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Management of Solid Waste Systems

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ABSTRACT

This paper attempts to analyze one aspect of the environment, that is, the solid waste problem. The nature and characteristics of solid waste management systems are discussed; the substantial differences between the litter problems and the solid waste problems are shown.

It is pointed out that major changes in the solid waste management system are possible, essentially through three different policy decisions: lowering the standard of living, recycling, and or multiple-purpose design. Lowering the standard of living is rejected on the ground that it is neither desirable nor necessary.

It is shown that banning nonreturnable bottles from the market will not ease to a noticeable degree either the solid waste problems or the litter problem.

It is stressed that, while the emergence of recycling as a national policy, in general, is a very encouraging sign, recycling by an engineered system should not be confused with "boy scout" recycling, that is, recycling by volunteer groups. Examples are cited which indicate that this type of voluntary action may even do greater damage to the environment.

It is asserted that solid waste management is a complex problem. Reasonable solutions can only be found by examining the whole gamut of human activities from resources extraction, through production and utilization of goods to disposal of solid waste. It is shown that simple solutions are not answers, that a wise management implies seeking the minimization of the adverse effects of solid waste on public health, reducing the nuisance, eliminating the ugliness, cutting costs, and increasing resource re-utilization by creation of sane governmental institutions and the

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development of a learned profession. Our management of solid waste should be multidimensional, time sensitive, multipurpose, and a conservationist endeavor.

Introduction

This paper attempts to delineate the nature and characteristics of solid waste management systems and will analyze the emergence of recycling as a national policy. It will be shown that the management of solid waste systems should be multidimensional, time sensitive, multipurpose, and a conservationist endeavor.

Solid Waste Management Systems

MUNICIPAL SECTOR

The nature and characteristics of municipal solid waste can be more conveniently and efficiently discussed by reference to Figure 1, where the flow of waste through various "control systems"* is shown. Collection is to

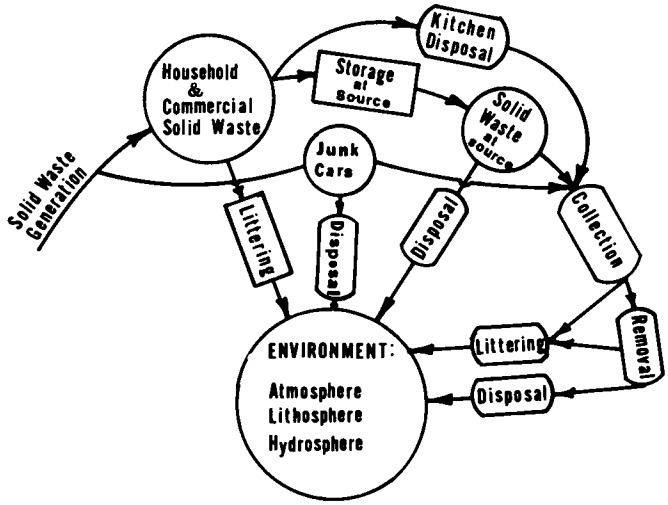

Figure 1. Municipal solid waste sector.

*The word control here implies potential rather than actual, i.e., the opportunity to exert control whether it is actually exerted or not. To understand the figure the reader should note that the circles signify some type of storage process and refer to certain stages of waste, rectangles indicate control processes which for the most part are only susceptible to individual actions, and rounded rectangles imply the control processes sensitive to institutional control.

be interpreted in this paper as the process by which the waste is removed from storage at the source to a vehicle for removal. Removal is meant to imply short-haul transport, normally using compactor-trucks. (For junk cars, other means are used.)

During 1968, the then newly established Solid Waste Program of the United States Public Health Service (now the Office of Solid Waste of the United States Environmental Protection Agency) initiated a national survey of community solid waste practices. The survey was designed by the Solid Waste Program, but the basic data was collected for the most part, by the respective state solid waste planning agencies. Among the interesting information obtained is that in the United States 337,000 persons operating 272,000 vehicles are involved in collecting, transporting, and disposing of in excess of one billion pounds per day of municipal solid waste for an annual cost of 4.5 billion dollars.[1]

PRODUCTION SECTOR

Despite the complexity of the municipal solid waste system, it is only a portion of the total solid waste picture. Another portion is the industrial, agricultural, and mining solid waste sector shown in Figure 2. Included in

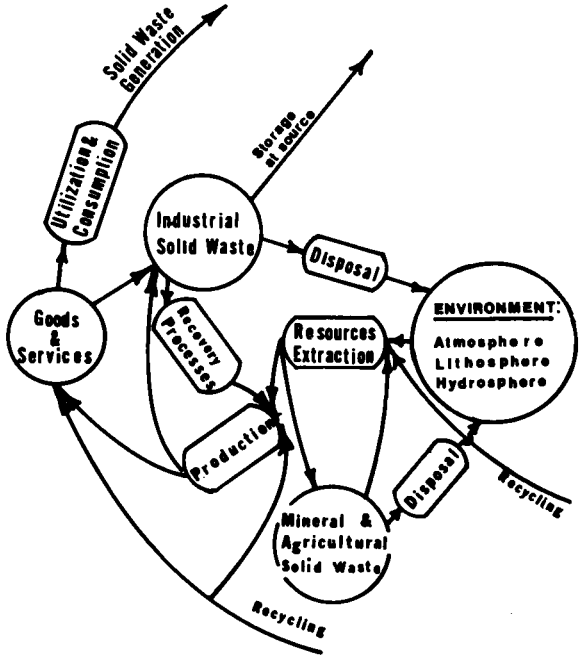

Figure 2. Industrial, agricultural and mining solid waste sector.

this sector, of course, is resources extraction, production, and distribution of goods and services. The problems here are as varied as the total range of production and service activities. It is estimated that industrial solid waste generation averages about 3.0, mineral solid waste averages about 30.8, and agricultural solid waste averages about 58.0 (15.0 for vegetation, and 43.0 for animal) pounds per capita per day respectively.[2]

RECYCLING SECTOR

Even this is not the total story. The solid waste management system has a third component shown in Figure 3. The recycling sector is in its own

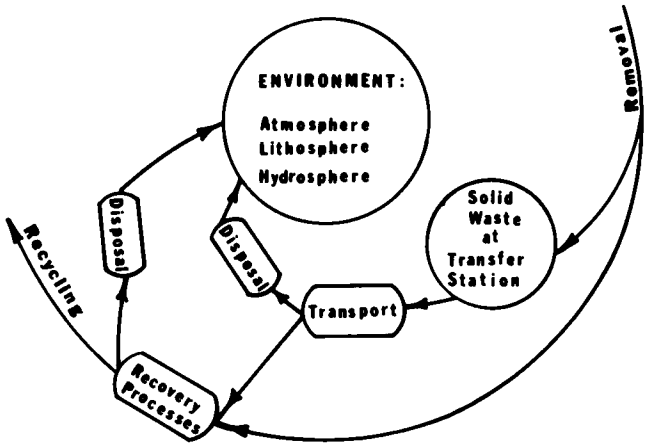

Figure 3. Recycle sector.

right a giant industry. The secondary materials industry (largely represented by NASMI, the National Association of Secondary Material Industries) which handles such commodities as non-ferrous metals, paper stock, and textiles is an 8 billion dollar per year business. In 1968, this industry supplied approximately 30 per cent of the aluminum (700,000 tons), 45 per cent of the copper and brass (1,500,000 tons), 52 per cent of the lead (700,000 tons), 20 per cent of the zinc (225,000 tons), and 20 per cent of the paper stock (11,400,000 tons) that was consumed in the United States.* Also, NAMSI members transacted 400 million dollars worth of textile secondary materials.[3]

In addition, during the same year, the iron and steel scrap processing industry handled or shipped more than 36 million tons of ferrous metals

*These percentages are rough estimates and somewhat exaggerated. Depending on several assumptions they may vary considerably.

for reuse by steel manufacturers.[4] The glass container industry has used cullet traditionally (crushed waste glass) for about 5 per cent of its raw material* and the percentage has steadily risen in recent years (figures of 10 to 30 per cent are mentioned).[5]

It is interesting to note that except for textiles, the major portion of these recycled materials were solid waste of industrial origin. Municipal solid waste is heterogeneous material in size, weight, shape, and composition and does not lend itself to economical separation and re-use with the presently available technology.**

A Few Observations on Solid Waste Management System

The overview of the solid waste management system can only be developed by observing all three sectors. Figure 4 is a composite of Figures 1, 2, and 3. Examination of this figure reveals the degree of complexity involved in the management of solid waste. Change in one point in the system inevitably produces change, to a lesser or a greater degree, in other points. Several significant conclusions can be drawn by considering Figure 4, rather than its subsystems.

1. *Litter*—When a person who generates solid waste discards the waste into the environment with no further processing, litter is produced. Litter is the result of irresponsible action of individuals. Some 50 per cent of those who were interviewed by a Gallop Poll,[7] in 1968, admitted to one or more littering practices. The litter problem, while one of the most visible components of the solid waste management system, does not present a significant segment compared with the whole. Solutions directed toward solving litter problems cannot be expected to ease solid waste problems to a great extent. On the other hand, legislation which may influence institutional control and, hence, affect the solid waste system are of little value in combating littering. In the long run litter problems will be eased only when individuals feel responsibility toward their environment.

A 1969 survey by the Highway Research Board for Keeping America Beautiful Inc. provided interesting information as to the quality and nature of littering.[8] Twenty-nine states participated in the study. A stratified random sample of approximately 10 highway segments, each two tenths of a mile in length, was selected for each of the 29 states. Litter was picked up in these segments twice at intervals of about one month. The first

*This is because cullet hastens the melting of the sand, limestone, and soda ash in the glass furnace.

**Processing plants for secondary materials are dependent upon the continuity of the supply of scrap and residues. Efficient scrap collection, transportation, grading, and classification are prerequisites for successful operation.[6]

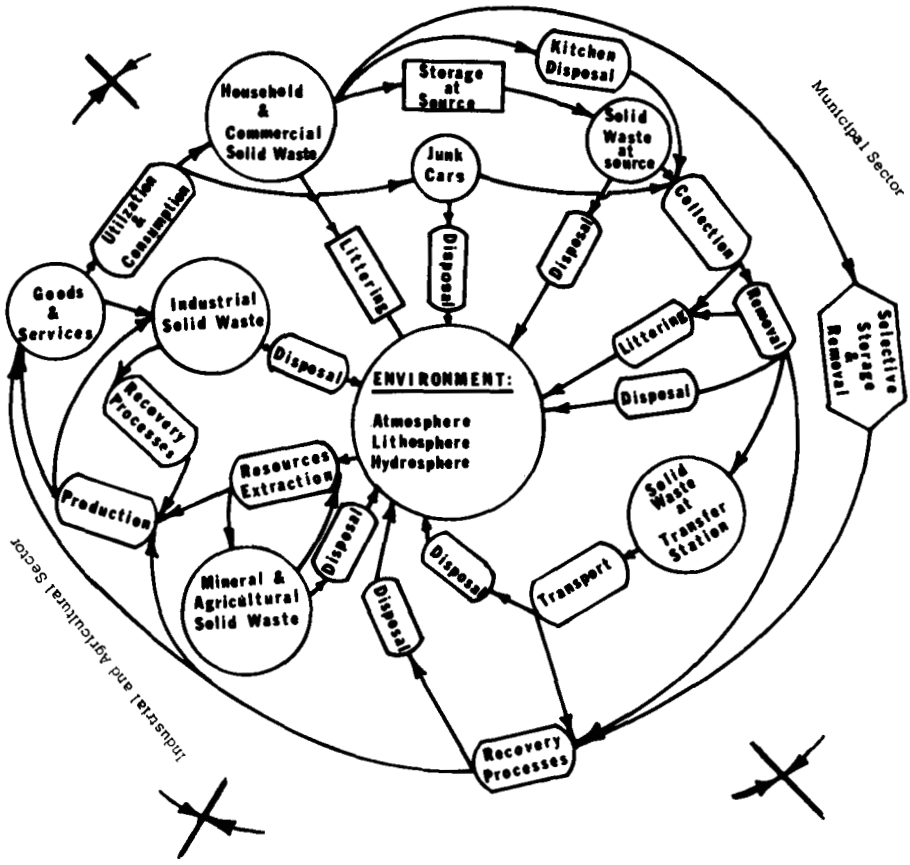

Figure 4. Solid waste management system.

pickup roughly indicated the steady state of accumulation for the study season (winter and spring) and the second pickup was taken as a rough indication of a month's littering. Table 1 presents the summary of the results of this survey. The data collected in the survey should only be regarded as a rough approximation of the litter problem because the survey does not take into consideration a number of significant factors including seasonal variations. However, at the present time it is the best information available.

Since glass is conspicuous as litter the argument is made and has gained widespread support that the banning of nonreturnable bottles could be a solution to the litter problem. Although, the data is sketchy, it is sufficient to compel one to question the wisdom of such a proposition. First,

Table 1. Number of Litter Items Per Mile[8]

	First Pickup		Second Pickup	
	Items per mile	*% of total*	*Items per mile*	*% of total*
Total number of paper items	1605	48.94	776	59.49
Beer cans	710	21.65	153	11.75
Soft drink cans	143	4.36	40	3.11
Food cans	33	1.00	8	0.64
Other cans	43	1.31	11	0.82
Total number of cans	929	28.32	213	16.31
Total number of plastic items	155	4.71	75	5.78
Total number of miscellaneous items	364	11.09	163	12.53
Returnable beer bottles	13	0.41	5	0.41
Nonreturnable beer bottles	90	2.74	30	2.31
Returnable soft drink bottles	53	1.62	21	1.62
Nonreturnable soft drink bottles	26	0.78	7	0.51
Wine or liquor bottles	25	0.77	8	0.64
Food bottles or jars	8	0.25	3	0.22
Other bottles or jars	12	0.36	2	0.17
Total number of bottles and jars	227	6.93	77	5.88

nonreturnable bottles only comprise approximately 2.82 per cent of the monthly litter generation per mile of highway. If they disappeared altogether the effect would not be great. Secondly, since approximately five returnable beer bottles already can be found on a mile of highway, it can be shown that banning nonreturnable beer bottles may possibly shift the present average composition of litter from 5 returnable and 30 nonreturnable beer bottles to 20 returnables.* However, since a returnable bottle contains more glass than a nonreturnable bottle, it is conceivable

*Since there are about 10 times more nonreturnable beer bottles on the market than returnable, and assuming three journeys for returnable bottles per month, the conversion of all nonreturnable beer bottles to returnable will increase the returnable bottles inventory on the market to about four times as much as the present time. This could increase the number of returnable beer bottles in litter to 5 X 4 = 20. In 1966, 577,000,000 returnable beer bottles; 5,031,000,000 nonreturnable beer bottles; 1,922,000,000 returnable soft drink; and 1,980,000,000 nonreturnable soft drink bottles were shipped to market in the United States.[10]

that a ban on nonreturnable bottles may even increase the amount of glass from beer bottles in the litter.* In addition, the argument has been advanced that the loss of state and Federal excise taxes would be significant if nonreturnable bottles were banned (because of the decline of business due to higher prices and inconvenience).[9]

The above analysis is, of course, very rough, but is illuminating enough to urge more caution in advocating simple solutions to the complex problem of litter. Littering is above all an individual act and its solution rests on the individual's concern and respect for his fellowman. It is obvious that the unchanged litter picture coupled with the revenue loss cannot be lauded as wise management. More study is required for a rational decision in regard to nonreturnable bottles.** It would be nice if simple solutions such as banning materials were the answer. But we deceive ourselves if we insist upon these types of solutions. Littering for the most part is the result of millions of careless actions and in a minor way due to psychological problems. To ease the litter problem we should work on these causes.

2. *Disposal Problems*—Disposal of solid waste is accomplished normally by burning, composting, ocean dumping or land disposal. Figure 5 indicates the component of environment affected by each practice. It is interesting to note that about 80 per cent of the municipal solid waste generated in the United States is disposed of in some type of dump, while only about 8 per cent is burned in some sort of incinerator.

No matter how ideal a management system is designed and operated, there are going to be end products that need to be disposed of. One should remember that the final sink for any unwanted material is the environment. It is true that one can reduce, change, or convert any waste, but what finally remains and is not needed any longer has to be put on land, in water, or in the air. The sooner we face this invarient of life, the faster we can ease some of our environmental problems. We cannot expect unwanted materials to disappear. Also, our neighbor's environment will not suffice as a disposal site any longer either. It is altogether proper that we should demand that disposal be made with the least insult to the environment, but insisting on no disposal at all is closing our eyes to the reality. In terms of

*The effect on the soft drink bottle is even less certain due to the presence in the litter of more returnables than nonreturnables.

**It may be argued that a rational analysis should also consider the effect of banning nonreturnable bottles on the total solid waste problem. However, since glass (of all kinds) only constitutes 8 per cent of solid waste [11] and nonreturnable bottles are about 24 per cent of domestic glass shipment of all kinds,[12] the total elimination of nonreturnable bottles without being substituted by returnables, will reduce the solid waste by only 1.9 per cent (actual increase in the number of returnable bottles will eliminate this gain considerably).

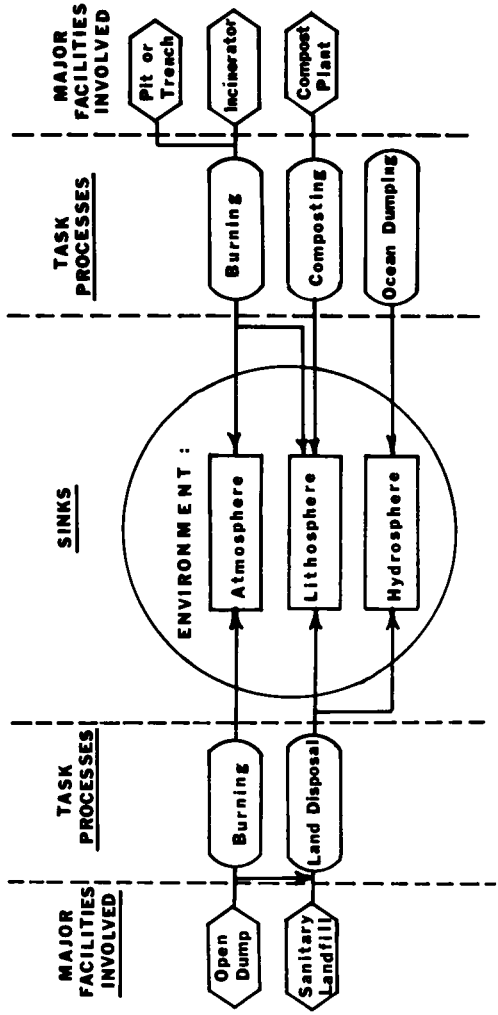

Figure 5. Final disposal sinks.

making policy this implies that communities, rather than waiting and wishing for some miracle, should plan realistically where and how they are going to dispose of their wastes with the least adverse effect.

3. *System Control*–Major changes in the solid waste management system are possible essentially through following three different policy decisions:

a. *Lowering Standard of Living*–This policy advocates reduction in the level of goods and services available to each person and is extremely effective in reducing solid waste problems. If, for instance, the United States would be successful in reducing the consumption of electricity only 10 per cent, about 2,500,000 tons per year of fly ash alone (not considering the solid waste generated during mining and transportation of coal) will immediately disappear. This can be extended to all aspects of life. A 10 per cent reduction in consumption will result in the disappearance of approximately 100,000,000 pounds of solid waste daily in only the municipal sector of the economy. The effect on the production sector (industrial, mining, and agricultural) will be much greater.

Some advocate this policy. It would certainly ease solid waste and other environmental problems. If this nation decides that this is what she wants, then it is definitely a viable solution to solid waste problems.

However, once this policy is accepted one should be aware of what he is buying–a lower standard of living. As a matter of fact, in 1970, the per capita consumption of a number of commodities had decreased. For instance, people in the U.S. used 545 pounds of paper per capita in 1970 as compared with 576 pounds of paper per capita in 1969, a total decrease of 3,000,000 tons (for population of 200 million). Since most of this paper would have found its way into the solid waste stream the reduction implies considerable savings in handling of solid waste. In addition, since about 17 trees are saved when one ton of paper is not used. In 1970 alone some 50,000,000 trees were saved. This, of course, seems very satisfying until one notices that 1970 was a very bad year economically. In its unhappy course, untold suffering was inflicted upon millions of families when their bread winners lost their jobs.*

b. *Recycling*–Since the material standard of living roughly depends on the number of available goods per person, one way to keep the standard of living high while reducing solid waste is to recycle used material into the

*According to Abrahms,[13] an international survey of 12 countries conducted by Keep America Beautiful, Inc., has found that a strong correlation exists between the standard of living in various countries and the amount of trash they produce. For example, in India about 200 pounds per capita of solid waste discarded each year as compared with more than 1,800 pounds in the United States.

economy.* As it was mentioned before this is already being done to a great extent. However, there is room for considerable improvement.

Basic changes in our attitudes, laws, and economics are required if we wish to accelerate recycling. The need for these changes is becoming accepted not only by the populace, but also by the lawmakers. A good indication of the fact that recycling is appearing as a national policy is evidenced by the enactment of the Resources Recovery Act of 1970.[14] This is a good beginning and should be followed by other state, local and Federal laws. Laws should not only address themselves to solid waste, but also consider the discriminatory transportation costs, introduction of tax incentives, re-examination of depletion allowances, and capital gains for mining and forestry. We need also to change our attitudes. We should accept the notion that reused materials are as good, healthy, safe, and usable as virgin materials.

While the emergence of recycling as a national policy in general is a very encouraging sign, one needs to be careful not to confuse recycling by an engineered system with "boy scout recycling," that is, recycling by volunteer groups. Unfortunately, in joining the fashion of the day we may lose sight of the real problems. Industry in general, always ready to capitalize on people's dreams and good will, now is joining the recycling crusade. Some with the utmost sincerity and some with an eye on the advertising value of exhibiting environmental sensitivity, are joining good will groups and initiating noisy programs which for the most part are non-effective as far as solid waste problems are concerned. Sometimes these programs are more harmful to the environment than good. Let us look at some examples. (These examples are selected to elucidate the nature of the problem. They should not be construed as doubting the sincerity of the industries involved.)

In 1970, an aluminum recycling program was initiated in 11 western states.[15] During this "Cash-for-Cans" Program 5.5 million pounds of aluminum were collected** in 122 collection centers. The study revealed the following: a) the typical seller of aluminum scrap was a boy under 16, driven to the collection center by his parents, b) most sellers came from suburban areas rather than the central part of the cities and the higher income neighborhoods participated far more than the poorer areas (not a single seller came from the "inner city area"), c) nearly half of the sellers lived

*For instance, if one ton of processed scrap iron is used, it not only eliminates this one ton from the solid waste stream, but also eliminates waste produced in extracting one and a half tons of iron ore, a ton of coke, and one half ton of limestone.

**Actually the report states that during the first eleven months of 1970 they collected 4.97 million pounds. 5.5 million pound figure was obtained by extrapolation.

five or more miles from the collection points, some as far as 50 miles or more, d) over two-thirds of the sellers were male, and e) the overall average weight of aluminum turned in per individual was 53 pounds.

On the surface the experiment could be termed a tremendous success: 5.5 million pounds of aluminum (this is equal to 2,750 tons) were saved. However, further analysis shows differently. Several claims can be made:

1) 2,750 tons of aluminum collected have helped to clean the environment by reducing solid waste and litter.

Since in 1970 aluminum food and beverage packaging materials only made up about 1/7 of 1 per cent (by weight) of urban and industrial waste[16] it is obvious that the effect of the program, even should it become nationwide and recover all the aluminum in use, is negligible (it should be obvious that a much larger effort is required to eliminate all aluminum from waste streams). The effect on the litter problem is even less. According to the Highway Research Board study,[8] 16.3 per cent of the monthly contribution to litter is by cans of all types. Since the aluminum can comprises less than 3 per cent of all cans used,* arguments are not necessary to prove the ineffectiveness of the program. On the negative side, damage to the environment could be considerable. Observing that on the average 53 pounds of aluminum was turned in per individual, and the individual on the average lived about five miles away from the collection center (ten miles round trip), and 5.5 million pounds of aluminum was collected during the experiment, then the whole operation involved about 1,100,000 miles of car travel (this estimate does not include individual search for aluminum cans). How much these trips have contributed to air pollution, highway maintenance expenses, and accidents is a story untold.

2) A second claim may be made that saving 2,750 tons of aluminum made a significant contribution to a nonrenewable resource.

However, one immediately notices that 2,750 tons is about 0.05 of one per cent of the aluminum produced in the United States.** An effort to conserve only 5 per cent of aluminum used in this manner would have required a national effort of 12,200 collection centers and 110,000,000 miles of car travel.

3) A third claim may be made that the purpose of such an endeavor is essentially to get people involved, to overcome apathy and focus attention on a critical situation.

This, of course, is a very noble proposition. However, the backlash may be much more real and damaging. Since these efforts will not even dent

*In 1970, 10,348 million pounds of steel cans and 329 million pounds of aluminum cans were consumed.[10]

**In 1969 aluminum production was 4,649,000 tons.[15]

> the solid waste or litter problems, it is conceivable that after a while the public will wear out and lose interest and trust. Since environmental problems will not be solved overnight or within years, consistent public support will be needed. The worst thing that could happen is that public expectation rises and the outcome does not match it—this we cannot afford.

Another example of the recycling hysteria is in connection with glass bottles. All over the land Boy Scouts, civic organizations, well doers, and the glass manufacturing industry are pushing for bottle redemption programs. Mr. Cheney of the Glass Container Manufacturers' Institute enthusiastically observes that "enthusiastic public response arising from growing concern with environment problems resulted in the unprecedented value of recycling."[17] It has been reported that recycling coordinated at all plants showed a sharp rise in the level of recovery in 1969. It rose from 6.5 million units in July, to 13 million units in August, and to 22.5 million glass containers in September. Now, assuming a 12 month effort on a level of 30 million units recovery per month* the program will recycle about 360,000,000 bottles annually. Comparison of this figure with 36,000,000,000 units of domestic shipment in 1969[12] reveals that a nationwide effort at a much higher level than now will only result in about one per cent recovery,** a mere token in solid waste management.†

Stories such as these can be told in connection with almost all industries. It is a part of our fascination for simple solutions. We forget that we are living in a very complex and highly technological society. We have the capability and resources to find the proper solutions, though they may be complex. We cannot afford to deceive ourselves by playing games. We must understand this, if we hope to solve our environmental problems.

In attempting to increase the recycling of waste materials, we first should establish what is worthy of recycling. Secondly, we should develop technology which in a mass action can recover large percentages of that material from solid waste streams.†† Thirdly, we should enact laws which encourage the use of secondary materials. Fourthly, we should not expect overnight solutions. And, finally, we should examine what kind of side

*Note that this is more than collected at the present level and much more effort will be needed to reach this point.

**Since glass comprises only 8 per cent of municipal solid waste[11] the effect on solid waste will only be about 0.08 of one per cent reduction.

†In addition, it also may be asked in passing why we are so preoccupied with glass. Glass is chemically inert, composed of materials most abundant in nature and is compatible with almost all disposal methods. When sanitary landfill is practiced it is one of the most ideal materials. If our concern is with litter it is shown that unless we cure the individual who litters, there cannot be much hope for solutions.

††This is true for only municipal solid waste. The situation may be different for industrial or mining wastes where there is a large concentration of a single material.

effects the decision to recycle a certain material would have. For instance, the National Academy of Engineering[18] proposed that within the next decade we should increase recycled paper from the present 20 per cent to 50 per cent of the consumption. We are told that this will save about 300,000,000 trees annually. It is very important that we should ask what implications such action would have on the forest industry and the states whose economy depend on that industry.* Another significant question would be to ask whether the market for secondary paper can be developed simultaneously.**

Separation at the home, for whatever reason, is a regressive action. It is a practice belonging to past centuries. It is not consistent with the modern way of life. If it was the only way to affect recycling one could accept the idea, though involuntarily. However, there is no need to do so. The United States Bureau of Mines had already developed technology which mechanically separates various components of municipal solid wastes from incinerator ashes.[22–24] Work is under way to separate the components from untreated solid waste.

c. *Multipurpose design*–Examination of Figure 4 also indicates that disposal of solid waste should not only be made with the goal of getting rid of solid waste (with a minimum possible insult to the environment) but should also have other secondary goals.† Table 2 indicates some of these secondary goals and some of the technological tools available to management to achieve those goals.

4. *Design of goods as a solid waste management tool*–The interrelationship of the generation sector of the economy and the waste sector points out the possibility of designing consumer goods with disposal and recovery in mind. For instance, it is suggested that cars may be designed to simplify the recovery of valuable components. We should provide incentives to encourage industry to embrace this concept on a wide scope.

*This should be examined in light of the following information:

Year	*Total Forest Area in U.S.*	*Year*	*Total Forest Area in U.S.*[19]
1630	950	1938	630
1920	614	1945	624
1930	615	1953	648

In addition, the decision should be made based on the knowledge that 1) already scientific improvement has produced superior trees which in a shorter period of time yield much larger quantities of fiber per tree[20] and, 2) new forestry practices have substantially increased the yield.

**In considering such a question, it should be remembered that future market would be different from the present. New markets may open and change the demand for certain materials. For instance, should the Louisiana State University investigators who are studying turning cellulose waste into low cost high protein food be successful, the market for secondary paper will indeed be expanded.[21]

†An interesting secondary goal may be power generation.

Table 2

Goals of Solid Waste Treatment		
Primary	*Secondary*	*Technical Tools of Management*
Disposal	Volume reduction	Incinerator
		Composting
		Densification
		Pre-sizing
		shreding
		grinding
		Separation
	Land reclamation	Sanitary Landfill
		Composting
	Energy conversion	Heat generation
		Gas turbine
	Homogenization	Shreding
		Grinding
	Recycling	
	Material reuse	Secondhand use
		Separation
		manual
		magnetic
		ballistic
		melting
		pulping
		screening
	Material conversion	Pyrolises
		Biodegradation
		Fusion

Various Aspects of Solid Waste Management Systems

The complex system described in previous sections has a number of implications which need consideration. These aspects are:

Public Health
Nuisance and Aesthetics
Economics
Resources

Institutional
Professional
Environmental and Philosophical

PUBLIC HEALTH ASPECT

A recent comprehensive literature survey, based on circumstantial and epidemiologic information supports the notion that "to some diseases, solid waste bears a definite, if not well defined, etiologic relationship. The diseases so implicated are infectious in nature; no relationship can be substantiated for noncommunicable disease agents associated with solid waste not because of negating data, but because of lack of data."[25] Flies which are the most serious carrier of many infectious disease agents (typhoid fever, cholera, summer diarrhea, dysentery, intestinal worms, and others) can proliferate enormously in the breeding opportunities afforded by litter and poorly handled solid waste. The same study shows that the importance of solid wastes to mosquito-borne diseases and rodent borne zoonoses is far less clear. However, mishandled solid waste provides breeding grounds for both and, therefore, by at least implication, a certain relationship can be assumed. A significant finding of the study has also been that a high accident frequency rate exists among sanitation workers.

NUISANCE AND AESTHETICS ASPECT

There is no need to elaborate on this.

ECONOMICS ASPECT

Solid waste is a big business. The United States spends 4.5 billion dollars annually to dispose of its solid waste. The amount budgeted by municipalities for handling solid waste is third only to highways and education. In addition, as already mentioned, the secondary industry is an 8 billion dollar a year enterprise.

Boiled down to its essential, proper management of solid waste will soon cost even more than is presently spent. Because of the forces which make it more and more difficult to find land close to population centers, the disposal points are being forced to go farther and farther away from the cities. This means that in the future more and more has to be spent in transporting solid waste. On the other hand, the demand for more environmentally consistent disposal practices and recycling will also push the cost higher. While technological advances may be relied upon to increase operating efficiency, nevertheless, some cost increase may be expected. There are just no two ways about it. We should be prepared to pay more in the future!

One aspect of economical consideration would be that it will eventually force integration of the existing small units of management (each small city and county now operates its own solid waste system) scattered all over the land. The integration is expected to increase efficiency, thereby reducing operational costs, and benefitting from "economies of scale" which will be realized by recovery of recyclable material.

RESOURCES ASPECT

A U.S. Bureau of Mines publication speaks of a billion dollar wealth that each year is thrown away by the U.S. population in the form of iron, aluminum, copper, lead, zinc, and tin in municipal solid waste.[26] These are nonrenewable resources of great value to man. A recent study by Resources For the Future[27] indicates that there is a likelihood that the demand for copper, lead, and zinc may exhaust presently known and inferred reserves by the year 2000.* Consequently, it seems fitting that one should be concerned about wasting these vital resources via careless handling of our solid waste. The scarcity of material resources then becomes an important consideration in the management of solid waste.

Economists usually examine resource problems principally in terms of several indicators of scarcity. Fisher and Potter[23] have considered five indicators:

1. production or consumption per capita,
2. employment per unit of output,
3. relative price (or cost) trend for natural resources as compared to trends of prices (or costs) in general,
4. net foreign trades, and
5. trends in the rate of production and use of resources compared to estimated reserve.

Examining these indicators they conclude that they "find no general increased scarcity in more developed areas; the opposite trend is likely to continue. In the less developed areas several problems will be encountered, but the situation is not hopeless." Their study indicates that in general there is no reason for alarm.[28] However, recycling as good housekeeping is still a viable policy.

One interesting observation of the resources scarcity study is that in about 1920 the U.S. changed from a net exporter to a net importer of raw

*For iron, aluminum, and manganese the known and inferred reserves are expected[28] to supply demands at least as far as the year 2000 without significant increases in cost.

materials. This reliance upon foreign resources may prove a severe handicap in future growth, because of its political overtones. It is hard to conceive that less developed nations of the world would permit continuous flow of their resources to the U.S. while their own standard of living is many times lower. In this context recycling emerges as an instrument of national defense.

INSTITUTIONAL ASPECT

Solid waste management at the present time is a fragmented enterprise which is deeply intertwined with politics. While it is one of the most complex socio-technical undertakings, it is handled in a haphazard way. Within a region many small governmental and private organizations are engaged in the solid waste business. Governmental institutions are not yet prepared to deal with solid waste as a whole. The most visible part of government concerned with solid waste (sanitation departments in various cities) is usually only concerned with the collection, removal, and sometimes disposal of municipal solid waste. However, gradually a national policy is developing in regard to solid waste. Many years will be needed to construct governmental institutions that can address themselves to the overall task, and can meet the challenge. An interesting concept which recently is being tried in several cities is the management of solid waste as a utility.[29]

PROFESSIONAL ASPECT

One of the major problems with the management of solid waste is the non-existence of a learned profession in this field. Prior to enactment of the Solid Waste Disposal Act of 1965,[30] not very many professionals either in universities, government or private institutions would have identified themselves with the field of solid waste. It was a lowly job. As a result the field essentially has remained unexplored and underdeveloped. The practice of collection, removal, and disposal of solid waste has essentially remained unchanged for decades. Management as it is known in more advanced fields is unheard of. As a result, when solid waste as a part of the public's environmental concern emerged as a national problem, except for some notable exceptions, there was a dire lack of experts to deal with it. It will take many years to build a learned profession, and this we must do if we wish to face the future with more confidence than we do now. Training and education of experts in the field of solid waste is a necessity of the first order.

ENVIRONMENTAL AND PHILOSOPHICAL ASPECT

It is also essential that each of us re-examine our position and responsibilities toward the complicated environmental question. *We cannot*

ultimately solve our solid waste problems if we do not come to terms with ourselves.

Since it is an invariant of nature that we have to pay the price for what we want, we should decide what it is that we want. Some say we should want less. Well, even if we accept less (and we should in many cases), we cannot expect the whole hungry world, outside and inside this country, who already have nothing to want anything but more. Since the have-nots are many more than the haves, the startling fact is that even if some of us ask for less, far less, in gross, the occupants of this space ship earth will require more of everything. In absolute terms then, no matter what people in this country decide, humanity needs more than it has now. The trouble with those who urge the rest of the world to demand less is that they are only sensitive to their own affluent conditions and are oblivious to the rest of the world.

In Summary

In this paper it is pointed out that solid waste management is a complex problem. It attempted to show that reasonable solution can only be found by examining the whole gamut of human activities from resources extraction, through production and utilization of goods, to disposal of solid waste. It strived to show that simple solutions are not answers. It indicated that a wise management implies seeking the minimization of the adverse effects of solid waste on public health, reducing the nuisance, eliminating the ugliness, cutting costs, and increasing resource re-utilization by creation of sane governmental institutions and the development of a learned profession. The management of solid waste should be multidimensional, time sensitive, multipurpose, and a conservationist endeavor.

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