Asian Resonance

Planning for optimizing transport and treatment of waste by using goal programming

Rajesh Dangwal
Deptt. of Mathematics,
H.N.B. Garhwal University,
Pauri Campus

Arvind Kumar
Deptt. of Mathematics,
A.C.C. Wing. Indian
Military Academy.
Dehradun.

Vivek Naithani
Deptt. of Mathematics,
H.N.B. Garhwal University,
Pauri Campus

Abstract

Waste production is associated to human activities and human activities will always keep going. Amount of waste is increasing with population and this is a big ecological problem. We cannot stop production of waste, but with the help of technology we can reduce its toxicity and quantity up to some extent. In India, such waste treatment plants are less in number and at far distances from waste production sites, due to which very feeble amount of waste is treated and waste treatment becomes costly and time taking process. In this paper we are trying to use a goal programming model to optimize quantity of waste treated, cost and time to maintain an ecological and economic balance.

Keywords: Waste treatment, Goal Programming, optimize, ecological balance, economic balance.

Introduction

Disposal of waste is a big environmental problem in today's developing world. We can get rid off this problem in either of two ways; either reduce production of waste or dispose it away from our habitat. We are living in a developing world and our desires of development are unlimited so reduction in waste production seems impossible. For development more human activities are required and more the activities, more is the production of waste. The growing population and increasing infrastructure has already created shortage of land so we cannot spare it for waste disposal above some certain limits.

So, it becomes necessary to find some way between development and conservation of ecosystem for proper disposal of waste. In this direction, a number of waste treatment plants have been constructed for proper treatment of waste such that its quantity and quality should be reduced. By treating these wastes in these plants the toxicity of these byproducts due to xenobiotic activities can be reduced up to such a level that it should not harm any of the biotic or abiotic factors of our ecosystem. This way any kind of pollution could be managed. Also the quantity of waste gets reduced and it occupy considerably less space thus our growing population gets more space for accommodation and development. One important aspect of waste treatment is that it avoids wastage of natural resources and spread of harmful diseases. During waste treatment a number of things are sent to recycle system thus avoiding wastage of natural resources and thus, we extract fewer resources from nature which helps in maintaining a balance between nature and human beings.

Goal Programming:

Goal programming (GP) is an important analytical approach devised to solve many real world problems, where targets have been assigned to all attributes and where decision makers (DM) are interested in minimizing the non achievement the corresponding goal. [Chin Nung Laio]. GP was first introduced by Charnes and Cooper (1961) and further developed by Lee (1972), Ignizio (1976), Tamiz et.al. (1998), etc.

Generally GP minimizes undesired deviations from target values. In this method the DM can consider many goals simultaneously during the search for compromise solution and is supported by Mathematical Programming Optimization Potential (Martel and Aouni, 1998). GP is a powerful tool which draws upon the highly developed and tested techniques of LP but provides a simultaneous solution to a complex system of competing objectives (Banashri Sinha and N Sen, 2011).

GP is a mathematical programming technique which treats the constraints of linear programming problem as their goal. Linear programming as a goal in the objective function, optimization means, coming as close as possible to achieve these goals, in order of priority by

the decision maker. Goal programming is applicable to single or multiple goal although it is a greater usefulness occurs when the multiple goal are conflicting and cannot satisfied simultaneously.

Weighted Goal Programming (WGP) is also known as Archimedean GP. Its achievement function consists of both the unwanted deviation variables associated with rigid constraints and flexible constraints each weighted according to priority. As long as the unwanted deviations are minimized, we achieve a satisfactory solution. The mathematical of a WGP model is as:

Minimize $\sum (\alpha_i d_i^+ + \beta_i d_i^-)$, i = 1,2,3,…..n.

Subject to: $f_i(X) + d_i^+ - d_i^- = g_i$, i = 1,2,…..,n.

$d_i^+, d_i^- \geq 0$, i = 1,2,…,n.

X ε F (F is a feasible set). [Chin Nung Laio, 2008].

Waste Treatment:

India is a developing economy with world's second largest population and about 1.6 % of total land of world. Due to these reasons waste production is high and space for waste disposal is low, which is a big ecological problem. The waste from industrial and municipal areas is being disposed either in rivers or vacant plots, which is creating pollutions of land, water and air. The waste treatment plants are negligible in comparison to production of waste. The most probable reasons for this are less public awareness and low economy. Waste is being produced in every corner of the country, but treatment plants are situated at far off places. So, to treat it transportation cost and extra treatment time is added to the total expenses along with danger of spread of infections and diseases.

Waste treatment is becoming the necessity as it decreases the toxicity as well as quantity of harmful wastes. It is very helpful in controlling pollution and tries to create and maintain an ecological balance.

The main waste concerns of waste treatment in our country are:

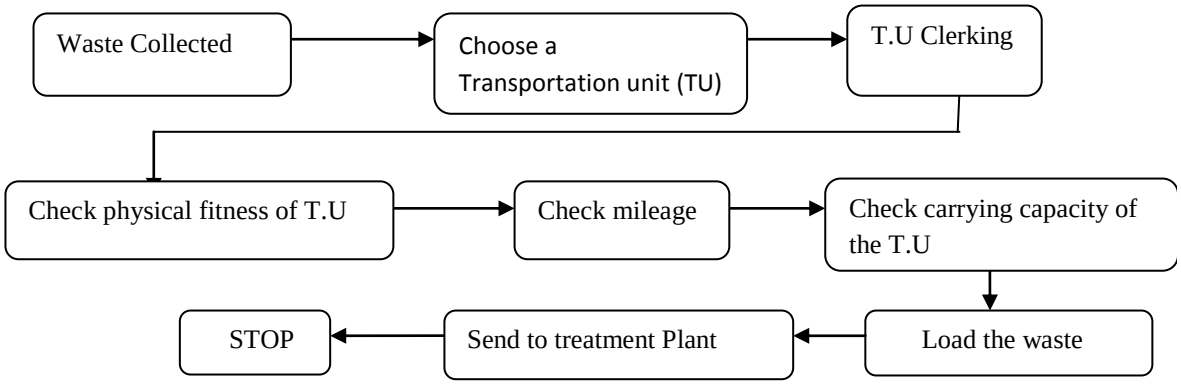
1. **Transportation of waste:** The amount of waste is increasing with population, industrial and technological advancements but ecological awareness is still in its infancy in our nation. People are either illiterate or more concerned about monetary profits. So, no one cares to develop waste treatment plants along with industrial and municipal settlements. Due to these reasons waste treatment plants are feeble thus making transportation a necessary part.
2. **Maximizing amount of waste treated:** Amount of waste is high but treatment plants are less in number so, it becomes necessary to increase the efficiency of our plants in ordre to minimize the waste.
3. **Minimizing waiting time and cost:** When waste reaches the plant it has to wait unless the treatment process going inside is completed as rate of service is low, this can be even more harmful as the waste becomes the breeding ground for germs and their vectors. In can even cause pandemics. So waiting time should be as less as possible.

Our economy is developing and we cannot spare too much currency in waste disposal so we have to do it in minimum possible cost.

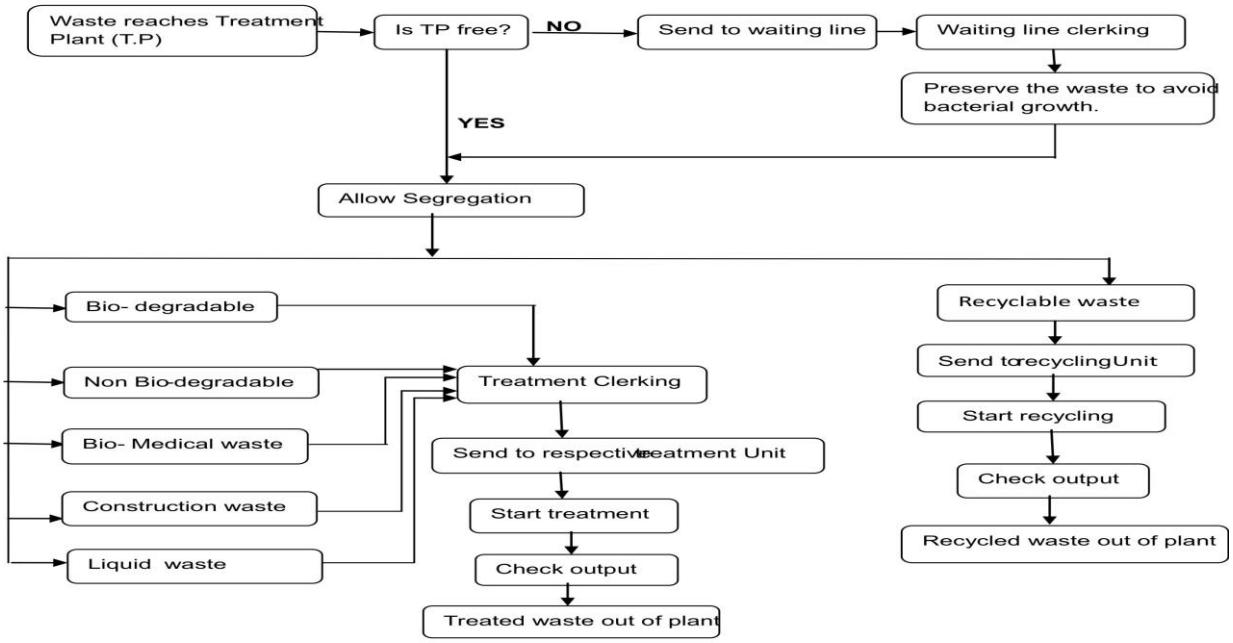
Priority structure:

1. To maximize the capacity of transporting units carrying waste from different places to the plants.
2. To minimize the transportation cost per unit distance.
3. To minimize waiting time outside the plant.
4. To maximize amount of waste treated per unit time.
5. To minimize treating time per unit waste.
6. To minimize treatment cost per unit waste.

Simulation Model.

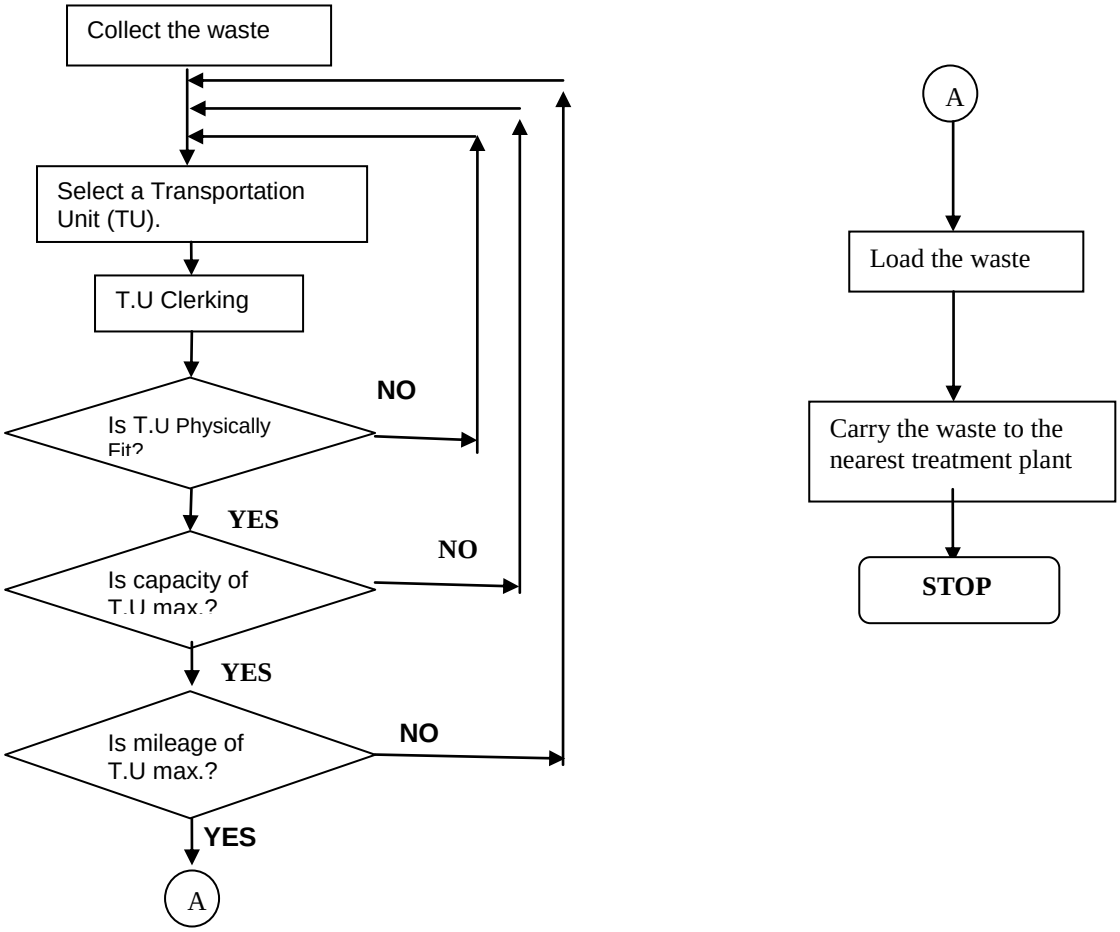


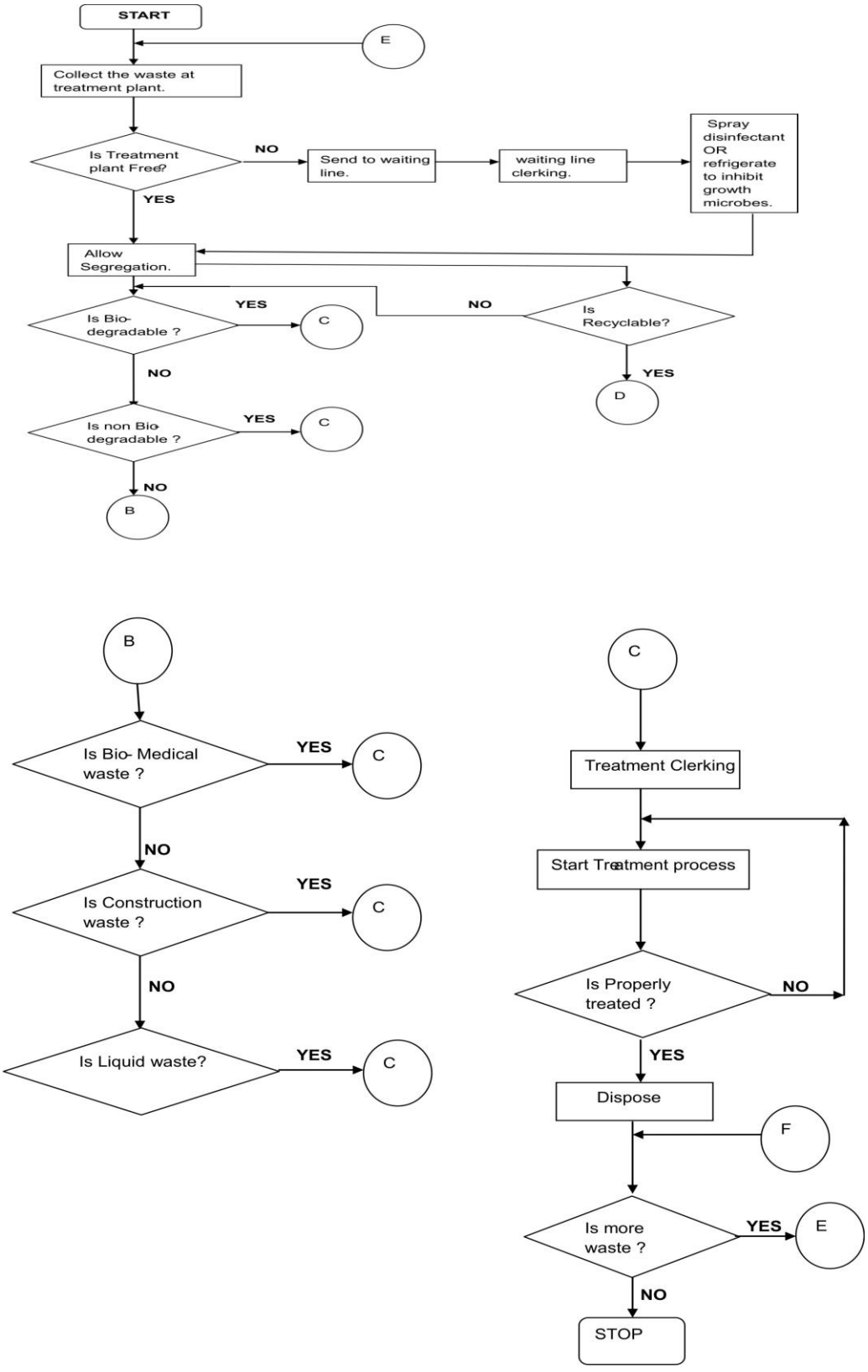
SIMULATION MODEL. 1

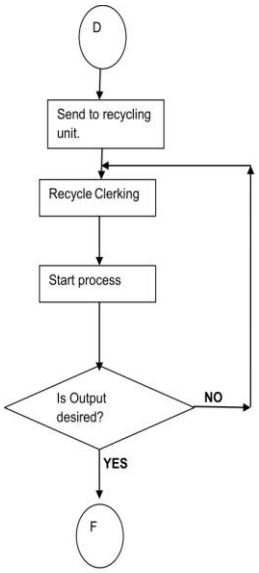


Simulation Model. 2

Computer Algorithm




START
E
Collect the waste at treatment plant.
Is Treatment plant Free?
NO
Send to waiting line.
waiting line clerking.
Spray disinfectant OR refrigerate to inhibit growth microbes.
YES
Allow Segregation.
Is Bio-degradable ?
YES
C
NO
Is Recyclable?
YES
D
NO
Is non Bio-degradable ?
YES
C
NO
B
B
Is Bio- Medical waste ?
YES
C
NO
Is Construction waste ?
YES
C
NO
Is Liquid waste?
YES
C
C
Treatment Clerking
Start Treatment process
Is Properly treated ?
NO
YES
Dispose
F
Is more waste ?
YES
E
NO
STOP



Final Modelling:

Min. Z =

$$\frac{w_1 d_1^-}{\chi_1} + \frac{w_2 d_2^+}{\chi_2} + \frac{w_3 d_3^+}{\chi_3} + \frac{w_4 d_4^-}{\chi_4} + \frac{w_5 d_5^+}{\chi_5} + \frac{w_6 d_6^+}{\chi_6}$$

Subject to:

$\sum C_i \; t_i + d_1^- - d_1^+ = \chi_1$

$\sum TC_i \; t_i + d_2^- - d_2^+ = \chi_2$

$\sum W_i + d_3^- - d_3^+ = \chi_3$

$\sum TW_j \; H_j + d_4^- - d_4^+ = \chi_4$

$\sum T_j \; \alpha + d_5^- - d_5^+ = \chi_5$

$\sum \lambda \; \alpha + d_6^- - d_6^+ = \chi_6$

Notations And Symbols:

C_i = Capacity of i^{th} transporting unit.

TC_i = Transportation cost charged by i^{th} transporting unit.

t_i = Number of times i^{th} transporting unit is used.

W_i = waiting time for i^{th} transporting unit.

TW_j = Amount of waste treated by j^{th} plant.

H_j = Number of working hours for j^{th} plant.

T_j = Time taken by j^{th} plant to treat unit amount of waste.

α = Total amount of waste to be treated.

λ = Cost required to treat unit amount of waste.

$\chi_1, \chi_2, \chi_3, \chi_4, \chi_5, \chi_6$ are aspiration levels.

d_1^- , d_1^+ are negative and positive deviations from goals respectively.

Conclusion:

Waste treatment is a big challenge in this fast increasing economy and population. Almost every sector of today's economy contributes in production of waste and thus towards pollution. Through this paper we are trying to propose a simulation model as well as a GP model which can help decision makers (DMs) to make optimum decision about carrying capacity of transportation units, transportation cost, and waiting time, amount of waste treated, treating time and treatment cost. Optimization of transportation units is also a big challenge accompanying the challenge of waste treatment as carrying maximum waste and reaching in minimum time is very important aspect of this whole study. Apart from this today we are concerned about fuel efficient vehicles due to acute shortage of petroleum in near future so, it is necessary that the transportation unit selected must provide maximum mileage with power. Here a combination of simulation and GP is applied to handle multi- objective decision making that can arise during the process of waste treatment. Data can be entered in simulation model which can be used as input which further enables the GP model to be built to do trade off analysis. Different weights can be attached to positive and negative deviations from different objectives to do this. Thus paper presents an optimization approach to achieve environmental stability. This can be taken as a basic study for further researches.

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