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Optimization of Solid Wastes Disposal Strategy by Fuzzy Topsis Method

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ABSTRACT

The non-biodegradable wastes have been increasing widely day by day. These wastes not only cause harm to the environment and its resources, but also they have an adverse impact on the human health causing a number of health problems. In order to control this issue, a number of approaches have been done and carried out by the hosts. In the present article, we are discussing this issue taking into consideration certain factors and strategies. The factors of waste disposal were identified to be human health, waste reduction, sustainability, cost effective and environmental benefits using the disposing strategies such as landfills, incineration, energy transform, reuse and recycling. The non-biodegradable wastes include plastics, construction wastes, metal scraps, rubber tyres, man-made nylons, polyesters, glass, cable wires, cellophane, CDs, DVDs, processed wood, styrofoam, aluminium cans and bottles. The survey was carried out using the Fussy Topsis Method, which is a multi-criteria decision making optimization tool. It helps us in making the best choice out of the available options. The results obtained revealed that recycling is the most efficient method, whereas the landfill is an unpleasant option of solid waste management.

INTRODUCTION

The disposal of the non-biodegradable wastes has become a serious issue worldwide and especially in the developing countries. In addition to this, the problems such as ecological imbalance, epidemic of certain diseases have been ruling the world, leading to deterioration of the natural environment and its resources. Many of the biological species are on the verge of extinction leading to severe ecological imbalance. This is all due to the mounting use of non-biodegradable wastes such as plastic and the harmful chemicals used to synthesize them. Fussy topsis is a mathematical tool that helps us making the best decision from a number of options which suits our goal in order to obtain the anticipated results (Izadikhah et al. 2014). The survey concerning the issue of non-biodegradable solid waste management was executed in Nashik city of state Maharashtra, India. On an average the city generates about 300-350 tons of solid waste per day (Patil et al. 2014). The solid waste, which is not capable of any further processing, is dumped into the engineered sanitary landfills. The rest of the solid waste is further taken for the processing so as to convert them into different forms of energy through combustion.

FACTORS OF SOLID WASTE MANAGEMENT

The present paper work consists of 5 major factors which are under the impact of solid waste disposal. These factors are the most affected ones due to the improper disposal of solid wastes. Human health, waste reduction, sustainability, cost effective and environment benefits are the 5 major factors considered in this work. Human health is adversely affected by the unattained solid waste management. The increasing percentage of cancer and other diseases are a result of the increasing disposal of hazardous solid wastes. Waste reduction can be explained as the reduction of waste by using appropriate methods of solid waste management. Sustainability is the optimum utilization of resources in a way that they shall be available for use by future generation. It refers to the use of resources so that there is a productive use as well as the non-renewable or non-biodegradable resources remain long lived. Cost effective can be explained as the correct disposal of waste by proper utilization of resources that shall lead to economic profits. The conversion of waste material to certain other form of energy earns a high amount of earning not only in terms of money, but also in terms of different energy forms useful in day-to-day life. Environmental benefits encourages the green living which ultimately creates a healthy environment for the living organisms. This can be achieved by using the eco-friendly ways of solid waste disposal. This in turn, will result in the conservation of the earth's biodiversity.

STRATEGIES OF SOLID WASTE MANAGEMENT

Landfill is defined as dumping of the solid waste from all over the city/town onto the barren lands for the purpose of its burial. The properly maintained landfills can prove to be hygienic and easy method for the disposal of wastes, but the poorly maintained landfills can cause a number of problems such as loss of biodiversity, hazards to human health, emission of greenhouse gases, etc. Incineration is an alternative method of waste disposal in which the waste is combusted and converted into the harmful forms such as gases, ash, heat, etc., which are then emitted into the air. As the solid wastes are treated at a very high temperature in incineration, it is also known as "thermal treatment" of solid wastes. This is a less preferred method of waste disposal as it causes more pollution compared to other methods. Energy transform is also called waste-to-energy or energy-from-waste. It is the method in which the usable energy is obtained from the waste in different forms such as electricity or heat, through combustion, gastification, anaerobic digestion, pyrolyzation etc. Reuse is defined as the usage of same material for repeated time in different ways. The best example of this is using the old pieces of cloth or towels for the cleaning purpose. This method is not only cost effective, but it also reduces the environmental burden as it prevents the solid waste to enter onto the landfills and incineration process of waste disposal. Recycling is the process of collecting, reprocessing and reusing the non-biodegradable substances such as plastic, glass, bottles, metal scraps, cartons, polyethylene, etc. It results in less energy usage and reduces pollution to a great extent.

ANALYSIS AND DISCUSSION

Table 1 consists of five factors and five strategies which are assigned notations F1, F2, F3, F4, F5 and S1, S2, S3, S4, S5 respectively (Wei et al. 2014).

Table 1: Factors and strategies.

Factors	Description	Strategies	Description
F1	Human Health	S1	Landfills
F2	Waste Reduction	S2	Incineration
F3	Sustainability	S3	Energy Transform
F4	Environment Benefits	S4	Reuse
F5	Cost Effective	S5	Recycle

In Table 2 and 7, variables/ratings are assigned to the factors as well as the strategies so as to assign the fussy numbers for the further calculations.

In Table 3, the opinion of 3 decision makers concerning different factors of solid waste disposal is been stated using the 7 variables/ratings assigned to the factors in Table 2. Later the aggregated fussy number is also defined in the same. The aggregated fussy number is obtained by calculating the average of the three opinions by the decision maker. Let the aggregated fussy number be presented as (w1, w2, w3) and the opinions of the three decision makers be (a1, a2, a3), (b1, b2, b3), (c1, c2, c3) respectively, (Feng et al. 2014). Then, so as to obtain (w1, w2, w3) for each factor, the calculation was performed as below;

(a1+b2+c3)/3 to get w1

(a2+b2+c3)/3 to get w2

(a3+b3+c3)/3 to get w3

This process of calculation is carried out for all the 5 factors and respective strategies in the same way.

Table 4 states the opinions of the decision maker about the strategies with respect to the factors associated. In other words, it gives us the opinion about how the use of a particular strategy will contribute to the corresponding factor in proficient solid waste management (Lodha et al. 2015). The opinion is given in terms of variables/ratings assigned to strategies in Table 2.

Table 5 is the fussy decision matrix which is obtained using Table 2 and Table 4. The corresponding fussy numbers assigned to the strategies in Table 2 are written in respective places of the ratings shown in Table 4.

In Table 6, each value included in Table 5 is divided by 10 to obtain the normalized fussy decision matrix. The values of normalized fussy decision matrix are denoted by n1, n2, n3.

Table 7 is known as the weighted normalized fussy decision matrix. The values for this matrix are denoted as v1,

Table 2: Variables and the assigned fussy number.

Factors			Strategies		
Variables	Notations	Fuzzy no.	Variables	Notations	Fuzzy no.
Not Affected	NA	(0, 0, 0.1)	Below Average	BAv	(0, 0, 1)
Barely Affected	BA	(0, 0.1, 0.3)	Average	AV	(0, 1, 3)
Very Less Affected	VL	(0.1, 0.3, 0.5)	Above Average	AA	(1, 3, 5)
Less Affected	LA	(0.3, 0.5, 0.7)	Good	GD	(3, 5, 7)
Moderately Affected	MA	(0.5, 0.7, 0.9)	Very Good	VG	(5, 7, 9)
Highly Affected	HA	(0.7, 0.9, 1)	Excellent	EX	(7, 9, 10)
Very Highly Affected	VH	(0.9, 1, 1)	Outstanding	OS	(9, 10, 10)

Table 3: Decision maker's opinion on the above factors.

Factors	DM1	DM2	DM3	Aggregated Fuzzy no.
F1	VH	HA	HA	(0.76, 0.9, 1)
F2	MA	VH	VH	(0.76, 0.9, 0.96)
F3	LA	MA	LA	(0.36, 0.56, 0.76)
F4	HA	VH	HA	(0.76, 0.93, 1)
F5	VL	BA	HA	(0.26, 0.43, 0.46)

Table 4: Decision maker's opinion of each strategy w.r.t each factor.

	F1	F2	F3	F4	F5
S1	AA	GD	AV	AV	EX
S2	BAv	VG	BAv	AV	GD
S3	GD	VG	VG	VG	AA
S4	OS	EX	VG	EX	EX
S5	OS	EX	EX	OS	VG

Table 5: Fuzzy decision matrix.

	F1	F2	F3	F4	F5
S1	(0, 1, 3)	(3, 5, 7)	(0, 1, 3)	(0, 1, 3)	(7, 9, 10)
S2	(0, 0, 1)	(5, 7, 9)	(0, 0, 1)	(0, 1, 3)	(3, 5, 7)
S3	(3, 5, 7)	(5, 7, 9)	(5, 7, 9)	(5, 7, 9)	(0, 1, 3)
S4	(9, 10, 10)	(7, 9, 10)	(5, 7, 9)	(7, 9, 10)	(7, 9, 10)
S5	(9, 10, 10)	(7, 9, 10)	(7, 9, 10)	(9, 10, 10)	(5, 7, 9)

Table 6: Normalized fuzzy decision matrix.

	F1	F2	F3	F4	F5
S1	(0, 0.1, 0.3)	(0.3, 0.5, 0.7)	(0, 0.1, 0.3)	(0, 0.1, 0.3)	(0.7, 0.9, 0.10)
S2	(0, 0, 0.1)	(0.5, 0.7, 0.9)	(0, 0, 0.1)	(0, 0.1, 0.3)	(0.3, 0.5, 0.7)
S3	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0, 0.1, 0.3)
S4	(0.9, 1, 1)	(0.7, 0.9, 0.10)	(0.5, 0.7, 0.9)	(0.7, 0.9, 0.10)	(0.7, 0.9, 0.10)
S5	(0.9, 1, 1)	(0.7, 0.9, 0.10)	(0.7, 0.9, 0.10)	(0.9, 1, 1)	(0.5, 0.7, 0.9)

Table 7: Weighted normalized fuzzy decision matrix

	F1	F2	F3	F4	F5
S1	(0, 0.09, 0.3)	(0.228, 0.45, 0.672)	(0, 0.056, 0.228)	(0, 0.093, 0.3)	(0.182, 0.387, 0.046)
S2	(0, 0, 0.1)	(0.38, 0.63, 0.864)	(0, 0, 0.076)	(0, 0.093, 0.3)	(0.078, 0.215, 0.322)
S3	(0.228, 0.45, 0.7)	(0.38, 0.63, 0864)	(0.18, 0.392, 0.684)	(0.38, 0.651, 0.9)	(0, 0.043, 0.138)
S4	(0.684, 0.9, 1)	(0.532, 0.81, 0.096)	(0.18, 0.392, 0.684)	(0.532, 0.837, 0.1)	(0.182, 0.387, 0.046)
S5	(0.684, 0.9, 1)	(0.532, 0.81, 0.096)	(0.252, 0.504, 0.076)	(0.684, 0.93, 1)	(0.13, 0.301, 0.414)

Table 8: Relative closest coefficient of strategies and rank.

Strategies	$C^* = D^-/(D^+ + D^-)$	Rank
S1	0.2417	5
S2	0.2678	4
S3	0.4499	3
S4	0.4981	2
S5	0.5561	1

v2, v3. Each value from the Table 6, i.e. the normalized fussy decision matrix is multiplied by the corresponding value of the aggregated fussy number from Table 3. In other words, all the values of F1 are multiplied with the aggregated fussy number which corresponds to F1 (Girubha et al. 2012). Consider n1, n2, n3, the normalized fussy decision matrix values from Table 6, and w1, w2, w3, the aggregated fussy numbers from Table 3. Hence the weighted normalized fussy decision (v1, v2, v3) values can be obtained as;

$$(v1, v2, v3) = \{(n1 \times w1), (n2 \times w2), (n3 \times w3)\}$$

The same is done for all the five factors with respect to strategies.

In Table 8, we obtain the relative closest coefficient of strategies (C*) using the formula,

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

Consider the weighted normalized fussy decision matrix values (v1, v2, v3) obtained in Table 7. To this we apply the formula,

$$D^+ = \Sigma \tfrac{1}{2} \{(|v1-1|, |v3-1|) + |v2-1|\}$$

In this formula, we take the greater number from |v1-1| & |v3-1| for further addition with |v2-2|. This is how we obtain the D^+ value.

Now, so as to obtain the D^- value we apply the formula,

$D^- = \Sigma \frac{1}{2} \{(|v1-0|, |v3-0|) + |v2-0|)\}$

Similar to above, in this formula also, we add the greater value from |v1-0| & |v3-0| to |v2-0|. This gives us the D^- value.

Hence, we put these values of D^+ & D^- in the formula and obtain the C* value.

In this way, we calculate C* for all the 5 strategies. Finally, we assign the ranks to each strategy with respect to its C* value. The higher C* value gets the 1st Rank and so on.

CONCLUSION

A survey regarding solid waste management was carried out. The different factors and strategies of solid waste management were determined. To this, we applied the multi criteria decision making fussy topsis tool so as to find out the best method for the disposal of solid waste. From the above results, we observed that recycling is the most excellent method for the non-biodegradable solid waste management as it gets the highest ranking, whereas the landfill method is the nastiest way for disposal of non-biodegradable solid waste. The non-biodegradable wastes are the wastes which do not decompose easily into the earth's surface. Thus, the use of landfill method of disposal directly affects the land and environment. It makes the land futile by deteriorating its quality and also emits toxic substances along with a foul smell into the air. Conversely, recycling is proved to be the 'conventional' method of solid waste disposal. It provides human with a fresh supply of the utilizable material. This reduces the pollution caused due to other methods of waste disposal. Hence, recycling is one of the best methods of solid waste reduction. Similarly, fussy topsis method can be applied in certain other aspects to decide on the most appropriate option to achieve the best expected results (Purohit et al. 2015).

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