Integer Programming Model for Integrated Planning of Solid Waste Management in Jaipur

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Abstract--Rajasthan's economic growth has stimulated urbanization, but lack of commensurate investment in urban infrastructure and services has resulted in an overall deterioration of urban quality of life. Jaipur is the capital of the largest state of country, having an inefficient, outdated and unscientific waste management system. Jaipur socio-economic development potential relies on sound environmental management so that tourism may grow and become sustainable. This paper attempts to assess the existing state of municipal solid waste management (MSWM) in Jaipur city with the aim of identifying the main obstacles to its efficient and prospects for improvisation of solid waste management system in the city.

Keywords- RDF-refuse derive fuel, MSWM- municipal solid waste management, Jmc- Jaipur municipal -corporation, MT- metric tons.

1. INTRODUCTION

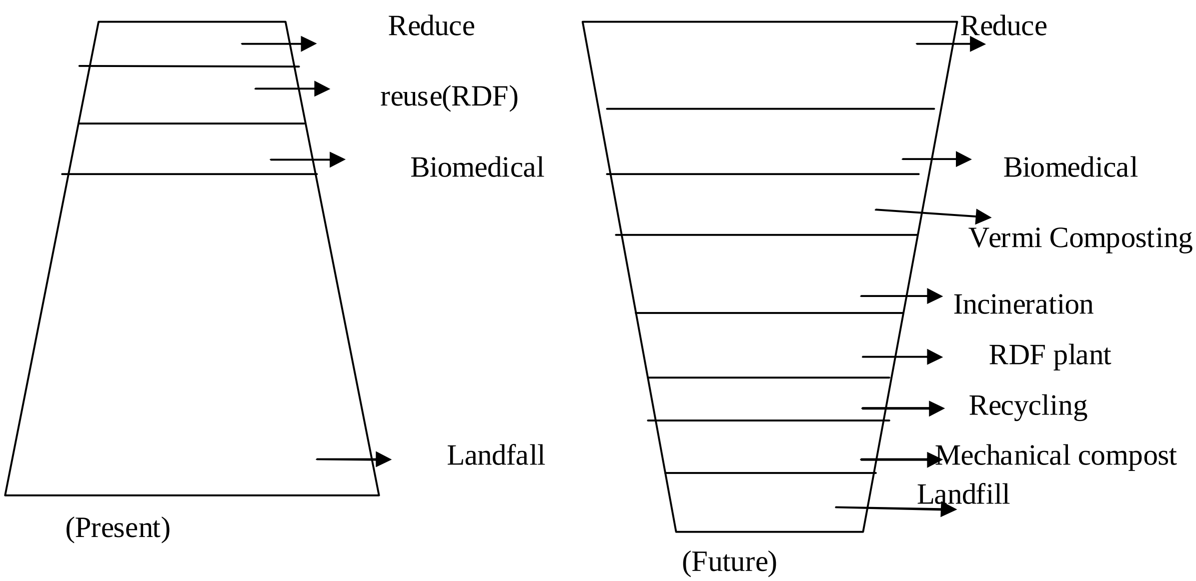
Maharaja Jai Singh second founded Jaipur city in the year 1728.It is a uniquely planned city with rich architectural heritage which attract to foreign tourist and known as the "Pink city". But environment degradation and lack of basic amenities threaten its viability. Solid waste management system of a city has vital role on quality of life. As per 2001 census the population of Jaipur city was 23 lacks approx. and as per Jmc's figure it will increase by the rate of 2.8% per annum so the present population of Jaipur in 2010 is 29 ,25,663.It is observed that bigger the size of the city (population and density wise) , greater is the quantity of waste generated. As per information received from various sources, Jaipur city generates 1000-1100 MT of waste per day. There by usual everyday practice maximum solid waste goes in to dumping sites without any recycling and separation process. On an average more than 60% of the population disposed off their solid waste on streets, open spaces, drains, lanes, and storm water drainage. The system has resulted unhygienic conditions in the city.

So presently approx. 600-650 Ton/day of waste is crudely dumped at mathuradaspura dumping sites and 400-450 Tons/day at sevapura dumping sites without segregation and reuse.

Presently we have only one RDF plant based on BOOT basis by ms.Grasim India Ltd. At Lagadiyawas, one bio-medical treatment plant at Khorarupadi on PPP run by Instromedics India private Ltd. And two open dumping spaces located at mathuradaspura and Sevapura sites. As per gathered information approximate 15% of total waste is used in RDF plant without segregation but it is not in everyday practice. The quantity of bio-medical waste expected to be generated 4 to 4.5MT in which approx.800kg.glassware has to be disinfected chemically, and only 0.15 MT is autoclaving and about 2.8 MT burned and disposed off at the site of plant. In Jaipur proper sanitary landfill has not been developed but one is under construction process at Lagadiyawas. Not proper plannining of collection and transportation method followed. Some time the collected waste of some wards goes to transfer station some time it will go to any dumping sites either sevapura or mathuradaspura.

So Proper planning and scheduling must be required in the present situation and we have to think with increasing emphasis on resource recovery of useful commodities from the waste (recycling), utilization of waste as a substitute for fuel in power plant , composting and other advance technologies. In this paper our aim is to suggest the better way to improve the present system by implementing some changes in collection and transportation method, by applying segregation method, and empirically establish the existence of economics of scale for vermicular compost plant, recycling plant, mechanical compost plant, incinerator and one more sanitary landfill. So proposed model is used as an effective tool for efficient management when planner has made decision regarding political, social, and other practical aspects of the problem which are difficult to quantify. In our scientific optimization model we have total two transfer stations. MSW from a specific region should be firstly collected at different nodes, and by choosing suitable roots must be sent to a transfer station, then there it will sorted out by workers and allocated to various waste treatment plants like mechanical compost plant, vermicular compost plant RDF plant, recycling, incinerator or landfills. Biomedical waste should be collected from all hospitals, dispensaries, clinics and diagnostic centers and directly sent to bio- medical treatment plant. With these versatile programming techniques, different waste diversion rates under multiple policy scenario and complex uncertainties could be analyzed which will be very helpful to reduce quantity of disposal waste in a better economic and more sustainable way.

The current practice MSWM in all urban centers of the country is biased towards achieving 100% collection and its subsequent disposal with partial or no treatment/processing. Therefore an urgent need to shift the paradigm from open cycle to close cycle of waste. (given in fig 1.)



(Fig. 1) In Jaipur, change in strategy in waste management hierarchy

Model

This section describes the mathematical formulation of the integer linear programming model for integrated waste management planning. The model has been built upon the following assumptions.

1. Waste nodes are located at the centers of waste generating areas.

2. Waste separation is done at transfer stations.

3. All the proposed plants in the model are situated near landfill sites so that transportation cost of inert material transported from these plants to landfill is negligible.

Variables:-

Xit1, Xjt2, i=1, 2…5, j=1…4:- respectively total number of trips made by dumpers to carry waste from node i to transfer station at t1 and from node j to transfer station at t2.

xit1, xjt2, , i=1,2…5, j=1,…4:- respectively total number of dumpers used everyday to carry waste from node i to transfer station at t1 and from node j to transfer station at t2.

Yt1r, Yt1m, Yt1s, Yt1ℓ1, Yt2n, Yt2v, Yt2ℓ2:- respectively total number of trips made by dumpers to carry waste from transfer station at t1 to R.D.F. plant at r, mechanical compost plant at m, recycling plant at s, landfill at ℓ1 and from transfer station at t2 to incinerator at n, vermicular compost plant at v, landfill at ℓ2.

yt1r, yt1m, yt1s, yt1ℓ1, yt2n, yt2v, yt2ℓ2:- respectively total number of dumpers used everyday to carry waste from transfer station at t1 to R.D.F. plant at r, mechanical compost plant at m, recycling plant at s, landfill at ℓ1 and from transfer station at t2 to incinerator at n, vermicular compost plant at v, landfill at ℓ2.

Krℓ1, Kmℓ1, Ksℓ1, Knℓ2, Kvℓ2:- respectively total number of trips made by dumpers to carry waste from R.D.F. plant at r, mechanical compost plant at m, recycling plant at s, to a landfill at ℓ1 and from an incinerator at n, vermicular compost plant at v, to a landfill at ℓ2.

krℓ1, kmℓ1, ksℓ1, knℓ2, kvℓ2:- respectively total number of dumpers used everyday to carry waste from R.D.F. plant at r, mechanical compost plant at m, recycling plant at s, to a landfill at ℓ1 and from an incinerator at n, vermicular compost plant at v, to a landfill at ℓ2.

Po: - number of trips made by special vehicles which collect the waste from all hospitals, dispensaries, clinics, and diagnostic centers of city to carry biomedical waste to biomedical treatment plant.

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Zr, Zm, Zs, Zn, Zv, Zo , Zℓ1, Zℓ2:- 0-1 variables indicate respectively, the presence of RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o and landfills at ℓ1and ℓ2.

Wr, Wm, Ws, Wn, Wv, Wo, Wℓ1, Wℓ2:- amount of waste transported everyday respectively, to a RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o and landfills at ℓ1and ℓ2.

D1 , D2 : -respectively total numbers of dumpers used and special vehicle used for biomedical waste everyday.

Input Data Parameter:-

a_{it1}, a_{jt2}, i=1, 2…5, j=1…4:- expected number of trips respectively made by dumpers per day to carry waste from node i to transfer station at t1 and from node j to transfer station at t2.

b_{t1r}, b_{t1m}, b_{t1s}, $b_{t1\ell1}$, b_{t2n}, b_{t2v}, $b_{t2\ell2}$:- expected number of trips respectively made by dumpers per day to carry waste from transfer station at t1 to R.D.F. plant at r, mechanical compost plant at m, recycling plant at s, landfill at ℓ1 and from transfer station at t2 to incinerator at n, vermicular compost plant at v, landfill at ℓ2.

$\lambda_{r\ell1}$, $\lambda_{m\ell1}$, $\lambda_{s\ell1}$, $\lambda_{n\ell2}$, $\lambda_{v\ell2}$:- expected number of trips respectively made by dumpers per day to carry waste from R.D.F. plant at r, mechanical compost plant at m, recycling plant at s, to a landfill at ℓ1 and from an incinerator at n, vermicular compost plant at v, to a landfill at ℓ2.

α:- capacity (in tons) of a dumper.

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C_{it1}, C_{jt2}, i=1, 2…5, j=1…4:- respectively transportation cost from node i to transfer station at t1 and from node j to transfer station at t2.

d_{t1r}, d_{t1m}, d_{t1s}, $d_{t1\ell1}$, d_{t2n}, d_{t2v}, $d_{t2\ell2}$:- *respectively transportation cost from transfer station at t1 to R.D.F.* plant at r, mechanical compost plant at m, recycling plant at s, and a landfill at ℓ1 and from transfer station at t2 to incinerator at n, vermicular compost plant at v, and a landfill at ℓ2.

h_o:-transportation cost of special vehicles which collect the waste from all hospitals, dispensaries, clinics, and diagnostic centers of city.

C_r, C_m, C_s, C_n, C_v, C_o :- revenue respectively per unit of waste from a RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o.

f_1, f_2 :-respectively cost of buying dumpers and special vehicle for bio medical waste.

ψ_1, ψ_2 :- are respectively total amount of waste at transfer stations at t1 and t2.

ρ_r, ρ_m, ρ_s, ρ_n, ρ_v, ρ_o :- fraction of unrecovered waste respectively at RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o.

Q_r, Q_m, Q_s, Q_n, Q_v, Q_o , $Q_{\ell1}$, $Q_{\ell2}$:-capacity per day respectively for a RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o and landfills at ℓ1and ℓ2.

∂_r, ∂_m, ∂_s, ∂_n, ∂_v, ∂_o , $\partial_{\ell1}$,$\partial_{\ell2}$:-respectively fixed cost incurred in opening a RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o and landfills at ℓ1and ℓ2.

ξ_r, ξ_m, ξ_s, ξ_n, ξ_v, ξ_o , $\xi_{\ell1}$,$\xi_{\ell2}$:-respectively variable cost incurred in handling a RDF plant at r, mechanical compost plant at m, a recycling plant at s, an incinerator at n, vermicular compost plant at v, bio-medical treatment plant at o and landfills at ℓ1and ℓ2.

Objective function

Objective function represents the overall daily management cost.

The first component (F_1) gives the total of transportation cost i.e. Transportation cost from nodes i=1,…5 to transfer station at t1 + transportation cost from nodes j=1,…4 to transfer station at t2 +transportation cost from transfer stations at t1 and t2 to either at any treatment plant or to a landfill sites at ℓ1and ℓ2 respectively + transportation cost of special vehicles used to collect biomedical waste. The second component (F_2) gives the investment and handling expenses. The third component (F_3) gives the total cost for buying all dumpers and special vehicles for bio-medical waste. The fourth component (B) gives the benefits at plants owing to the production at different plant.

$$\left[\begin{aligned} F_1(X,Y) = &\sum_{i=1}^{5} C_{it1}\alpha X_{it1} + \sum_{j=1}^{4} C_{jt2}\alpha X_{jt2} + \sum_{t1r} d_{t1r}\alpha Y_{t1r} + \sum_{t1m} d_{t1m}\alpha Y_{t1m} + \sum_{t1s} d_{t1s}\alpha Y_{t1s} \\ &+ \sum_{t1\ell1} d_{t1\ell1}\alpha Y_{t1\ell1} + \sum_{t2n} d_{t2n}\alpha Y_{t2n} + \sum_{t2v} d_{t2v}\alpha Y_{t2v} + \sum_{t2\ell2} d_{t2\ell2}\alpha Y_{t2\ell2} + \sum_{o} h_o\alpha P_o \end{aligned}\right] \quad [1]$$

$$\begin{aligned} F_2(Z,w) = &\sum_r (\delta_r Z_r + \xi_r w_r) + \sum_m (\delta_m Z_m + \xi_m w_m) + \sum_s (\delta_s Z_s + \xi_s w_s) \\ &+ \sum_n (\delta_n Z_n + \xi_n w_n) + \sum_v (\delta_v Z_v + \xi_v w_v) + \sum_{\ell1} (\delta_{\ell1} Z_{\ell1} + \xi_{\ell1} w_{\ell1}) + \\ &\sum_{\ell2} (\delta_{\ell2} Z_{\ell2} + \xi_{\ell2} w_{\ell2}) + \sum_o (\delta_o Z_o + \xi_o w_o) \end{aligned} \quad [2]$$

$$F_3(x,y,k) = \sum f_l(D_1) + \sum f_2(D_2) \quad [3]$$

$$\begin{aligned} B(w) = &\sum_r C_r(1-\rho_r)w_r + \sum_m C_m(1-\rho_m)w_m + \sum_s C_s(1-\rho_s)w_s \\ &+ \sum_n C_n(1-\rho_n)w_n + \sum_v C_v(1-\rho_v)w_v + \sum_o C_o(1-\rho_o)w_o \end{aligned} \quad [4]$$

So the objective function F to be minimizes is

$$\mathbf{F = F_1 + F_2 + F_3 - B} \quad [5]$$

Mass balance constraints:-

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Total waste moved from each waste collection points i=1,…5 and j=1,…4 should at least be equal to

the total amount of waste at that point.

$$\sum_{i=1}^{5}\alpha X_{it1} + \sum_{j=1}^{4}\alpha X_{jt2} \geq \Psi_{t1} + \Psi_{t2} \quad [6]$$

In constraints (7) and (8) amount of waste carried from transfer stations at t1 and t2, to different plants should at least be equal to the amount of waste found at that point.

$$\sum_{t1r}\alpha Y_{t1r} + \sum_{t1m}\alpha Y_{t1m} + \sum_{t1s}\alpha Y_{t1s} + \sum_{t1\ell 1}\alpha Y_{t1\ell 1} \geq dt1 \quad [7]$$

$$\sum_{t2r}\alpha Y_{t2r} + \sum_{t2m}\alpha Y_{t1m} + \sum_{t2s}\alpha Y_{t2s} + \sum_{t2\ell 2}\alpha Y_{t2\ell 2} \geq dt2 \quad [8]$$

In constraints (9) – (13) amount of waste carried away from every plant to landfills ℓ1and ℓ2 should at least be equal to amount of waste found at that point.

$$\rho_r w_r \leq \sum \alpha\, K_{r\ell 1} \quad [9]$$

$$\rho_m w_m \leq \sum \alpha\, K_{m\ell 1} \quad [10]$$

$$\rho_s w_s \leq \sum \alpha\, K_{s\ell 1} \quad [11]$$

$$\rho_n w_n \leq \sum \alpha\, K_{n\ell 2} \quad [12]$$

$$\rho_v w_v \leq \sum \alpha\, K_{v\ell 2} \quad [13]$$

In constraint (14) amount of waste collected from all hospitals , dispensaries, clinics, and diagnostic centers should at least be equal to the amount of waste found at that point.

$$\rho_o w_o \leq \sum \alpha\, P_o \quad [14]$$

Capacity limitation constraint:-

In constraint (15)-(20) the maximum capacity for processing plants are accounted means amount of waste taken to different plants should not exceed the plant capacities. In constraints (21) and (22) same thing is done for sanitary landfills ℓ1and ℓ2.

$$W_r \leq Q_r Z_r \quad [15]$$

$$W_m \leq Q_m Z_m \quad [16]$$

$$W_s \leq Q_s Z_s \quad [17]$$

$$W_n \leq Q_n Z_n \quad [18]$$

$$W_v \leq Q_v Z_v \quad [19]$$

$$W_o \leq Q_o Z_o \quad [20]$$

$$W_{\ell 1} \leq Q_{\ell 1} Z_{\ell 1} \quad [21]$$

$$W_{\ell 2} \leq Q_{\ell 2} Z_{\ell 2} \quad [22]$$

Technical constraints:-

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Constraints (23)-(34) means that, once the flow to either plant or sanitary landfill is positive that plant or landfill must exist. In constraint (35) same thing is done for bio-medical waste.

$\alpha\, Y_{t1rg} \leq Q_r Z_r$ [23]

$\alpha\, Y_{t1mg} \leq Q_m Z_m$ [24]

$\alpha\, Y_{t1sg} \leq Q_s Z_s$ [25]

$\alpha\, Y_{t1\ell 1g} \leq Q_{\ell 1} Z_{\ell 1}$ [26]

$\alpha\, Y_{t2ng} \leq Q_n Z_n$ [27]

$\alpha\, Y_{t2vg} \leq Q_v Z_v$ [28]

$\alpha\, Y_{t2\ell 2g} \leq Q_{\ell 2} Z_{\ell 2}$ [29]

$\alpha\, K_{r\ell 1g} \leq Q_{\ell 1} Z_{\ell 1}$ [30]

$\alpha\, K_{m\ell 1} \leq Q_{\ell 1} Z_{\ell 1}$ [31]

$\alpha\, K_{s\ell 1g} \leq Q_{\ell 1} Z_{\ell 1}$ [32]

$\alpha\, K_{n\ell 2g} \leq Q_{\ell 2} Z_{\ell 2}$ [33]

$\alpha\, K_{v\ell 2g} \leq Q_{\ell 2} Z_{\ell 2}$ [34]

$\alpha\, P_{og} \leq Q_o Z_o$ [35]

Variable conditions:-
All the variables are integers and positive.

i.e., X_{it1}, X_{jt2}, are integer, i=1,…5, j=1,…4 and ≥ 0

Y_{t1r}, Y_{t1m}, Y_{t1s}, $Y_{t1\ell 1}$, Y_{t2n}, Y_{t2v}, $Y_{t2\ell 2}$ are integers

and ≥ 0

Variables in (36)-(43) are defined as Boolean. These are

used to determine existence of either plant or a landfill.

$Z_r \in \{0, 1\}$ [36]

$Z_m \in \{0, 1\}$ [37]

$Z_s \in \{0, 1\}$ [38]

$Z_n \in \{0, 1\}$ [39]

$Z_v \in \{0, 1\}$ [40]

$Z_o \in \{0, 1\}$ [41]

$Z_{\ell 1} \in \{0, 1\}$ [42]

$Z_{\ell 2} \in \{0, 1\}$ [43]

Definition:-
In definition (44)-(57) which were already mentioned in the beginning gives the expected number of trips made by dumpers per day from waste nodes i=1,…,5 and j= 1,…,4 to transfer stations t1 and t2, and from transfer stations at t1 and t2 to different plants and landfills are given.

$X_{it1} = a_{it1}\, x_{it1}$ I = 1,…, 5 [44]

$X_{jt2} = a_{jt2}\, x_{jt2}$ I = 1,…, 4 [45]

$Y_{t1r} = b_{t1r}\, y_{t1r}$ [46]

$Y_{t1m} = b_{t1m}\, y_{t1m}$ [47]

$Y_{t1s} = b_{t1s}\, y_{t1s}$ [48]

$Y_{t2n} = b_{t2n}\, y_{t2n}$ [49]

$Y_{t2v} = b_{t2v}\, y_{t2v}$ [50]

$Y_{t1\ell1} = b_{t1\ell1}\, y_{t1\ell1}$ [51]

$Y_{t2\ell2} = b_{t2\ell2}\, y_{t2\ell2}$ [52]

$K_{r\ell1} = \lambda_{r\ell1}\, k_{r\ell1}$ [53]

$K_{m\ell1} = \lambda_{m\ell1}\, k_{m\ell1}$ [54]

$K_{s\ell1} = \lambda_{s\ell1}\, k_{s\ell1}$ [55]

$K_{n\ell2} = \lambda_{n\ell2}\, k_{n\ell2}$ [56]

$K_{v\ell2} = \lambda_{v\ell2}\, k_{v\ell2}$ [57]

Definitions (58)-(62) indicates the amount of waste transported from transfer stations at t1 and t2 to processing plants, while definitions (63) and (64) gives the amount of waste transfer to landfills at ℓ1and ℓ2.equation (65) gives amount of waste collected from all hospitals, dispensaries, clinics and diagnostic centers and send to bio-medical treatment plant

$W_r = \sum \alpha\, Y_{t1r}$ [58]

$W_m = \sum \alpha\, Y_{t1m}$ [59]

$W_s = \sum \alpha\, Y_{t1s}$ [60]

$W_n = \sum \alpha\, Y_{t2n}$ [61]

$W_v = \sum \alpha\, Y_{t2v}$ [62]

$W_{\ell1} = \sum \alpha\, Y_{t1\ell1}$ [63]

$W_{\ell2} = \sum \alpha\, Y_{t2\ell2}$ [64]

$W_o = \sum \alpha\, P_o$ [65]

Equations (66)-(67) indicates the amount of waste disposed of in a sanitary landfills ℓ1and ℓ2, everyday. Equation (68) gives total amount of waste collected from all waste sources per day. (This excluded waste generated from plants.)

$$\phi_{\ell1} = W_{\ell1} + \sum_r \alpha\, K_{r\ell1} + \sum_m \alpha\, K_{m\ell1} + \sum_s \alpha\, K_{s\ell1} \quad [66]$$

$$\phi_{\ell2} = W_{\ell2} + \sum_n \alpha\, K_{n21} + \sum_v \alpha\, K_{v\ell2} \quad [67]$$

$$W = \sum_r W_r + \sum_m W_m + \sum_s W_s + \sum_n W_n + \sum_v W_v + \sum_{\ell1} W_{\ell1} + \sum_{\ell2} W_{\ell2} + \sum_o W_o \quad [68]$$

Equation (69) gives the total number of dumpers and Special vehicles used per day are determined.

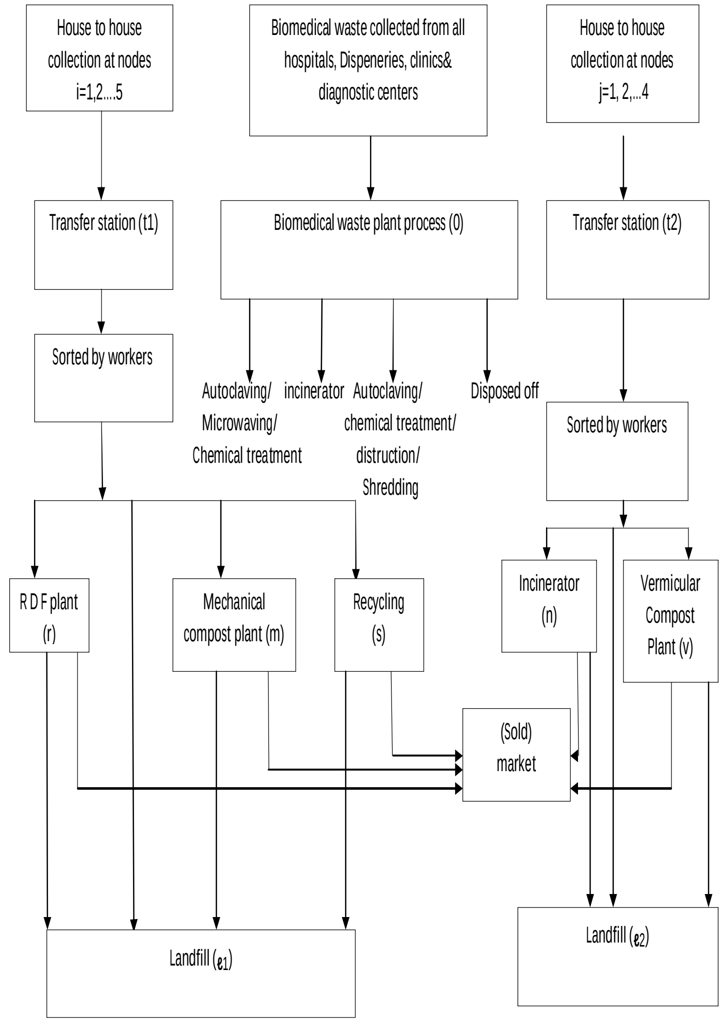
$$D = \sum_{i=1}^{5} x_{it1} + \sum_{j=1}^{4} x_{jt2} + \sum_{t1r} y_{t1r} + \sum_{t1m} y_{t1m} + \sum_{t1s} y_{t1s} + \sum_{t1\ell1} y_{t1\ell1} + \sum_{t2n} y_{t2n} + \sum_{t2v} y_{t2v} + \sum_{t2\ell2} y_{t2\ell2} + \sum_o p_o \quad [69]$$

Model application:-

Jaipur is divided in eight Zones having 77 wards.Zonewise quantity of waste generated per day in Jaipur is given in figure (3). In our model we have two transfer stations, First at Delhi road near meena petrol pump (t1) and second at Zalana (t2) and two landfill sites, first at Lagadiyawas (ℓ_1) and second at Sevapura(ℓ_2). RDF plant (r) , mechanical compost plant (m), and recycling plant (s), are located at Lagadiyawas site land and Incinerator (n), and vermicular compost plant (v), are located at Sevapura site land, and one bio-medical treatment plant located at khorarupadi.City is divided by north east corner to south west corner in such a way that waste from Hawamahal (east), Hawamahal (west), Motidugri zone, Amer zone, and Civil line zone(18-22, 41-43, 63 wards) will be collected at nodes i=1,…5 respectively and then transfer to the transfer station at (t1). Waste from Saganer zone, Mansarovar zone, Vidyadharnagar zone, and Civil line(11-14 wards) will be collected at nodes j=1,…4 respectively and then transfer to the transfer station at (t2).At transfer station waste are segregated by workers and then transfer to the different plants which is shown in figure (2). Collection cost from house to house collection to nodes i=1…5 and j=1…4 will not be incorporated in the model. Biomedical waste shall be segregated into containers/bags at the point of generation treated and disposed in accordance with category given in the following table1.

Biomedical waste is handled without any adverse effect to human health and the environmental. The following precautions should be taken by every person/occupier of an institution who involved in handling of biomedical waste.

1. Bio-medical waste shall not be mixed with other waste.
2. No untreated bio-medical waste shall be kept beyond a period of 48 hours.
3. Not withstanding any thing contained in the motor vehicle act, 1988, on rules there under untreated bio-Medical waste shall be transported only in such vehicle



(Fig.2)Waste flow chart

as may be authorized for the purpose by the competent authority as specified by the government.

4. Deep burial shall be an option available only in towns with population less than five lakes and in rural areas.

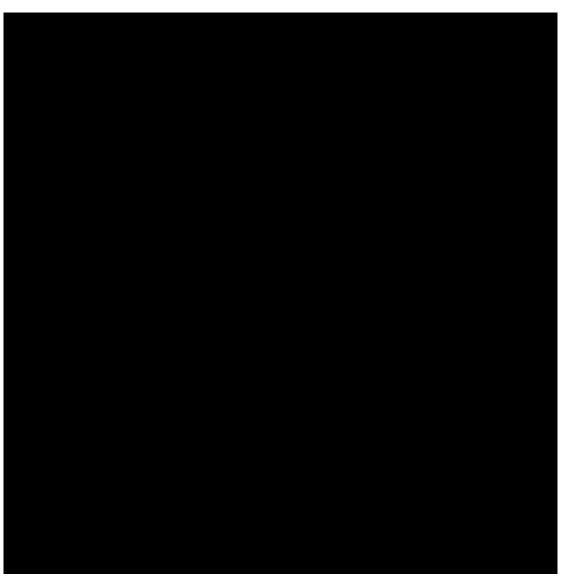
5. Chlorinated plastics shall not be incinerated.
6. Mutilation/shredding must be such so as to prevent unauthorized reuse.
7.Liquid waste generated from laboratory, wasting, cleaning, also liquid chemical waste should be disinfected by chemical treatment and discharge into drains.

Table:1`.Container color coding, type of container Used for waste category and treatment option for Disposal of bio-Medical wastes.

Container color coding	Type of container-Waste category	Treatment option
Yellow	Plastic bags-human anatomical waste, animal waste, microbiology and biotechnology waste, solid waste items contaminated with blood.	Incineration/deep burial
Red	Disinfected container/plastic bag- microbiology and biotechnology waste, solid waste generated from disposal items other than the sharps such as tunings, catheters, intravenous sets etc.	Autoclaving/ microwaving/ chemical treatment
Blue/white translucent	Plastic bags/puncture proof-waste sharps like needles, syringes, scalpels, blades, glass etc., and also waste generated from disposal items other than waste sharps.	Autoclaving/ microwaving/ chemical treatment and destruction/shredding
Black	Plastic bags- discarded medicines and cytotoxic drugs, ash from incineration of any biomedical waste, chemicals used in production of biological, chemicals used in disinfection, as insecticides, etc.	Disposed in secured landfill

Zone wise Quantity of waste generated in Jaipur shown

by the following chart.(Fig.3)



Conclusion and future development:-

The proposed model is a good starting point upon which future variation can be built. The existing status of waste management and the littered streets all over the city Cleary speak about the poor environmental health of the city. The aforesaid policies, if implemented have the potential to bring an improvement in the SWM system in the Jaipur city. A careful attention has been paid to provide a proper characterization of the system, as regards waste composition, heating value, material recovery and possible treatment which are mentioned in the proposed model. In such a way, it would be possible to determine optimal sequence of interventions, (building of new plants) over a given time horizon, capable of optimally deriving the MSW management system from the Present configuration to a final one.

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