur city (Maharashtra) and the methods to be applied for its proper disposal. There is 1 government hospital in shirpur with 150 beds, 1 Municipal hospital with 200 beds, around 30 private nursing homes with 10-20 beds and 150 private clinics with 2-8 beds along with veterinary hospitals, blood bank and pathology labs in the city. In this paper we used Multi Criteria Decision-Making Fuzzy Topsis tool for selecting the method of disposal to be adopted for biomedical wastes. Fuzzy numbers are functions whose domain is a specified set they depict the physical world more realistically than any single valued numbers ². This technique is used for selecting the order of preference for any operation ^{3,4}. From our survey and calculations incineration is the best method among the selected 5 for the disposal of biomedical waste in Shirpur. For this purpose, we classified biomedical waste on the basis of its impact on different aspects of environment as below.

Classification of biomedical waste

Bio waste which cause hazards to human health include Vomitus, feces, pus and urine of infected patients, Infected animals from labs, Mercury waste from broken equipment spillage, Cadmium waste from discarded batteries, Expired medicines and pharmaceutical products, Needle, Syringes, Broken glass etc. Waste including Mercury from broken equipment spillage, Cadmium from discarded batteries, Waste from surgery and autopsies, Expired medicines and pharmaceutical products, Glass bottles, infected animals from labs, Disposable items used in surgery is hazardous to soil. Biomedical waste causing hazards to water include Vomitus, feces, pus and urine of infected patient, Infected animals from labs, Waste from hemodialysis of patient, Mercury waste from broken equipment spillage, Cadmium waste from discarded batteries ⁵. Waste hazardous to air includes Vomitus, feces, pus and urine of infected patients, infected animals from labs, Cultures. Mercury waste from broken equipment and Cadmium waste from discarded batteries are hazardous to biodiversity

Methods for disposal of biomedical waste

On the basis of reviews, the 5 methods selected for survey are Incineration, Autoclaving, Chemical treatment, Microwave irradiation, Deep burial. Incineration is a process which involves the use of high thermal temperature to convert the waste into inert gas, ash or flue which is then no more hazardous to environment. This process is majorly used for Waste generated from autopsies and surgery which includes tissues, organs and body parts (category No.1 waste), Waste which includes infected animals from veterinary hospitals and waste generated therein by them (category no. 2 waste), Waste coming from pharmaceuticals which includes expired and discarded medicines, cytotoxic drugs (category no. 5 waste), Solid waste like items

dressings, cotton swabs, bleeding and other body fluids, plasters and material contaminated by blood (category no. 6 waste). Autoclaving involves the use of steam under pressure to kill/destroy all types of microorganisms and spores. types of biomedical waste can be disposed using autoclaving include Microbiology waste which includes cultures, specimen of microorganism, vaccines, toxins and devices used to transfer culture (category no. 3 waste), Sharp waste which includes needle, syringes, glass bottles, vials, blades (category no.4 waste), Autoclaving can also be done for solid waste which is contaminated by blood and other body fluids, dressings and plasters (category no. 6 waste), Solid waste which is generated by disposable items(category no. 7 waste). In chemical treatment liquid wastes are treated by chemicals like 1% hypochlorite solution or any other solutions so as to kill microbes and ensures disinfections. This is carried out for the waste like Liquid chemical waste which is used in production of biological, disinfectants, insecticides (category no. 10 drugs),

Liquid waste generated from laboratory washings, house keepings and disinfecting activities (category no. 8 waste), Solid wastes like disposable items are also chemically treated before autoclaving (category no.7 waste), Sharps waste like needles, syringes, glass bottles vials are also treated chemically before autoclaving (category no. 4 waste). Microwave irradiation involves application of high frequency electric field which generates heat and kills unwanted microbes and spores. Biomedical waste that can be disposed using this process include Microbiology waste discussed above and be also disposed using microwaving (category no. 3 waste), Sharps waste like needles, glass bottles, syringes (category no. 4 waste), Solid waste contaminated by blood and other body fluids (category no. 6 waste), Solid waste generated by disposable items (category no. 7 waste). Deep burial is another method for disposal which involves burial of waste in the trenches made in soil.

Table 1: Impact of biomedical waste and methods for disposal

Impact	Description	Methods adopted	Description
C1	Hazardous to human health	A1	Incineration
C2	Hazardous to soil	A2	Autoclaving
C3	Hazardous to water	A3	Chemical treatment
C4	Hazardous to air	A4	Microwave irradiation
C5	Hazardous to ecosystem	A5	Deep burial

Table 2: Linguistic variables for criteria and alternatives

Impact of biomedical waste			Methods for disposal		
	Notation	Fuzzy no.		Notation	Fuzzy no.
Non hazardous	NH	(0,0,0.1)	Very poor	VP	(0,0,1)
Low hazardous	LH	(0,0.1,0.3)	Poor	P	(0,1,3)
Medium low hazardous	MLH	(0.1,0.3,0.5)	Medium poor	MP	(1,3,5)
Medium hazardous	MH	(0.3,0.5,0.7)	Fair	F	(3,5,7)
Medium high hazardous	MHH	(0.5,0.7,0.9)	Medium good	MG	(5,7,9)
Highly hazardous	HH	(0.7,0.9,1)	Good	G	(7,9,10)
Very highly hazardous	VHH	(0.9,1,1)	Very good	VG	(9,10,10)

Table 3: Decision maker's opinion about the impact of biomedical waste

Methods adopted	DM1	DM2	DM3	Aggregate fuzzy no.
C1	VHH	HH	VHH	(0.84,0.97,1)
C2	MHH	VHH	HH	(0.7,0.87,0.97)
C3	MHH	HH	MLH	(0.44,0.64,0.8)
C4	HH	MH	MHH	(0.5,0.7,0.87)
C5	MLH	MHH	HH	(0.44,0.64,0.8)

Table 4: Decision maker's opinion about methods adopted wrt types of waste

	C1	C2	C3	C4	C5
A1	VG	VG	G	VG	MG
A2	VG	G	F	G	P
A3	G	G	MP	P	G
A4	G	G	P	G	VP
A5	F	VP	MP	MG	VP

Table 5: Fuzzy decision matrix

(9,10,10)	(9,10,10)	(7,9,10)	(9,10,10)	(5,7,9)
(9,10,10)	(7,9,10)	(3,5,7)	(7,9,10)	(0,1,3)
(7,9,10)	(7,9,10)	(1,3,5)	(0,1,3)	(7,9,10)
(7,9,10)	(7,9,10)	(0,1,3)	(7,9,10)	(0,0,1)
(3,5,7)	(0,0,1)	(1,3,5)	(5,7,9)	(0,0,1)

Table 6: Normalized fuzzy decision matrix

(0.9,1,1)	(0.9,1,1)	(0.7,0.9,1)	(0.9,1,1)	(0.5,0.7,0.9)
(0.9,1,1)	(0.7,0.9,1)	(0.3,0.5,0.7)	(0.7,0.9,1)	(0.0,1,0.3)
(0.7,0.9,1)	(0.7,0.9,1)	(0.1,0.3,0.5)	(0.0,1,0.3)	(0.7,0.9,1)
(0.7,0.9,1)	(0.7,0.9,1)	(0.0,1,0.3)	(0.7,0.9,1)	(0,0,0.1)
(0.3,0.5,0.7)	(0,0,0.1)	(0.1,0.3,0.5)	(0.5,0.7,0.9)	(0,0,0.1)

Table 7: Weighed normalized fuzzy decision matrix

(0.75,0.97,1)	(0.63,0.87,0.97)	(0.30,0.57,0.8)	(0.45,0.7,0.87)	(0.22,0.44,0.72)
(0.75,0.97,1)	(0.49,0.78,0.97)	(0.13,0.32,0.56)	(0.35,0.63,0.87)	(0,0.064,0.24)
(0.58,0.87,1)	(0.49,0.78,0.97)	(0.044,0.19,0.4)	(0,0.07,0.26)	(0.30,0.57,0.8)
(0.58,0.87,1)	(0.49,0.78,0.97)	(0,0.064,0.24)	(0.35,0.63,0.87)	(0,0,0.8)
(0.25,0.48,0.7)	(0,0,0.97)	(0.044,0.19,0.4)	(0.25,0.49,0.78)	(0,0,0.8)

Table 8: Relative closest coefficient of alternatives and ranking

Alternatives	D*	D-	$C_i^* = D_i^+ / (D_i^+ + D_i^-)$	Rank
A1	2.04	3.94	0.65	1
A2	2.74	3.19	0.53	2
A3	3.03	2.93	0.49	4
A4	2.76	3.1	0.52	3
A5	3.46	1.95	0.36	5

ANALYSIS AND DISCUSSION

Table 1 shows impact of biomedical waste on various sectors of environment like hazardous to human health, soil, water, air, ecosystem each denoted with C1, C2...C5⁶. Methods adopted for its disposal as alternatives incineration, autoclaving, chemical treatment, microwave irradiation, deep burial denoted by A1, A2...A5⁷.

Linguistic variables are assigned for impact of waste like non-hazardous, low hazardous, medium low hazardous and so on; similarly, linguistic variables are assigned for methods for disposal like very poor, poor, fair and so on. (Table 2)

In Table 3 suggests on the methods to be adopted for disposal are given according to three decision makers included in column no.2, 3 and 4⁸. Then the aggregated set of linguistic variables is calculated based on decision makers' opinions as mentioned in column no. 5.

Let's consider the following for better understand the formation of aggregated fuzzy set:

Aggregated fuzzy no: (w1, w2, w3)

Decision maker 1: (a1, a2, a3); Decision maker 2: (b1, b2, b3);

Decision maker 3: (c1, c2, c3);

$w1 = (a1+b1+c1)/3$;

$w2 = (a2+b2+c2)/3$;

$w3 = (a3+b3+c3)/3$;

For example, consider the calculation of aggregated fuzzy no. for C1 in table 3. We take aggregate of fuzzy no. variables suggested by decision makers.

(a1, a2, a3) = (0.9, 1, 1);

(b1, b2, b3) = (0.7, 0.9, 1);

(c1, c2, c3) = (0.9, 1, 1);

Therefore, $w1 = (0.9 + 0.7 + 0.9)/3 = 0.84$; $w2 = (1 + 0.9 + 1)/3 = 0.97$; $w3 = (1 + 1 + 1)/3 = 1$;

So aggregate of decision maker's opinion for C1 becomes (0.84, 0.97, 1). Same method is applied for further calculation of other aggregates.

In Table 4 decision maker's opinion regarding the type of waste wrt to the methods to be adopted in order to minimize its impact on environment is given.

In Table 5 we assign the fuzzy numbers to the linguistic variables suggested by decision maker in Table 4 on the basis of values given in Table 2.

In Table 6 for calculation of Normalized fuzzy decision matrix each value in Table 5 is divided by 10.

In Table 7, for calculation of weighed normalized fuzzy decision matrix we multiply the values in Table 6 with the aggregated fuzzy no. of its respective column⁹. e.g.: first column of Table 6 is for C1 so values in first column are multiplied by the aggregated fuzzy no for C1 as calculated in table 3 for better understanding consider the following example in above Table 6 first cell shows normalized fuzzy matrix on C1 (hazardous to human health). A1 (incineration) so for calculation of weighed normalized fuzzy decision matrix for C1. A1 we multiply cell one matrix with aggregated fuzzy number matrix for C1 given in Table 3. Normalized fuzzy decision matrix: (m1, m2, m3); Aggregated fuzzy decision matrix for C1: (w1, w2, w3) therefore, weighed normalized fuzzy decision matrix (x, y, z) is equal to:

$$(x, y, z) = (m1 * w1, m2 * w2, m3 * w3);$$

In Table 8, column no.2 shows Fuzzy positive ideal solutions (FPIS D*) and column no.3 shows Fuzzy negative ideal solutions (FNIS D-)

D* can be calculated by following formula:

$$D^* = \sum 1/2 [\max(|1^{st}-1|; |3^{rd}-1|) + (2^{nd}-1)]$$

Here we consider weighed normalized decision matrix set from table no. 7 and the value greater between $|1^{st}-1|$ and $|3^{rd}-1|$ is selected and added with $(2^{nd}-1)$.

Now D- is given by:

$$D^- = \sum 1/2 [\max(|1^{st}-0|, |3^{rd}-0|) + |2^{nd}-0|]$$

Similarly, we find out D- by adding the greater value with 2nd term. We obtain the Relative Closest Coefficient of Strategies (C*) using the formula,

$$C^* = D^- / (D^* + D^-)$$

So we substitute the above calculated value of D* and D- to calculate C. For example, consider the calculation for A1:

$$D^* = 1/2 \{ (|0.75-1|, |1-1|) + |0.97-1| \} + 1/2 \{ |0.63-1|, |0.97-1| + |0.87-1| \} + 1/2 \{ |0.30-1|, |0.8-1| + |0.57-1| \} + 1/2 \{ |0.45-1|, |0.87-1| + |0.7-$$

$$1\} + \frac{1}{2}\{|0.22-1|, |0.72-1| + |0.44-1|\} = 0.14 + 0.25 + 0.56 + 0.42 + 0.67$$

$$D^* = 2.04$$

Similarly, we can calculate D* for all values.

$$D^- = \frac{1}{2}\{|0.75-0|, |1-0| + |0.97-0|\} + \frac{1}{2}\{|0.63-0|, |0.97-0| + |0.87-0|\} + \frac{1}{2}\{|0.30-0|, |0.8-0| + |0.57-0|\} + \frac{1}{2}\{|0.45-0|, |0.87-0| + |0.7-0|\} + \frac{1}{2}\{|0.22-0|, |0.72-0| + |0.44-0|\} = 0.98 + 0.92 + 0.68 + 0.78 + 0.5$$

$$D^- = 3.94$$

Similarly, we can calculate D- for all values.

$$C^* = D^-/D^+ + D^-$$

$$= 3.94/2.04 + 3.94$$

$$= 0.65$$

Similarly, all C values are calculated and compared¹⁰. The method with highest C value is ranked 1st and going so on ranks are assigned to the methods using Fuzzy Topsis.

CONCLUSION

The survey on biomedical waste was carried out. Impacts of biomedical waste on environment and different methods to be adopted for its disposal were studied. Here by using multi criteria decision making Fuzzy topsis tool we gave the order of preference to the methods of disposal selected. The highest ranking was given to incineration method so we conclude that incineration is the best method for the disposal of biomedical waste as it causes least harm and can be used for mostly all types of waste followed by autoclaving, microwave irradiation, chemical treatment and the lowest ranking is given to deep burial as this method is not eco-friendly and there are high chances of ground water pollution along with soil pollution. Deep burial also leads to foul smell and cause certain diseases. Incineration converts the total waste in ash and thus chances of infection and hazards are minimized. Hence incineration is the best method to be adopted for disposal of biomedical waste is concluded. Fuzzy Topsis Method can be applied in certain other aspects also to make suitable decisions.

REFERENCES

1. Patil chetan Vitthal, Chaudhary Saurabh Sanjay, Bhavna R Sharma, M. Ramachandran, Need of Biomedical Waste

- Management in Rural Hospitals in India. Int. J. Pharm. Sci. Rev. Res. 2015; 35(1): 175-179.
2. Izadikhah M, Saeidifar A, Roostaei R. Extending TOPSIS in fuzzy environment by using the nearest weighted interval approximation of fuzzy numbers. Journal of Intelligent and Fuzzy Systems 2014; 27(6):2725-36.
3. Kumar S, Ramachandran M. A novel approach for the vendor selection in the refrigeration industry. International Journal of Applied Engineering Research 2015; 10(11):10119-22.
4. Wei Z. An extended TOPSIS method for multiple attribute decision making based on intuitionistic uncertain linguistic variables. Engineering Letters 2014; 22(3):1-9.
5. Sharma natasha, Agarwal dilip, khinchi mahaveer, gupta M.K, Bisht Shradha, Pharmaceutical waste management: A Challenge to make Environment Eco friendly. Int. J. Res. Ayurveda Pharm. 2010; 1(2):332-338.
6. Jain M, Ramachandran M. Buy/Make decision making framework for pump product development with multi criteria decision making. International Journal of Applied Engineering Research 2015; 10(11):10486-9.
7. Feng X, Zuo W, Wang J, Feng L. TOPSIS method for hesitant fuzzy multiple attribute decision making. Journal of Intelligent and Fuzzy Systems: Applications in Engineering and Technology 2014; 26(5):2263-9.
8. Lodha S, Ramachandran M. Need of multi criteria decision making in vendor selection for the automobile industry. International Journal of Applied Engineering Research 2015; 10(11):10301-4.
9. Shanian A, Savadogo O. TOPSIS multiple-criteria decision support analysis for material selection of metallic bipolar plates for polymer electrolyte fuel cell. Journal of Power Sources 2006; 159(2):1095-104.
10. Pulkit Purohit, M. Ramachandran, Selection of Flywheel Material using Multicriteria Decision Making Fuzzy Topsis, Indian Journal of Science and Technology 2015; 8(33): 1-5.

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