SHORT COMMUNICATION

Economic Analysis of Waste Management in Nigeria

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ABSTRACT: The generation, utilization and disposal of wastes (which constitute environmental hazards) are highlighted in this paper as a network flow problem. In this configuration, we construct and solve as optimal network flow, the problem of minimizing the cost of disposing wastes from sources of generation to dumpsites. Numerical applications based on iterative procedures suggest an appreciable (optimal) reduction in the cost of disposing wastes generated at production sites to various dumpsites. © *JASEM*

Wastes or effluents have over the years been growing in virtually every known city of the world since the great Industrial Revolution of Great Britain in the nineteenth century. The reason for this is that the quest for economic growth as well as development has led many a country to establish industries that can produce variety of goods and services required by the people. In the course of production and consumption of such goods and services, wastes are necessarily generated.

Since about 1970, the boom in the city solid wastes can only have matched the boom in the oil sector in Nigeria, heaps of which tend to disfigure the city image coupled with the tremendous environmental health hazards it poses.

The rapid urbanization of major cities in Nigeria has led to serious environmental degradation with domestic and industrial wastes constituting with significant major forms of environmental problem. To this end, various levels of government, manufacturing industries and organizations have been trying their possible best to manage. Wastes generated particularly in the urban areas.

In view of the above, various of approaches and methods have been suggested and adopted at waste management vis-a-vis their cost effectiveness. Such methods include large scale incineration by use of incinerators Oduola (1986). This has been criticized for not being cost effective and poses environmental pollution problems, Oluwande and Owebokun (1986)

Filani and Abumere (1986) suggest that any waste management approach in Nigerian cities will depend on the ability to forecast the magnitudes of the waste based on accurate data on present and future waste generation rates. This is in order to handle the problem efficiently and at the lowest possible cost: since the major factors that influence the volume of wastes in Nigerian cities include population size, standard of living, Land - use make up as well as other cultural factors. Other methods of wastes management such as compaction, crushing and comminution, tipping etc have been adopted without any meaningful success Nze (1977). The implication is that the resources expended in finding an effective means of waste management have gone down the drain, Okpala (1986), Egunjobi (1986).

A novel approach suggested in this paper is to study waste management as a system of network flow problem, whereby we seek optimal procedures for disposing wastes from their sources of production to their destination or dumpsites at a minimal cost. Numerical applications of this method reveal some appreciable cost – effectiveness.

GENERATION, UTILIZATION AND DISPOSAL OF WASTES.

In the Nigerian environment, wastes are generated by households and the business sector, especially the manufacturing industries. Given the diversity of the sources of these wastes, several categories of wastes can then be identified. Both processible and non – processible wastes go directly to the disposal sites, usually landfills. However, the processible wastes can be turned into other useable products.

The composition of the processible wastes is the basis for calculating the quantities of recoverable materials and the potential energy yield. The processible wastes are composed usually of combustible ferrous materials, aluminum and all other inorganic. A further breakdown of the combustibles will include papers, Cardboard, Yard wastes, plastic, rubber, among others. The non – combustibles are broken down into sub-categories such as glass, non-ferrous metals, among others

The utilization of wastes in itself is a way of disposing (indeed minimizing) of wastes. If for instance, a heap of decomposed rubbish is thrown or scattered in a form land, it automatically turns to manure, provided that the ferrous content is not much. A heap of discarded papers that is meant to undergo some processing can be turned into toilet

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tissues. In the same manner old and broken glasses and bottles can be utilized in the manufacture of new glassware. The gas usually flared in the process of refining crude petroleum is capable of polluting the environment. However, this potential danger and disadvantage are turned around in gas recycling plants

WASTE MANAGEMENT AS NETWORK PROBLEM.

COFIGURATION OF NETWORKS.
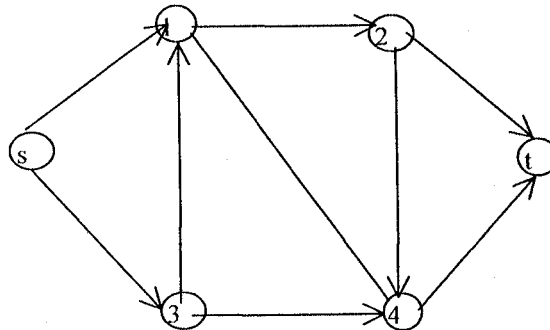
The above figure represents a typical flow from source (s) to sink (t) with four modes (N) (1), (2), (3) (4) and arcs (A), (cs,1), (cs,3) (1,2), (1,3) (3,4), (2,4) etc.

Therefore, for each arc (n_I , n_j) of the multi-source – sink network, G = (N,A) (where no represents modes in the network and a reforecast arcs in the network) having maximum capacity flow of C (n_I, n_j) and non – negative cost $r(n_I , n_j)$ from sources to sinks such that total flow cost

$$\Sigma F(n_I , n_j) - \Sigma F(n_j , n_i) = (n_I n_j) \in A_i(n_I n_j) \in A_j$$

and
$F(n_I , n_j) \le C(n_j , n_i)$ i.e since flow cannot exceed the capacity
Where $F(n_I , n_j)$ is the flow from node I to node j
$C(n_I , n_J)$ is the maximum flow from node i to node j

A_j is the set of arcs with initial node n_I
A_j is the set of arcs with terminal node n_j

$$V\left[c^1\left(n_1,n_j\right), \gamma^1\left(n_{1,}\, n_j\right)\right] = Min\left[C\left(n_i^k , n_j^k\right), \gamma\left(n_i^{k^1} , n_j^{k^1}\right)\right]$$

Where $k = k^1$ or $k \ne k^1$
Step2.

$r(f) = \Sigma\Sigma \gamma (n_I , n_j)$ is minimal
j $(n_I n_j) \in A$
and flow capacity
$C(f) = \Sigma\Sigma C(n_I , n_j)$ is maximal
j $(n_I n_j) \in A$

Having generated wastes from whatever sources, it behoves its generator to effect (or search for) optimal methods for its management (specifically, their disposal to sinks or disposal sites). One such method proposed by Chukwu and Nduka (1993) is that which iteratively searches the route for the maximal allocation of commodity flows from their restricted or relaxed sources to their corresponding sinks at minimal cost.

In this paper, we shall present the basic conservation requirement of network flow and propose an algorithm for solving an important class of flow problem; static – multi – source and – sink flow without intermediate routes. The basic conservation requirements are given by-:

$$\begin{cases} v_I \text{ if } n_I \in s \\ \\ - v_I \text{ if } n_I \in t \\ 0 \quad \text{otherwise} \end{cases}$$

V is the value of the flow at either source (s) or sink (t)

FORMULATION OF THE ALGORITHM FOR SOLVING THE STATED PROBLEM.
Step 1: Initalization
Choose the integer – valued network flow on the arc or combination of arcs (n_I , n_J) of the network G = (N,A) such that

(i) Based on V(C^{1}r^1) construct an associated incremental network G^1(V) and search for a flow – augmenting path from sources to sinks which is of maximal flow and minimal cost or whose incremental network flow is not an improvement over the original network flow.

(ii) For subsequent iteration(s), update a network flow by adding the present V(C^1, r^1) on all forward arcs and subtracting the sum of V(c^1, r^1) and its immediate predecessor on all reverse arcs.

(iii) If M is the total number of arcs in the original network and β$_j$ (<<M) is the number of arcs satisfying (I) above for an iteration,

then the number of arcs saturates by β$_j$ per iteration.

(iv) If particular iteration(s) in the constructed incremental network is not optimal, go back to the last optimal iteration and re-update network flow and continue.

Step 3.

If the number of iteration k (k^1) ≠ 0, got to step 2, otherwise stop: optimal solution is attained.

For proof: see Chukwu and Nduka (1993).

Numerical application: Consider this hypothetical case of a company which generates wastes at its two production centres (S$_1$, and S$_2$) and twenty- nine sites for dumping these wastes. The volume s of waste generated and the cost of transporting them at the dump sites are shown in the network below.
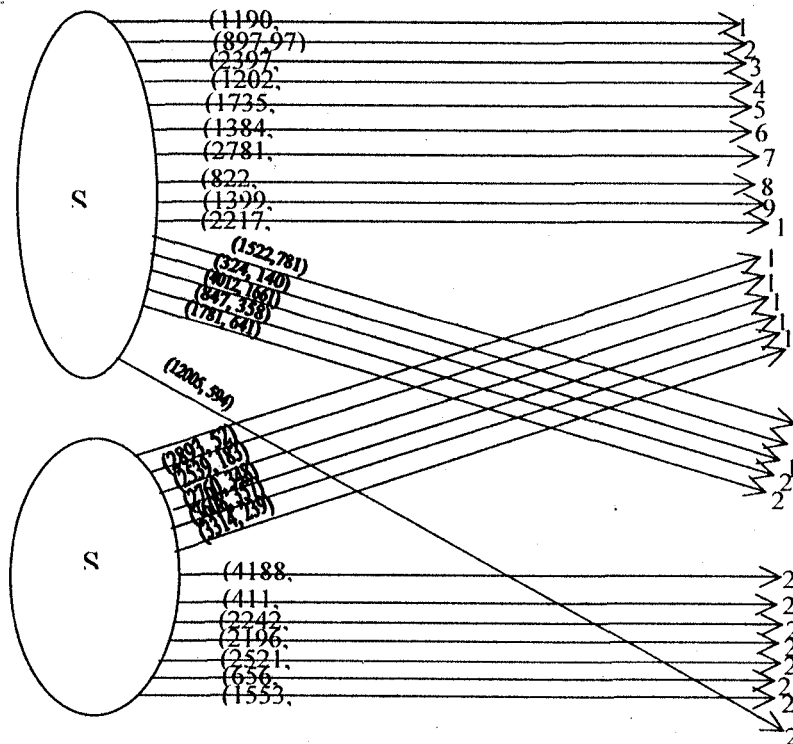

Fig 2. Original network Step 1

In the first iteration, starting with min $\left[C\left(n_i^1, n_j^1 \right); \quad \gamma\left(n_i^1, n_j^1 \right) \right] = (324, 52)$ as a feasible solution,

the associated incremental network whose flow-augmenting path is of maximal flow and minimal cost is represented below:
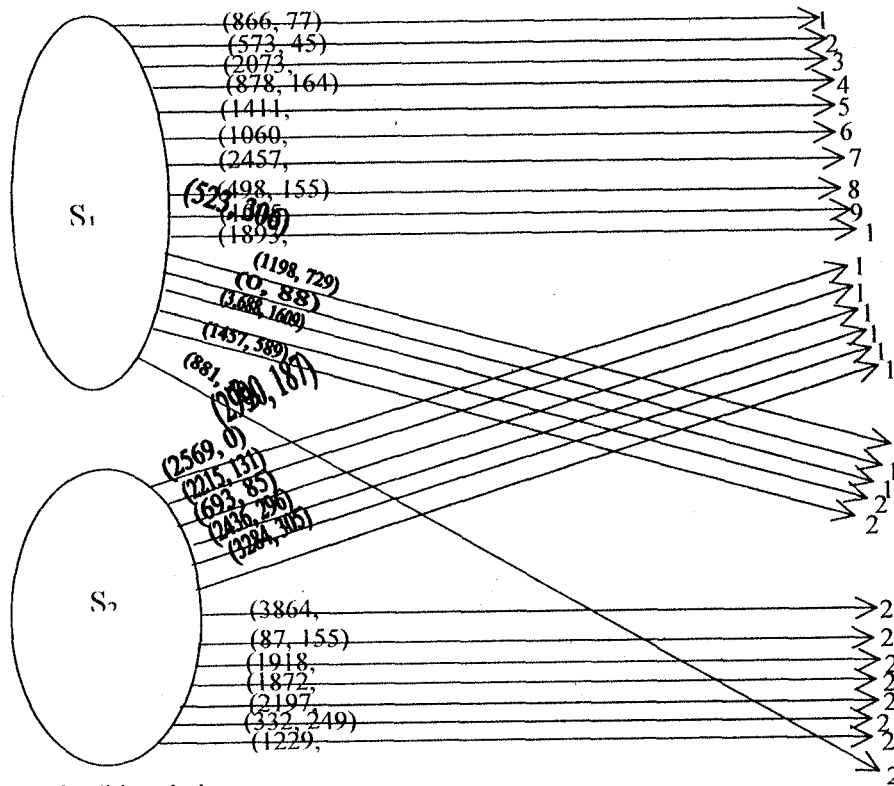
Step 2:

Fig 3. First feasible solution

The iteration process is continued until the optimal solution is obtained as shown in the following network flow.
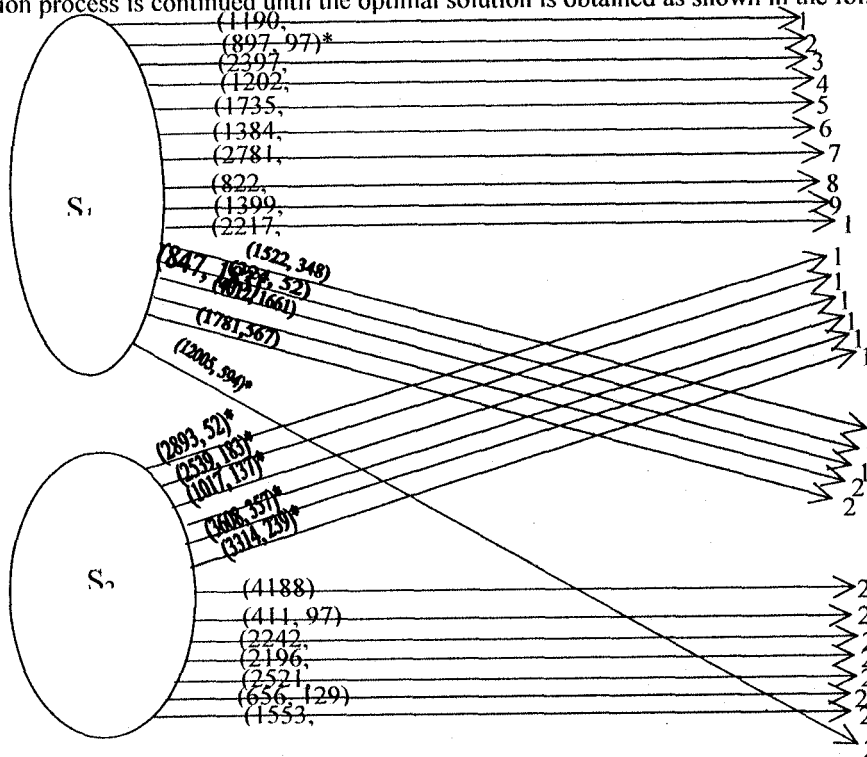

Fig 4. Optimal solution indicates that their distribution schedule is optimal abinition.

The quantity of waste generated at the two production centres S_1, and S_2 are 36,515 and 29,898 respectively while their distribution cost are N7, 373.00 and N7,113.00 respectively. This gives a total quantity of 66,413 at a cost of ₦14,486.00. However, applying the algorithm, the optimal distribution cost is ₦12,420.00, which represents a total cost reduction of ₦2,066.00. (14.26%). This implies that the company in handling its waste disposal system should adopt the schedule in fig 4 and not the schedule in fig 2 as is the case presently.

SUMMARY AND CONCLUSION.
The foregoing discussion has highlighted the several forms of waste generation in our system particularly in the urban areas, with their attendant socio-economic and environmental problems: Given that increased generation of wastes in the cities has come in the wake of increased urbanization as well as increased industrial and commercial activities, there is need for more practical solutions to be proffered. It is our strong belief that the beginning of the solution to the problem is for the society, the relevant agency or ministry to be aware of the quantity and composition of wastes being generated within the system before treatment of wastes.

Among the conventional methods of wastes disposal such as compaction, crushing (comminution), extruders, wet processors, tipping as well as incineration, a more proper waste management process, should be put in place. In this case, analytical and efficient methods like the optimal search method as applied here is highly recommended. The method based on numerical application optimally disposes wastes to various dump sites at minimum cost. The method has demonstrated a cost reduction of 14.26% in waste disposal to dump-sites.

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