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Optimal Solution for Planning of Disposal of Wastes using Mathematical Model

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Abstract: As in any other business, the business of disposal of wastes should also take care of many areas to improve the business. Improvement in the area like return on sales, storage cost, expenditures of the unit, missed sales of waste, transportation cost, helps the unit in profit generation. Profit generation in the disposal unit is a challenging task. Proper planning ensures profit of the unit. To improve the profit of waste disposal plant, goal programming technique might be used. Proposed goal programming model aims for enhancing return on sales, decreasing the loss due to missed sale of wastes, minimizing the storage costs of wastes in the unit, minimizing the expenditure & enhancing the profit, controlling the transportation cost. Implementation of goal programming model which we developed helps the disposal plants in improving their business.

Keywords: *Goal Programming, Radioactive, Infectious, Optimization, vendor, underachievement, overachievement.*

1. INTRODUCTION

Waste considered as any unwanted or useless material. The Improper and unhygienic method of waste disposal such as dumping of waste poses the serious problem to human beings as well other lives and the environment. Normal life, health, and hygiene of people affected apart from adversely affecting the environment due to the dumping of wastes in open areas, water body's drain and low-lying areas. As the volume of wastes increases, it poses the greater problem to human beings & other lives. Reasons for growing volume of wastes are growing population, rapid economic development, unplanned urbanization and rising levels of disposable income. Due to the burning of garbage on various parts of the city, smoke generated which is giving alarm bells among citizens about its impact on the air quality. Due to an unhygienic and unplanned burning of wastes in addition

to vehicular pollution, unpleasant pollution levels arise. To avoid this problem, the proper methods of disposal of wastes required to adapt in the city. A proper disposal method not only prevents causing serious problems but also leads to conservation of natural resources, minimizing the air pollution, employment opportunities which results in economic improvement of the country by reusing newly generated materials. Whenever establishment of waste disposal unit takes place, such a step leads to economic development of the country at the same time it also reduces the unsanitary conditions & health hazards in these countries. An instance, the developed country referred here. Sweden prepares almost half of its electricity from renewable. It is also noted that Sweden has run the shortage of garbage and the Scandinavian country forced to import wastes from other countries to keep state of the art recycling plants going (recently published in The Hindu).

From the above, it's understood that Garbage disposal unit is an emerging industry since wastes are in high demand. Garbage disposal unit needs to do systematically work by collecting the wastes from various sources, segregate them into wet, dry, medical wastes and further segregate the dry and medical wastes, sell them to the right vendors by giving tender notifications. With this type of competitive tendering, disposal unit selects the better rate for each type of wastes which will eventually benefit the unit. The Manager selects the right vendors who give the best rate for the waste materials and a unit can make the profit out of it. While selling the wastes, Manager should concentrate on return on sales, storage cost, missed sales, expenditures, transportation cost & also profit of the unit. As in any other business Disposal unit work effectively if the manager is able to enhance return on sales & profit, also decrease storage cost, missed sales cost and expenditures, transportation cost. Waste management companies collect wastes from disposal units according to their need. These companies recycle the procured waste products and convert them into new useful by-products. By selling the new products formed from wastes, the company gets profit out of it. Thus efforts of both disposal plant as well as waste management companies aimed towards minimizing the harmful air pollution of the environment and indirectly help the society by overcoming the negative impacts deliberated in the earlier paragraphs.

General goal programming mathematical model which is an optimization technique for planning of disposal of wastes formulated by considering various constraints such as return on sales of waste, cost of wastes which are not sold out, storage cost of missed sale of waste, expenditures of the disposal unit, transportation cost for waste collection & dispose also profit of the disposal unit. The goal programming model would help in minimizing deviation of the desired goals if any and in identifying the deviations of the goals and the manager can take proper measures and proper steps to avoid these deviations in future. This study involves Goal Programming technique with multiple goals and multiple variables. In this technique, Goals fixed manager for improvement of the disposal unit and the deviation observed in their goals. Observed deviations help the manager to take better decision. Thus our study helps in profit generation in the unit under some constraints by goal programming. If competing goals involved then this technique is very helpful.

2. REVIEW OF LITERATURE

Optimum allocation of resources done using a goal programming approach as in [2]. Optimum allocation of resources in university done through goal programming explained as in [3]. Explanation of developing goal programming model in financial portfolio management as in [4], helped us to frame model in our study. In [5] bi-objective mathematical model developed for performance of municipal solid waste management. The use goal programming model in agricultural land allocation problem as in [6], gave the idea of development of goal programming model. Formulation of model using goal programming for rubber wood door manufacturing factory explained in [10], which gave us the idea of developing the goal programming model for our study. As in [7], model developed for facility location planning which also helped us to formulate the constraints as well as achievement function.

3. MATHEMATICAL MODEL FOR THE CURRENT PROBLEM

3.1. Goal 1

To Enhance Return On Sales: Performance of any firm depends on their sales activities. Sales activities involve many stages like giving the tender notification and choice of vendors who give best rate etc. Increasing the return on sales of waste will be leading to more profit. This is by choosing right vendors of different waste management companies. Right vendors choice is by giving tender notification. The sales of wastes to the proper vendors (who give best rate) will give good profit to the unit.

$$\sum_{t=1}^{12} R_{wt} C_{wt} + \sum_{i=1}^{6} \sum_{t=1}^{12} R_{Dit} C_{Dit} + \sum_{i=7}^{12} \sum_{t=1}^{12} R_{Mit} C_{Mit} + d_1^{RS-} - d_1^{RS+} = R_t$$

3.2. Goal 2

Decreasing the Missed Sales of Waste: Vendors of different waste management companies collect different wastes from disposal plant. They buy these wastes according to their need. Their requirement depends on their preparation by products. Only some of the types of wastes might be in demand. Wastes sold easily which are in demand but some of the types of waste are in demand always. Such missed sales of wastes need to promote to different waste management companies. But still there is a likelihood of l missed sales of waste in the disposal unit. Such missed sales decreased as much as possible.

$$\sum_{t=1}^{12} M_{wt} C_{wt} + \sum_{i=1}^{6} \sum_{t=1}^{12} M_{Dit} C_{Dit} + \sum_{i=7}^{12} \sum_{t=1}^{12} M_{Mit} C_{Mit} + d_2^{MS-} - d_2^{MS+} = M_t$$

3.3. Goal 3

Decreasing the Storage Cost: When amount of collection is more than demand level of vendors of different waste management companies disposal plant forced to store them. Therefore this brings about imposing of extra storage cost which is an unfavourable cost for the disposal plant. Management of the disposal plant determined to decrease storage of products as much as possible. Some wastes stored in such a way that it should not harm the human beings.

$$\sum_{t=1}^{12} S_{wt} C_{wt} + \sum_{i=1}^{6} \sum_{t=1}^{12} S_{Dit} C_{Dit} + \sum_{i=7}^{12} \sum_{t=1}^{12} S_{Mit} C_{Mit} + d_3^{SC-} - d_3^{SC+} = S_t$$

3.4. Goal 4

Controlling the Expenditure of Each Type of Wastes: Expenditure of the firm includes general expenses, collection expenses, salary expenses, electricity expenses, water expenses and development charges etc. Expenditure should not exceed the allocated budget. This goal achieved by attempting to decrease the deviation variable.

$$\sum_{t=1}^{12} E_{wt} C_{wt} + \sum_{i=1}^{6} \sum_{t=1}^{12} E_{Dit} C_{Dit} + \sum_{i=7}^{12} \sum_{t=1}^{12} E_{Mit} C_{Mit} + d_4^{E-} - d_4^{E+} = E_t$$

3.5. Goal 5

Boosting the Profit: Profit is the main aim of the any firm/Industry. Profit making business encourages the people to take up that business. If more and more people take up this disposal of waste business it will benefit to the environment and society. So maximizing the profit in the disposal unit treated as one of important goal.

$$\sum_{t=1}^{12} P_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} P_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} P_{Mit} C_{Mit} + d_5^{P-} - d_5^{P+} = P_t$$

3.6. Goal 6

Decreasing the Transportation Cost: Transportation cost is the main expenditure involved in waste collection. One of the main responsibilities of the disposal unit is to cut the transportation cost. One of the major costs for disposal plant is transportation cost. Dry and wet wastes are collected from houses, temples, hotels, hostels, party halls etc. Medical wastes are collected from different hospitals, clinics, dispensaries etc. Transportation cost includes both collection cost & disposal of non-recyclable wastes. Non-recyclable wastes need to send for landfilling. The transportation cost of non-recyclable wastes from disposal unit to landfilling is also included in the model.

$$\sum_{t=1}^{12} T_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} T_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} T_{Mit} C_{Mit} + \sum_{t=1}^{12} T_{NRt} C_{NRt} + d_6^{TC-} - d_6^{TC+} = T_t$$

4. PRIORITY LEVELS

Table 1
Priorities

	Goal	*Priorities*
1	Return on sale	P_1
2	Profit	P_2
3	Transportation cost	P_3
4	Missed sales	P_4
5	Storage cost	P_5
6	Expenditure	P_6

5. ACHIEVEMENT FUNCTION/OBJECTIVE FUNCTION

$$\text{Minimize } Z = P_1 d_1^{RS-} + P_2 d_5^{P-} + P_3 d_6^{TC+} + P_4 d_2^{MS+} + P_5 d_3^{SC+} + P_6 d_4^{E+}$$

6. CONSTRAINTS

1. $$\sum_{t=1}^{12} R_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} R_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} R_{Mit} C_{Mit} + d_1^{RS-} - d_1^{RS+} = R_t$$

2. $$\sum_{t=1}^{12} M_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} M_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} M_{Mit} C_{Mit} + d_2^{MS-} - d_2^{MS+} = M_t$$

3. $$\sum_{t=1}^{12} S_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} S_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} S_{Mit} C_{Mit} + d_3^{SC-} - d_3^{SC+} = S_t$$

4. $$\sum_{t=1}^{12} E_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} E_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} E_{Mit} C_{Mit} + d_4^{E-} - d_4^{E+} = E_t$$

5. $$\sum_{t=1}^{12} P_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} P_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} P_{Mit} C_{Mit} + d_5^{P-} - d_5^{P+} = P_t$$

6. $$\sum_{t=1}^{12} T_{wt} C_{wt} + \sum_{i=1}^{6}\sum_{t=1}^{12} T_{Dit} C_{Dit} + \sum_{i=7}^{12}\sum_{t=1}^{12} T_{Mit} C_{Mit} + \sum_{t=1}^{12} T_{NRt} C_{NRt} + d_6^{TC-} - d_6^{TC+} = T_t$$

Assigning the weights to the priorities we get the solution set with deviation values. By changing the priorities we get different solution set. By comparing the Z value & finding out which case is of minimum Z value and that case considered as the best which helps the manager to take better decisions.

7. VARIABLES AND CONSTANTS

i is the characteristic of garbage collected on the type of watse

i = 1,2,3,4,5,6 represents 6Lvarieties of dry waste like paper, plastic, glass, wood, tetrapack, metal

i = 7,8,9,10,11,12 represents 6 varieties of medical wastes such as sharps, infectious, radioactive, pathological, pharmaceutical & generalwastes

t is the characteristic of monnths of collection of wastes, *t* = 1,2....12

C_{wt} is the collected amount of garbage of wet variety is the collected in *t th* month

C_{Dit} is the collected amount of garbage of *i th* variety of dry waste in *t th* month

C_{Mit} is the collected amount of garbage of *i th* variety of medical waste in *t th* month

C_{NRt} is the amount of collection of non recylable wastes in *t th* month

R_{wt} is he return on sale of each unit of garbage of wet variety in *t th* month

R_{Dit} is he return on sale of each unit of garbage of *i th* dry variety in *t th* month

R_{Mit} is he return on sale of each unit of garbage of *i th* variety of medical waste in *t th* month

d_1^{RS-} is the negative deviation from the target of return on sales

d_1^{RS+} is the positive deviation from the target of return on sale

M_{wt} is he missed sale of each unit of garbage of wet variety in *t th* month

M_{Dit} is he missed sales of each unit of garbage of *i th* dry variety in *t th* month

M_{Mit} is the missed sale of each unit of garbage of *i th* variety of medical waste in *t th* month

d_2^{MS-} is the negative deviation from the target of missed sales

d_2^{MS+} is the positive deviation from the target of missed sales

S_{wt} is he storage cost of each unit of garbage of wet variety in *t th* month

S_{Dit} is he storagecost of each unit of garbage of *i th* dry variety in *t th* month

S_{Mit} is the storage cost of each unit of garbage of *i th* variety of medical waste in *t th* month

d_3^{SC-} is the negative deviation from the target of storage cost

d_3^{SC+} is the positive deviation from the target of storage cost

E_{wt} is he expenditure of each unit of garbage of wet variety in *t th* month

E_{Dit} is he expenditure of each unit of garbage of *i th* dry variety in *t th* month

E_{Mit} is the expenditure of each unit of garbage of *i th* variety of medical waste in *t th* month

d_4^{E-} is the negative deviation from the target of missed sales

d_4^{E+} is the positive deviation from the target of missed sales

P_{wt} is he Profit of each unit of garbage of wet variety in *t th* month

P_{Dit} is he Profit of each unit of garbage of *i th* dry variety in *t th* month

P_{Mit} is the Profit of each unit of garbage of *i th* variety of medical waste in *t th* month

d_5^{P-} is the negative deviation from the target of Profit

d_5^{P+} is the positive deviation from the target of Profit

T_{wt} is he Transportation costof each unit of garbage of wet variety in *t th* month

T_{Dit} is he Transportation cost of each unit of garbage of *i th* dry variety in *t th* month

T_{Mit} is the Transportation cost of each unit of garbage of *i th* variety of medical waste in *t th* month

T_{NRt} is the transportation cost of disposal of nonrecyclable waste for landfiling in *t th* month

d_6^{TC-} is the negative deviation from the target of Transportation cost

d_6^{TC+} is the positive deviation from the target of Transportation cost

R_t is the Target of return on sales of wastes in disposal unit

M_t is Target of missed sales of wastes in disposal unit

S_t is Target of Storage cost of wastes in disposal unit

E_t is Target ofexpenditure of the dispoal unit

P_t is Profit Target of the disposal unit

T_t is Target of Transportation cost of wastes

8. CONCLUSION

In this paper, multi-objectives taken into consideration and goal programming model developed for the same. The business of disposal of wastes not only benefits to the unit but also helps in saving the environment and society. Planning plays an important role in bringing largest revenue to the firm. The largest revenue generation from this disposal waste business may urge more people/firms to take up the business of sale of wastes which also urge the improvement in the economic development, sustainable development as well as health & safety of the public and environment. In this study, totally 186 variables are taken into consideration. This model is helpful in identifying the deviations in goals while disposing different types of wastes in one year. This model could be effective. Proposed mathematical model could be effective when many goals need to meet. Effectiveness confirmed by observing the results and verifying their accuracy by users and managers of the company.

On the basis of data collected the solution might be achieved. The model solved by use of TORA Software /MATLAB / EXCEL SOLVER once collection of data carried out. Based on this result the manager can take better decision to improve the business. Goal Programming technique which we used in this study indirectly give towards the safety and cleanliness of environment and society and make the place suitable for better to live in by increasing quality of life. Our paper also helps in profit generation within some specified constraints. This encourages the people to take up wastes selling business which also helps in promoting cleanliness and good health. Our technique helps in converting Trash to Treasure. It also aims at educating the private sector about the business value of wastes and availability of economic opportunities is one of the aims of our study. This study may help to change the way the world think about the wastes. This paper with its idea of providing goal programming techniques for converting waste into useful by-products and contributing for cleanliness and make a better place for living also would give positively towards *Swatch Bharat*.

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