Economics of Solid Waste Disposal -- A Regional Approach

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PREFACE

This report contains a summary of the economic and planning aspects of the comprehensive studies on solid waste management conducted by a multi-disciplined group involving economics, planning, engineering, operations research and public health.

The long term objectives of the economic and planning team are; 1) formulations of mathematical models for studying solid waste generation, 2) development of pertinent information through formation of functional regions, and 3) impact of changes in transfer and disposal of solid wastes on land use planning, private and public expenditure, jurisdictional conflicts and public interest. These objectives are pursued sequentially permitting necessary overlapping subject to contingencies of research.

The present discussion concerns the first two items relating to the regional approach being adopted with San Francisco nine county Bay Area as an illustration.

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I alone am responsible for the opinions expressed in this paper.

S. Ananda Rao

ECONOMICS OF SOLID WASTE DISPOSAL

AN APPROACH

By

S. Ananda Rao, Ph.D.*

General Remarks

The affluence of modern civilized life has produced both "what is needed by society" and what is discarded as "waste" in the course of everyday life. Changes in comsumption habits and production technologies have significantly affected the nature and composition of solid wastes in the past decade. These have challenged the available body of technology for efficient disposal of wastes. In addition to the inadequacies of presently available technology, the problem has been compounded by unrealistic approaches to waste management as it is practiced today, due to a fragmented political jurisdictional approach. The latter has to some extent slowed down the process of application of different methods of waste disposal. Thus, the only acceptable method of disposal has been the traditional sanitary landfill which is practiced in many Bay Area communities and outside as the sole method being acceptable to the community as it meets the area's esthetic and health requirements.

Solid waste is inherently integrated into the total problem of air and liquid waste pollution. Thus, the burning of solid wastes may increase air pollution, while the use of garbage grinders necessarily increases

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the load on the liquid waste disposal system. On the other hand, measures undertaken to abate the air pollution problem or to decrease the output of liquid wastes usually result in an increase in the quantity of solid waste that must be handled.

While there has been a constant change in the amounts and types of solid wastes generated by the several segments of society, the physical and technical ability to cope with the problem is growing at a less than desired rate. This is due to a combination of several factors important among which are the dwindling supply of available land for sanitary landfill, and a somewhat slow rate of development and acceptance of alternative methods of ultimate disposal. The handling of wastes itself is sometimes haphazard, and the collection transfer and disposal functions become the targets for analysis.

Factors Affecting the Solid Wastes Management Problems

The current status on available body of disposal technology can be briefly stated as follows, to gain some idea on the limitations of each method of treating solid wastes:

At present, the basic methods disregarding many environmental differences are sanitary landfill, incineration, composting, and disposal at sea.

Sanitary landfill has been traditionally the accepted procedure of disposing waste and has been perfected over a long time. Due to fast disappearing of cheap and accessible land for sanitary landfill, this method may no longer be attractive and lucrative due to increased land acquisition costs in time to come. Composting has been limited in its application due to the conviction that the compost should be a saleable product in the face of a virtually nonexistent market. However, the use of compost to improve land quality still remains a possibility.

Although incineration has been practiced extensively, high operating costs and the persisting raising of air pollution standards have been influential in limiting its use on a wide scale. A considerable amount of residue in the form of burnt ash and noncombustible material remains to be ultimately disposed of through landfill.

Disposal at sea is currently confined almost entirely to the dumping of radioactive wastes. Someday disposal at sea may become an effective and acceptable method provided the solid wastes are processed such that they will sink in the ocean and remain submerged.

Other disposal methods currently in practice or as yet in the experimental stage are: 1) grinding garbage for transport to and treatment in existing sewage treatment facilities; 2) swine feeding; 3) wet oxidation; 4) pyrolization; 5) aerobic digestion; and, 6) anaerobic digestion. The last four named methods are as yet in the experimental stage from the standpoint of applicability to solving the waste disposal problems. With the exception of swine feeding, these methods are undergoing a thorough investigation as a part of our overall continuing research on solid wastes management.

Apart from inadequate technology, the present unrealistic method of approaching the problem of waste management through fragmented political jurisdictions, has also contributed significantly to the problems of waste management.

Each political entity bases its waste disposal method on inherited operational procedures or on methods that are the result of hasty decisions made for solving a pressing disposal problem. Unfortunately, the latter methods generally provide only temporary, or at most, short range solutions to the problem. Since at its source, solid waste is of negative utility, the modus operandum has been to provide at the least possible direct cost of disposal and satisfy the immediate requirements of health and esthetic standards.

Waste handling has generally become a function of a haphazard combination of public and private sectors. While this need not be a noticeable deterrent to efficient waste disposal operation, it has in fact reduced the efficiency of current waste management both economically and aesthetically.

Urban growth has now reached a point where one's "backyard" is now someone else's "frontyard," and in this respect, the constraint of fragmented political jurisdictional approach can only serve as a deterrent to effective waste management practices.

The problems described above, together with the inability of individual areas to absorb their own wastes because of limitations of present technology, plus an unrelenting increase in volume and constant change in composition of solid wastes, all combine to render too complex the management of solid wastes within traditional political jurisdictions.

Effective comprehensive planning of solid waste management therefore becomes a problem at large and should be treated accordingly with a full-scale study of the impact of proposed solutions on the entire community with respect to its population, employment in commercial, industrial, and agricultural activities, land use, and the like. In concluding the introductory statements, it should be said that the existing state of the art with regard to disposal methods, the fragmented political jurisdictional approach and its attendant disadvantages, the complexities of the sources generating wastes, all point toward the need of a fresh approach, be it named "effective" or "overall" or "regional" in character.

The complexities themselves suggest heuristically that a regional or subregional approach to waste management practices which transcends the political jurisdictions can come to grips with the real problem and can lead to long-lasting solutions that are both efficient and satisfactory to the community at large.

A Regional Approach to Solid Waste Management Problems

Meaningful discussions of alternative approaches and optimum solutions to problems can evolve only after the dimensions of the problem are clearly recognized, the rationale underlying the mathematical model building approach is well defined, and the types of information needed for analysis are stipulated.

In order to facilitate a regional approach to the solid waste problem, it is therefore, necessary to compile accurate information concerning quantity, source, composition, distribution and variability of solid wastes. Further there is need for compiling information on related economic variables such as population, employment, income, land use and the like, which are used as explanatory variables in explaining their interrelationships with solid waste generation. Finally, the mathematical model should be specified as completely as possible in order to make use of currently available body of knowledge and also being capable of incorporating additional knowledge as it is acquired.

The Regional model building approach should be conceptually sound and operationally feasible for any given region.

The rationale underlying the model building approach is the development of alternatives and of an optimum solution to the regional solid waste management problem which is based on factual data. Since standards of solid wastes management depend on criteria which are based on esthetic values, public health requirements as well as on economic efficiency, it is necessary that these constraints be effectively recognized within the model. With an awareness of such social and political aspects, alternative solutions to the problem are developed with the aim of making it possible to select an optimization program.

Although a model uses mathematical analysis to solve the quantitative problems, it is seldom possible to make qualitative predictions within a mathematical framework. Comparisons with past qualitative changes resulting from changes in associated variables could serve as a basis for estimating future qualitative changes. Additionally, an inquiry into technological progress with respect to containers and associated waste producing products will clarify the expected changes in composition that might result from this progress. Generally, a high degree of uncertainty exists within the qualitative aspects of solid waste, and this should be borne in mind while estimating the possible future changes.

Objectives and Method

The principal objective of the waste generation model is to develop a comprehensive factual basis for the quantitative aspects of the regional solid waste problems by specific categories and to use them as data inputs in estimating future volumes of solid waste.

The statistical technique used in the model consists of multiple regression analysis whereby the solid waste volume is considered a dependent variable and regressed upon possible explanatory variables such as population, income, employment and land use, appropriately selected for each category of solid waste. The extent of the interrelationships existing between the several variables will be determined on a spatial basis and then projected to a future period utilizing the best available economic growth projections for the area.

In order to test the validity of the model, an area of presently fragmented jurisdictions that encompasses all of the complexities of the waste problem has been chosen. Because of the diverse nature and proximity of the area the nine county San Francisco Bay Area has been selected for the empirical study to make the model operational.

The results of the waste generation model form the basis for further analyses consisting of the effects on the present solid waste systems, impact on the regional land use planning with location of future disposal plant sites as an integral part of overall planning, and finally the questions of private and public expenditure and jurisdictional conflicts. The latter items of analyses form the subject of investigation during the rest of the current year and future periods.

The Approach

The initial step of the model building approach is the early recognition of the important variables that should be included in the multiple regression study. Before we actually specify the variables for inclusion, it is necessary to recognize the relationships between sources and composition of solid wastes. Solid waste data is classified by various criteria depending upon the purpose for which it is intended to be used. For purposes of estimating future volumes of wastes, it is necessary to list the various sources or generators of waste and the waste factors. And for evaluating the feasibility of different disposal methods, it is imperative to know the composition of solid wastes, by physical and/or chemical properties. A one to one relation between sources and composition of wastes, is thus necessary so that the primary data on solid waste volumes can be identified for different purposes. As a starting point in eliciting these cross-relationships, the source-composition definition adopted by the American Public Works Association is utilized.

The <u>second step</u> is to specify the variables that explain different categories of solid wastes.

In an ideal analytical model, every conceivable interrelationship between the sources and types of waste, and the activities that might affect the generation of the waste, would be set forth and tested. While cost constraints and data limitations dictate that the actual dimensions of the model may be less than ideal, the establishment of relevant relationships should be specified as completely as possible. The particular case study relating to the Bay Area may aggregate the relationships to data needs but the theoretical formulation should be available for a more detailed analysis for different study regions or for the present study as additional data on solid wastes are developed in the future.

Considering the nature of available data and the theoretical requirements to specify all relevant variables, the attached table lists possible significant variables that influence the generation of various types of solid wastes by source.

The <u>third step</u> is to identify the location of disposal sites in which the solid wastes are deposited. Nearly 130 (or more) such disposal sites are located on the county maps of the study region, viz, nine county San Francisco Bay Area.

The <u>next step</u> (fourth) after the sites are located and before data on pertinent variables is actually collected and compiled is the development of

Source of Waste	Explanatory Variables
1. Household waste	Population Number of households Income Land Use: Lot size, intensity of use and apt. to single family ratio Time of year Collection rates Frequency of collection
2. Agricultural waste	Land Use, including intensity of use Time of year Internal method of disposal
3. Extractive waste	Nature and extent of activity
4. Manufacturing wastes	Nature of activity Size: Employment level and/or quantity of output Salvage values Internal methods of disposal
5. Commercial and services waste	Size: Employment and nature of activity
6. Special waste: Municipal waste: Street refuse	Population Number of streets Socio-economic characteristics of area
Park and other public areas	Number, size and nature of use
Sewage residue	Population Method of treatment
Abandoned vehicles	Number of vehicles Distribution by age Legal restrictions
Demolition and construction wastes	Number of new buildings Size of new buildings Type of material/construction Renewal projects Highway building, BART, etc.

functional boundaries into which the study region could be divided. These functional boundaries are defined as Disposal Service Areas or (DSA) in this study. Since this functional demarcation is instrumental in explaining the interrelationships between several variables, it is desirable to choose the smallest possible geographic unit so that a large number of independent observations could be developed for multiple regression analysis. The 1960 Census tracts were first considered as possible primary geographic unit due to the availability of a large body of relevant economic data. In the absence of comparable data on solid wastes by Census tracts, larger areas other than Census tracts had to be chosen as functional boundaries. The actual drawing of boundary lines for each DSA proceeds as follows. If a disposal site received waste generated from one or more Census tracts then that region was defined as a disposal service area. In some cases, Census tracts had to be split between functional boundaries due to the fact different scavenger companies servicing these parcels transfer the solid waste to different sites. In situations in which two or more disposal sites receive waste from two or more overlapping regions, and it is impossible to split the Census tracts meaningfully, a single disposal service areas was defined to consist of that total area. Thus the amount of waste deposited in the site (or sites) is always made comparable to the waste generators with reference to the functional boundary (or DSA), eliminating any arbitrary splicing of boundaries. In the present case the study region is divided into 31 functional boundaries following the above definition which transcends political boundaries. By its very nature, the DSA's may consist of portions of Census tracts of one or more counties.

Once the functional boundaries are defined for the study region, the next step (fifth) was to list the variables and compile data on a uniform basis referring to the same type period. The data are being collected and compiled by the 31 functional boundaries on the following variables:[1/] 1) solid waste volume; 2) population; 3) employment; 4) land use, and 5) personal income.

As the magnitude of the data to be handled is too large, the same is being compiled in the Computer Center of the University of California at Berkeley.

Data Sources and Present Status

(1) Solid wastes:

The data on solid wastes are being collected primarily by the California Department of Public Health (Mr. Peter Rogers and his staff) from the disposal site operators, scavenger companies, public and private agencies and are made available to this project. This decision was arrived at after conducting a pilot study in Santa Clara County and linking this project with that of the California state project on solid waste management.

The solid waste data so far collected by the California Public Health Department interviewers have been checked for internal consistency, and the discrepancies have been listed for eventual clarifications. The revised figures should become available during this month (November 1967) as soon as the discrepancies have been verified and the field work completed in Alameda and San Francisco counties.

[1/] The actual data are in the final stages of completion at the time of this writing. Readers who are interested in the data may kindly correspond with the author for the original report containing the maps, and data.

(2) Population:

Data on population had been gathered from primary sources namely, the local planning agencies of cities and counties in the Bay Area. The figures have been tabulated by functional boundaries except for necessary modifications regarding reference period corresponding to that of solid waste data.

(3) Employment:

The basic source for employment data is the California Department of Employment. These data had already been listed by Census tracts and are utilized in certain Bay Area Studies of Association of Bay Area Governments and Bay Area Transportation Studies commission. The employment data needs to be adjusted for seasonality and uniform coverage before they are aggregated to correspond to the functional boundaries of the study region.

(4) Land Use:

Data on land use are being collected by the Bay Area Transportation Studies Commission for a recent period 1965, in sufficient detail for the purpose of their on going studies on economic projections and transportation needs. These data and forecasts when they become available are greatly useful in enhancing the present case study of the Bay Area waste study. Meanwhile, alternative sources of land use are being tapped to obtain land use information by the functional boundaries.

(5) Personal Income:

Available published data on personal income refer to the counties in California. Special estimation is planned to be carried out to develop income data by functional boundaries.