

# Waste Minimization in Health Sector: An AHP Approach

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## Abstract

The prime focus of this paper is to determine the factors that affect waste management in health sector. Managing waste in health care holds much more importance as it can have adverse effects on human and environment. Our paper aims to determine the critical factors. A survey was conducted by taking five different hospitals across the state so as to determine the weightage of different factors by taking the opinion of the respondents and scientists. Then the ranking of the factors and hospitals are done using analytical hierarchy process (AHP). The results were analyzed and the consistency was calculated taking the factors that affected the hospitals. It is found that the private owned hospital cum medical college is ranked one as per its overall score and similarly the first factor i.e. conducting awareness program for the employees is found to be dominating factor among others.

## Keywords

Waste Management, AHP, Health Sector, Consistency Ratio, Sustainability Development

## I. Introduction

India rightly brands itself as incredible. The country's remarkable political, economic and cultural transformation over the past few decades has made it a geopolitical force. Healthcare is one of the industries that marks this strengthened global presence. Municipal wastes are the prime waste generated from health care sector and they need recovery and recycling. Plastic wastes makes up 19% of hospital waste and this high unexpected percentage is due to the overuse of non-recyclable trash instead of recycling and reusing for different purpose [1]. Green Supply Chain Management (GSCM) has gained popularity with both academics and practitioners with objectives of reducing waste and preserving the quality of product-life and the natural resources [2]. It represents integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing

processes, delivery of the final product to the consumer as well as end-of-life management of the product after its useful life. [3] Different key elements of waste minimization process are segregation, source reduction, resource recovery and recycling, responsible waste treatment. Treatment of waste can be reduced by substituting alternate product and technology. Through purchasing and product substitution, toxicity of waste can also be reduced through recovery and reuse of materials from the waste stream. Hospitals can implement fairly simple programs that divert these materials from the solid waste stream, lowering disposal costs. Most of the Indian Health Care Organisations are not maintaining proper waste minimization procedure due to different factors such as Better relationship among stakeholders, conducting an awareness program for the employees, recovery and recycling of plastic waste and develop eco-design service, use of life cycle analysis to improve waste management. The paper aims to find out the importance of the above factors in Indian Health Care Organisation. The structure of the paper is as follows: Section II entails the different past works by different researchers. Section III focuses the methodology used to determine the importance of different factors of selected Health Care Organisations. Section IV describes the application of model to the case organisation. Section V represents the results and discussions of the detailed analysis, where Section VI ends with conclusion and future scope of the work.

## II. Literature Review

Numerous literatures have been reviewed to obtain the different factors striking waste management. Waste management is the stockpiling, shipping, organizing, recycling or disposition and observing of waste materials.. There is a growing realization of the negative impacts that wastes have had on the local environment (air, water, land, human health etc.). sharp rise of hospitals in India has led to production of waste and forcing the government to take necessary action.

Table 1: Factors Affecting Waste Minimization in Various Sectors

AUTHOR	FOCUS	FINDINGS
LillianaAbarca Guerrero et al. (2013)	Role of stakeholders in waste management process	Factors that lead to failure of solid waste management system , and a list of stakeholders' who are involved in this process
S.M. Al-Salem et al. (2009)	Various modes of PSW treatment are discussed	The methods of treatment was found to be effective and further experiments can b carried on
Alexis Laurent et al. (2014)	Survey of practices involved in LCA and to see what constraints were involved	Methods to improve performance of waste management LCA
L. Giusti (2009)	Vulnerability of MSW and origin of waste	People residing near waste disposal sites are prone to harmful disease
A.Bosmans et al. (2013)	Capability of Thermo chemical process	Plasma Gasification is an effective tool for MSW and further research can lead to corporate success
José EzequielSantibañez-Aguilar et al. (2013)	Proposal of a model for effective handling of MSW management	Proper handling of MSW can lead to much help and will reap many advantages

G. Zotos et al. (2009)	Review of Waste Management Options , problems faced and tools involved for evaluation	Produces a well-structured plan for MSWM at domestic and non-domestic level
Rachael E.Marshall et al. (2013)	Review current practices of SWM and problems faced in developing countries	More stress is laid for finding new ways of SWM method, and to think of new innovations
PeeranartKiddee et al. (2013)	Impact of toxic substance present in e-waste on environment	EPR is a better way to tackle rising e-waste problems
Marco Caniato et al. (2014)	Incorporation of SNA and SA for reviewing solid MSW	Upgradation in relationship if stakeholders' and more involvement in planning and decision making process
Paul H.Brunner et al. (2014)	Incineration has become a recycling tool for Bottom Ash, harmful organic materials and APC residues	WTE plants delivering data regarding chemical waste

From the above table the following critical factors affect the hospital daily activity are listed below.

Table 2: Factors and its Importance

FACTORS	Importance
Factor 1 (F1) Conducting Awareness Program for the Employees	Conducting awareness program is sometimes necessary; it will make the employees realize their responsibility towards the environment. It will also make them to know about new innovation , and how to use it.
Factor 2 (F2) Recovery and Recycling of Plastic Waste and develop Eco-design service	Plastic solid waste need to be recycled and recovered so as to build an Eco design service.
Factor 3 (F3) Better relationship among Stakeholders	Stakeholders play important role in decision making program in health sectors. They include members who are involved in operation in management ant fund providing organizations.
Factor 4 (F4) Use of Life-cycle Analysis to improve Waste Management	Life cycle analysis illustrate the method for estimating and determining the habitat and amenity relating a product in its life span.The goal of LCA is to stalk the materials flow of energy.

### III. Methodology

For our study purpose we have considered five hospitals across the states out of which one is a private owned hospital cum medical college (H1), one is a government hospital (H2), one is a government hospital cum medical college (H3), one is a private hospital (H4) and other is a private hospital cum medical college (H5). Hospitals are belonged to both Government and private and these are first class. We have selected hospitals where numbers of beds are 1200, which recently has 800 working beds. The buildings have 5 floors and have 7 sections. The number of working staff is equal to 300 each. The data has been collected visiting the hospitals frequently. Information on waste removal is obtained by interviewing the hospital staffs. There are several methods to compare and rank the various attributes and organizations such as Descriptive Analysis, Nominal Group Technique (NGT) but AHP (Analytical Hierarchy Process) is a preferred technique to determine the different attributes of different Health Care Organisation. Generally, Analytical Hierarchy Process is used in project selection problems. It is a multi-criteria decision making (MCDM) process used to select alternatives based on many criteria. We applied AHP (Analytical Hierarchy Process) on these factors to rank the five hospitals in order of their performance level. In our AHP calculation twelve respondents have been participated. Out of twelve, four of them are from State Pollution Control Board and eight Scientists from Biomedical Waste Department having more than ten years of experience.

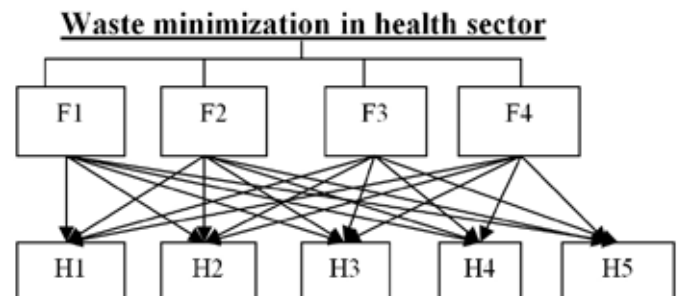


Fig. 1: Network Diagram Showing the Relationship Between Hospitals and Factors

### IV. Satty Scale

The decision-maker rates each factor and preference by making corresponding differentiation using the fundamental scale of absolute numbers. The AHP ranking system is a ratio scale where the proportion between values shows the degree of preference. The fundamental scale of absolute numbers has been the criterion to rate the system of AHP [4].

Table 3: The Fundamental Scale of Absolute Numbers [4]

Preference Table	Numerical Value
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6

Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

**V. Results Analysis and Discussion**

**A. Calculation Applying AHP Method**

F1 is moderately preferred to F3.F1 is moderately to strongly preferred to F4.F2 is strongly preferred to F1.F2 is extremely preferred to F3.F2 is Very strongly preferred to F4.F3 is equally to moderately preferred to F4.

Table 4: Pairwise Comparisons Matrix of the Main Factors With Respect to Goals

	F1	F2	F3	F4	Priority vector
F1	1	1/5	3	4	0.1993
F2	5	1	9	7	0.653
F3	1/3	1/9	1	2	0.0860
F4	1/4	1/7	1/2	1	0.0612

The criteria listed on the left are one by one differentiated with each factors listed above to find the most important factor. Firstly all the values in the respective column are added, and then each element of the column is divided by its corresponding summation result. After obtaining the new values, then all the values in the corresponding rows are calculated. Then the final value for each row is obtained by dividing the resultant with 4.the summation of all the priority vectors nearly equal to 1.

Calculation of AHP for Hospitals considering the factors:-

F1: Conducting Awareness Program for the Employees:

H1 is Moderately preferred to H2.H1 is Strongly preferred to H3.H1 is Strongly to very strongly preferred to H4.H1 is equally to moderately preferred to H5.H2 is moderately to strongly preferred to H3.H2 is Very strongly to extremely preferred to H5.H3 is Moderately preferred to H5.H4 is Extremely preferred to H2.H4 is Very strongly preferred to H3.H4 is Extremely preferred to H5.

Table 5: Pairwise Comparisons Matrix of the Hospitals With Respect to F1

	H1	H2	H3	H4	H5	Priority vector
H1	1	3	5	6	2	0.37374
H2	1/3	1	4	1/9	8	0.16396
H3	1/5	1/4	1	1/7	3	0.06338
H4	1/6	9	7	1	9	0.3358
H5	1/2	1/8	1/3	1/9	1	0.0628

The hospitals on the left are compared with the hospitals on top as to their importance with respect to factor1. Firstly all the values in the respective column are added, and then each element of the column is divided by its corresponding summation result. After obtaining the new values, then all the values in the corresponding rows are calculated. Then the final value for each row is obtained by dividing the resultant with 5.The summation of all the priority vectors nearly equal to 1.

F2: Recovery and Recycling of Plastic Waste and develop Eco-design service:-

H1 is Equally to Moderately preferred to H2.H1 is Moderately to strongly preferred to H3.H1 is Strongly preferred to H4.H1 is Equally to Moderately preferred to H5.H2 is Moderately preferred to H3.H2 is Very strongly preferred to H5.H3 is Equally

to moderately preferred to H5.H4 is Very strongly to extremely preferred to H2.H4 is Very strongly to very strongly preferred to H3.H4 is Very strongly to extremely preferred to H5.

Table 6: Pairwise Comparisons Matrix of the Hospitals With Respect To F2

	H1	H2	H3	H4	H5	PRIORITY VECTOR
H1	1	2	4	5	2	0.34668
H2	1/2	1	3	1/8	7	0.17346
H3	1/4	1/3	1	1/6	2	0.06516
H4	1/5	8	6	1	8	0.34964
H5	1/2	1/7	1/2	1/8	1	0.06464

The hospitals on the left are compared with the hospitals on top as to their importance with respect to factor2. Firstly all the values in the respective column are added, and then each element of the column is divided by its corresponding summation result. After obtaining the new values, then all the values in the corresponding rows are calculated. Then the final value for each row is obtained by dividing the resultant with 5.The summation of all the priority vectors nearly equal to 1.

F3: Better relationship among Stakeholders

H1 is Moderately to strongly preferred to H2.H1 is Strongly to very strongly preferred to H3.H1 is Very strongly preferred to H4.H1 is Moderately preferred to H5.H2 is Strongly preferred to H3.H2 is Moderately preferred to H5.H3 is Moderately to strongly preferred to H5.H4 is Extremely preferred to H2.H4 is Very strongly to Extremely preferred to H3.H4 is Extremely preferred to H5.

Table 7: Pairwise Comparisons Matrix of the Hospitals With Respect To F3

	H1	H2	H3	H4	H5	PRIORITY VECTORS
H1	1	4	6	7	3	0.41246
H2	1/4	1	5	1/9	3	0.1564
H3	1/6	1/5	1	1/8	4	0.06523
H4	1/7	9	8	1	9	0.31568
H5	1/3	1/8	1/4	1/9	1	0.05008

The hospitals on the left are compared with the hospitals on the basis of their priority with respect to factor 3. Firstly all the values in the respective column are added, and then each element of the column is divided by its corresponding summation result. After obtaining the new values, then all the values in the corresponding rows are calculated. Then the final value for each row is obtained by dividing the resultant with 5.the summation of all the priority vectors nearly equal to 1.

F4: Use of Life-cycle Analysis to improve Waste Management:-

H1 is Equally to moderately preferred to H2.H1 is Moderately to strongly preferred to H3.H1 is Very strongly preferred to H4.H1 is Moderately to strongly preferred to H5.H2 is Moderately preferred to H3.H2 is Very strongly preferred to H5.H3 is Strongly preferred to H5.H4 is Very strongly to extremely preferred to H2.H4 is Strongly to very strongly preferred to H3.H4 is Extremely preferred to H5.

Table 8: Pairwise Comparisons Matrix of the hospitals With Respect To F4

	H1	H2	H3	H4	H5	PRIORITY VECTORS
H1	1	2	4	7	4	0.3818
H2	1/2	1	3	1/8	7	0.1631
H3	1/4	1/3	1	1/6	5	0.08562
H4	1/7	8	6	1	9	0.33026
H5	1/4	1/7	1/5	1/9	1	0.03982

The hospitals on the left are compared with the hospitals on the basis of their priority with respect to factor 4. Firstly all the values in the respective column are added, and then each element of the column is divided by its corresponding summation result. After obtaining the new values, then all the values in the corresponding rows are calculated. Then the final value for each row is obtained by dividing the resultant with 5. The summation of all the priority vectors nearly equal to 1.

Table 6: Synthesizing to Obtain the Results

	F1(0.1993)	F2(0.6535)	F3(0.0571)	F4(0.0610)	Overall priority
H 1	0.37374	0.34668	0.041246	0.38184	0.35988
H 2	0.16396	0.17346	0.1564	0.16312	0.16946
H3	0.06338	0.06516	0.0652	0.08652	0.0571
H4	0.33588	0.34964	0.32568	0.33026	0.3479
H5	0.062845	0.06404	0.05008	0.03892	0.0610

H1=(0.37374×0.1993)+(0.34668×0.6535)+(0.041246×0.0860)+(0.03814×0.0612) =0.35988  
 H2=(0.16396×0.1993)+(0.17346×0.6535)+(0.1564×0.0860)+(0.16312×0.0612) =0.16946  
 H3=(0.06338×0.1993)+(0.0516×0.6535)+(0.0652×0.0860)+(0.08562×0.0612) =0.0571  
 H4=(0.33588×0.1993)+(0.34969×0.6535)+(0.37568×0.0860)+(0.33026×0.0612) =0.3479  
 H5=(0.062845×0.1993)+(0.06404×0.6535)+(0.05008×0.0860)+(0.03892×0.0612) =0.0610

The summation of the overall priority vectors nearly equal to 1. Based on the score, it is found that Hospital H1 is best.

**VI. Calculation of Consistency Ratio**

1. The consistency measure for each criterion is calculated.
2. The consistency index (CI) is calculated.
3. The consistency ratio (CI/RI where RI is a random index) is calculated.

Calculation of λ:-

Calculation of λ:-

$$\lambda \times \begin{pmatrix} 0.1993 \\ 0.6535 \\ 0.0860 \\ 0.0612 \end{pmatrix} = \begin{pmatrix} 1 & 1/5 & 3 & 4 \\ 5 & 1 & 9 & 7 \\ 1/3 & 1/9 & 1 & 2 \\ 1/4 & 1/7 & 1/2 & 1 \end{pmatrix} \times \begin{pmatrix} 0.1993 \\ 0.6535 \\ 0.0860 \\ 0.0612 \end{pmatrix}$$

Calculating the above we get,

$$\lambda = \begin{pmatrix} 4.1786 \\ 4.365 \\ 4.0349 \\ 4.024 \end{pmatrix}$$

Calculation of λmax:-

$$\lambda_{max} = \sum \lambda_i / 4, (i=1,2,3,\dots,n) = (4.1786 + 4.365 + 4.0349 + 4.024) \div 4 = 4.1552$$

Calculation of consistency index:- (CI)=

$$(\lambda_{max} - n) / (n - 1) = (4.1552 - 4) \div 3 = 0.0517$$

Calculation of consistency ratio:-

$$(CI/RI) = 0.0517 \div 0.90 = 0.0574$$

(Where RI=0.90 from random index table given below).

Table 7: random index table

N	Random index
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.51

The consistency ratio is less than 0.10. So the result is consistent.

**VI. Conclusion**

The kinds of problems a health industry may encounter during green practices are many and complex in nature, involving not only the ability to use the internal resources and processes but also to manage and measure the waste minimization capability successfully. To manage waste reduction successfully, the paper emphasizes the factors affecting the health organisation for waste minimization and uses an AHP approach to rank the best hospitals among all. From the result it is observed that conducting awareness program for the employees, recovery and recycling of plastic waste and develop ecodesign service, better relationship among stakeholders, use of life cycle analysis to improve waste management are the most important four pillars of any health care organizations to dispose its waste in a proper manner. The private hospital cum medical college found to be rank one using methodology AHP. Due to the number of awareness program for employees which make the employees to realize their responsibility towards environment. So this paper will give a direction to other health organization professionals for a better sustainability development. In future the study can be extended by taking more factors like e-waste, radioactive waste, process management, use of information technology to get a much more transparency related to the waste management of health care organizations.

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