

# OPTIMAL SOLUTION FOR DISTRIBUTION OF SEGREGATED WASTES OF GARBAGE DISPOSAL UNIT USING GOAL PROGRAMMING

Jyothi.P<sup>a</sup>, Dr.Vatsala GA<sup>b</sup>, Dr.Radha Gupta<sup>c</sup>

<sup>a</sup> Research Scholar, Jain University, Bangalore, Karnataka, INDIA, jyothi\_balu\_95@yahoo.co.in

<sup>b</sup> Associate Professor, Dept. of Mathematics, DSATM, Bangalore, Karnataka, INDIA, dr.vatsala.ga@gmail.com

<sup>c</sup> Professor, Dept. of Mathematics, DSCE, Bangalore, Karnataka, INDIA, radha.gaurav.gupta@gmail.com

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**Abstract** - Managing wastes is a one of the great challenge for any country due to large increase in generation of waste. The significant increase in population is one of the reasons for increase in waste. Developing countries undertake the establishment of disposal units which converts the waste into useful products. Types of waste includes Household waste, Industrial waste, Bio-medical waste, Bio-degradable waste, Solid waste, Liquid waste, Gaseous wastes etc. Sources of wastes are Residential, Industrial, Commercial, Institutional, Construction and Demolition, Agricultural, Municipal services, hospitals etc.

Now Garbage disposal unit is an emerging Industry. By-Products are formed through recycling such as bio-fuel, organic fertilizer, recycled glass, recycled papers, recycled plastics, recycled aluminum etc. are in high demand. It helps to keep the environment clean & also benefits the government/private sectors financially. Our study is to develop a Goal Programming model in order to optimize the customer's demands for by-products formed in Garbage disposal Unit which leads to profit generation.

A Goal Programming model which is a extension method of Linear Programming & it is formulated with the three objectives i) Maximizing the total distribution of 7 types of wastes to 3 different waste management companies ii) Minimizing the total expenses iii) Maximizing total profits. This developed goal programming model is useful tool for Garbage disposal unit to determine their distribution planning to satisfy the growing demands of their markets. Proper planning will ensure that all the demands will be met to avoid loss of customer's faith in the supply by ensuring sufficient supply to every waste management companies.

**Keywords**—Goal Programming, priorities, deviational variables, underachievement, overachievement

## 1. INTRODUCTION

An unused or non-usable material is waste material. Progress of civilization leads to large volume of waste generation & now it is a complicated issue. Population increase and urbanization are main reasons for the increase

in waste. Considering the growth of civic society, concentration of people in cities/urban centers, setting up several industries, hotels, big hospitals etc have significantly and largely contributed for increase in the problems being faced as far as 'wastes' are concerned. It is true because the amount of 'waste' is increased with no or very little effort in proper disposal and or recycle of wastes.

While growth/urbanization/setting up industries factories Hotels, Hospitals etc. are required for growth of the country, the appropriate disposal plan of the wastes is major concern. Dumping of wastes in open areas; water bodies; drains; low lying areas or burning them haphazardly cause severe problems affecting normal life, health and hygiene of people living in the nearby areas.

By proper and appropriate methods of disposal of wastes, the society can derive several benefits thereby can contribute positively rather than causing health and environment hazard. Some of the positive factors are (i) Sustenance of resources in the nature/ society (ii) reduced expenses; increased savings; (iii) growth of the economy; (iv) contribution by way of by-products; (v) Generation of more and more job opportunities (vi) Minimize pollution-land ,air, water etc and resultantly provide a better society to live.

The units which undertake the disposal of wastes carryout their task through various steps/process viz a) gathering of wastes from various sources, which including collection, transportation and carrying the wastes for the unit/site; b) appropriate action for their disposal like separation of different types of wastes -wet garbage and dry garbage. Further dry garbage can is separated into plastics, papers, tetra pack, glass, wood, metals etc. Medical wastes can be further classified. c) Take up the issue to the next level of proper action like processing which include segregating the items manually, involve technical methods like-compaction, incineration, thermal treatment etc.

The best method of disposal of wastes is to be decided on considering the various aspects and the type of

wastes. Such a method would have to meet several objectives which will be aiming at the positive contribution to the society and reducing the negative impact. The method should be economical one not costing enormously to the unit causing imbalance in the budget; the method of disposal should not cause health and hygiene hazards including bad odors and noise pollution; not to impact the air, water and land also the environment badly.

In this paper we concentrated on dry wastes and its utilization using goal programming technique. Dry Wastes collected can be distributed to different companies according to the demand of the location. By ensuring proper planning and proper distribution of wastes to different companies, disposal unit may maximize the profit.

## 2. RESEARCH METHODOLOGY:

Primary and Secondary data are collected from the various disposal plants which are necessary for the problem. Review of the literature provided an overview of factors affecting waste management systems. Data is gathered by various disposal units in & around Bangalore. Data collection, procedures of recycling process and details of production of by-products are collected by visiting more than 10 disposal wards in Bangalore. Review of literature also helped me to formulate goal programming model to find the best solution.

## 3. GOAL PROGRAMMING MODEL

The general GP model can be stated as follows

$$\text{Minimize } z = \sum_{i=1}^m w_i (d_i^- + d_i^+)$$

Subject to constraints

$$\sum_{j=1}^n a_{ij} x_j + d_i^- - d_i^+ = b_i, i = 1, 2, \dots, m$$

$$\text{and } x_j, d_i^-, d_i^+ \geq 0, \text{ for all } i, j$$

Where m goals are expressed by an m component column  $b_i$ ,  $a_{ij}$  represents the coefficient for the  $j^{\text{th}}$  decision variable in the  $i^{\text{th}}$  constraint,  $x_j$  represents decision variable,  $w_i$  represents the weights of each goal and  $d_i^-$  and  $d_i^+$  are deviational variables representing the amount of under achievement and over achievement of  $i^{\text{th}}$  goal respectively. According to the importance of the goals, Priority factors are assigned to deviational variables. Here P's are not given actual values, but this is simply a convenient way of indicating that one goal is important than another. The Priority factors have the relationship of  $P_j$  ( $j=1, 2, \dots, k$ ). Lower Priority goal can never be achieved at the expense of higher priority level.

## 4. SURVEY

In different fields a lot of research has been carried out in application of Goal Programming. **Charnes et al.**(1969) used the GP framework for the solution of manpower planning problems. Most of the cropping plan problems are multi-objective in nature. In 1976, **Ignizio** used GP as an effective tool for multi objective decision analysis has been successfully implemented to different farm planning problems. **Pecenka**(1986) has employed goal programming models for organizational sectors. Our Review focused on Published Journals in English books and unpublished reports and Textbooks related to the topic Goal Programming which is written by **Springer**. **Paolo** [2003] has given method for choosing from among transportation projects and he studied the multi-objective models and their areas of application adopted. **Issan Dhari and Habi Chabchoub**[2006] developed Nonlinear Goal Programming Model in Supply Chain based on ARIMA parameter.

**Pedro. M. Reyer & Gregory V Frazier** [2006] developed goal Programming Model for grocery shelf space allocation. **A O Salami** [2014] provides the information about Linear Programming Model through his paper on Application of Transportation Linear Programming Algorithms. **Ekezie Dan Dan & Onusha Desmond O** [2013] demonstrated GP Model for Budgetary Allocation of an Institution's higher learning. **Nasruddin Hassan & Zuraini Ayop** [2012] used for Goal Programming approach food Product distribution of SME. **Dr. Lakhimi Gogoi** [2013] has done case study of municipal waste disposal in Guwahati City.

## 4. STUDY OF THE CURRENT PROBLEM

There are many varieties of wastes. In the initial stage, collected wastes can be categorized into **wet** and **dry** waste. Further wet wastes can be recycled and can be converted into bio-fuel and organic compost and wormy compost. Dry wastes can be segregated further and the maximum utilization can be done from these wastes. Dry wastes include mainly papers, plastics, wood, metals, glass and tetra packs etc

- **Papers** can be reused and 100% utilization wastes can be done by recycling process. If we recycle newspaper it can be reused as wrapping paper and reprocessed into newsprint.
- **Plastic** wastes can be categorized further as PET bottles, Road wastes, mill covers, Plastic HDP, LD covers etc. and can be recycled and reused. 80% of the plastic wastes can be recycled and 20% of the plastics which cannot be recycled can be converted into plastic tars. Plastic resins can be remolded into new products such as toys, drainage pipes, car parts etc.
- **Glass** wastes can be recycled and 100% utilization is possible from these wastes. Recycling the glass

materials will yield us new glass container. Glass wastes can be reused and remolded by melting.

- **Metals** are also one of the dry wastes and metals can be categorized further iron, aluminum, copper and steel etc. Since used metals are of lesser density it can be recycled and used as thin sheets, car body parts, etc. 100% utilization of metal wastes can be done by recycling. 80% of the metal wastes can be reused by heating and molding into the required shapes. Aluminum wastes can be melted and can make Roller sheets of Aluminum which can be used for car bodies.
- 80% of the **Wood** wastes can be recycled and we can use them as thin wooden sheets, cardboards etc. 20% of the wood wastes which cannot be reused & it can be converted into organic fertilizer.
- **Tetra packs** (Juice cups) are another variety of wastes and they are made of only paper or only aluminum or combination of paper and aluminum (30%+70%). While recycling, we can separate the paper and aluminum. By- products of tetra packs are table, chair, sheets, bench, pen, book, pamphlets, stools etc. This can be manufactured according to the demand in different towns which gives economic benefit for the unit/industry.

Vendors from different companies collect different types of wastes according to their requirement. Their requirement depends on what type of material they produce. Their production depends on demand in the market.

### 6. ASSUMPTIONS

- Delivery costs are borne equally by both supplier and buyer.
- Gross profit =total sales - production cost of each product
- Demand from each company is average monthly demand of that location
- The monthly net profit must be at least 40% of the allocated budget
- Types of waste -products collected are sent to all three companies must not be nil

### MODEL DEVELOPMENT

1) Demand of the  $i^{th}$  product from company  $j$

$$y_{ij} = D_{ij} \text{ where } i=1,2,3,4,5,6,7, \text{ \& } j=1,2,3 \text{ -----(1)}$$

Where  $i$  represent the 7 different types of wastes which are Recycled plastic, Non recycled plastic, Aluminum metal, Iron metal, Papers, glass & wood.  $j$  represents 3 different waste management companies. After the tender notification, the waste management companies are selected by disposal unit according to their quoted rate for selling the wastes.

$$y_{ij} + d_k^- - d_k^+ = D_{ij},$$

$$i=1,2,3,4,5,6,7 \text{ \& } j=1,2,3 \text{ \& } k=1,2,\dots,21 \text{ -----(2)}$$

2) The net profit must be at least 40 % of the budget allocation of the garbage disposal unit

$$\sum_{i=1}^7 b_i y_{i1} - \beta_k + \sum_{i=1}^7 b_i y_{i2} - \beta_L + \sum_{i=1}^7 b_i y_{i3} - \beta_M \geq 0.4B \text{ ----- (3)}$$

The first part of the above inequality is the net Profit from Waste management company 1, 2 and 3 respectively. The difference between gross profit & delivery cost will results in net profit in each location.  $\beta_k, \beta_L, \beta_M$  are the delivery costs waste management company 1, 2 and 3

We obtain Net profit by subtracting delivery cost from gross profit

$$\sum_{i=1}^7 b_i y_{i1} - \beta_k + \sum_{i=1}^7 b_i y_{i2} - \beta_L + \sum_{i=1}^7 b_i y_{i3} - \beta_M + d_{22}^- - d_{22}^+ = 0.4B \text{ ----- (4)}$$

$$\Rightarrow \sum_{i=1}^7 b_i y_{i1} + \sum_{i=1}^7 b_i y_{i2} + \sum_{i=1}^7 b_i y_{i3} + d_{22}^- - d_{22}^+ = 0.4B + \beta_k + \beta_L + \beta_M \text{ ----- (5)}$$

3) The Expenditure of the disposal unit should be within the monthly allocated budget

$$\sum_{i=1}^7 \sum_{j=1}^3 c_i y_{ij} \leq B \text{ ----- (6)}$$

By introducing deviational variables we get

$$\sum_{i=1}^7 \sum_{j=1}^3 c_i y_{ij} + d_{23}^- - d_{23}^+ = B \text{ ----- (7)}$$

By selecting three waste management companies in which demand of every company differs according to customer needs. Delivery costs of each compay is different due to different distances.

4) The monthly supply to each waste management company must be within the maximum demand

$$\sum_{j=1}^3 y_{ij} \leq S_i^U \quad i=1,2,\dots,7 \text{ ..... (8)}$$

$$\sum_{j=1}^3 y_{ij} + d_{24}^- - d_{24}^+ = S_i^U \text{ -----(9)}$$

5) Supply of each waste must be at least 1

$$y_{ij} \geq 1 \quad i=1,2,\dots,7 \text{ \& } j=1,2,3 \text{ -----(10)}$$

$$y_{ij} + d_{25}^- - d_{25}^+ = 1$$

All overachievement and underachievement variables not allowed being negative

$$d_k^-, d_k^+ \geq 0, \quad k = 1, 2, \dots, 25 \quad (11)$$

The Priority level of the GP Model as follows

P<sub>1</sub>: Demand of wastes by each company are fulfilled

P<sub>2</sub>: The net profit is to be at least 40% of the total budget

P<sub>3</sub>: The Expenses of the unit does not exceed the allocated monthly budget

P<sub>4</sub>: Supply to each waste management company must be within maximum demand

P<sub>5</sub>: Minimum supply of waste to 3 companies should be at least 1

#### ACHIEVEMENT FUNCTION

$$\text{Minimize} = P_1 d_k^- + P_2 d_{22}^- + P_3 d_{23}^+ + P_4 d_{24}^+ + P_5 d_{25}^-$$

Where  $k=1, 2, \dots, 21$

#### RESULTS AND CONCLUSIONS:

The goal programming model is developed for finding the optimal solution to the distribution of segregated waste products which collected in Garbage disposal unit to different waste management companies. The waste products collected by disposal unit are Recycled plastic; Non-recycled plastic, Aluminum metal, Iron metal, Papers, glass & wood. This can be extended too many varieties of waste products and by considering more number of waste management companies.

Developed Goal Programming Model is useful tool for the profit of Garbage disposal unit. This determines the distribution of wastes to different companies to satisfy the growing demands of their markets. To meet all the demands of companies proper planning is required. This will ensure supply of wastes to different waste management companies by ensuring profit. Planning of distribution will ensure the profit of the organization. This developed model can be further tested with the statistical data.

In this paper we tried to formulate a **mathematical model** by considering only 7 types of waste products and 3 different waste management companies. By considering the sub products of plastics, metal, glass and paper, wood we get many varieties of waste products. Distribution of these varieties of wastes may be increased to more number of waste management companies & optimal solution may be achieved from this model. On the basis of data collected solution may be achieved. Solution may be achieved by manual calculations. But manual calculation is time consuming process and not easy. The use of software's like

MATLAB and Excel –Solver helps us to find the solution easily.

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## BIOGRAPHIES



Jyothi.P completed her post-graduation in Osmania University, Hyderabad in 1999. Presently working as Associate Professor and HOD, Department of Mathematics in City Engineering College, Bangalore, India. Presently pursuing PhD in Jain University, Bangalore. Area selected for research is 'Application of goal programming in Operation Research'. She has presented two papers in National Conferences. 17 years of teaching experience in Engineering and degree colleges. Qualification is M.Sc., M.Phil, MBA, (Ph.D.)



Dr. Vatsala G A graduate and Post Graduate from Gulbarga University, India and Received M Sc Degree in Applied Mathematics in 1997, Ph. D Degree in Mathematics CCS University, Mirut, India with the specialization Operation Research . She is having 19 years of experience in teaching and research. Her research work is carried in the field of "A complete technical solution of garbage disposal unit in Goal programming", "Antenna using convex optimization" and " A optimal solution in grow of crop using soil management and source of water in region" She published more than 12 papers in National and International journals and she presented 8 papers in National and International conferences. Presently she is working as a Associate Professor in the department of Mathematics, Dayananda Sagar Academy of Technology and Management, Bangalore, India



Dr. Radha Gupta, a faculty of Mathematics at Dayananda Sagar College of Engineering, under *Visvesvaraya Technological University*, Bangalore, is continuously engaged in teaching and research activities for past 19 years. Her area of specialization is Operations Research and Applied Mathematics. She has published few books, research monologue and many research papers in peer reviewed National and International Journals. She is a recipient of President's Gold Medal from Agra University and University Gold Medal from IIT Roorkee.