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ABSTRACT

This booklet is the second in a series of Environmental Resource Packets designed to encourage college science teachers to become professionally competent in selected environmental areas of study. Produced under a grant from the ESSO Education Foundation, each packet consists of a review paper(s) and a selected and annotated bibliography related to economics, politics, ethics, etc., as well as the natural sciences. In this packet dealing with solid wastes, Part One reviews aspects of solid waste management for municipal refuse (sanitary landfill, incineration, composing, new approaches), junked automobiles, industrial solid wastes, mining and processing wastes, and effects of solid wastes. Recommendations for controlling the problem are noted for each component. Part Two, the annotated bibliography, covers basic general references; solid waste management policy; economics of management; sources of municipal solid waste; automobiles, packaging and disposables; collection and transportation of municipal solid waste; solid waste processing: incineration, composing, sanitary landfill, salvage recycling and reuse; the future of municipal solid waste management; and student reading selections. Cross references are compiled after each section. Individual entries delineate the title, author's name, publisher, point of view, level of use, and a summary of the contents. A related document is ED 075 230. (BL)

NO DEPOSIT – NO RETURN

The Management of Municipal Solid Wastes

J. M. FOWLER AND K. E. MERVINE

APRIL 1973

An Environmental Resource Packet published under a Grant from the EXXON Education Foundation.

CONTENTS

PREFACE

During the last few weeks we have received hundreds of letters and returned questionnaires in response to our first packet, "Energy and the Environment". We appreciate the careful criticism which many of you contributed and have tried to incorporate in this packet as many of your recommendations as possible.

Three main "format" changes appear with this packet: a table of contents placed at the very front of the packet, an appendix listing additional bibliographic material, and a ranking system within each topic heading which places the references included there in descending order as to comprehensiveness, availability, and our judgement as to their relative merit.

Our experience in researching and compiling the first packet has led to a narrowing of our sights this time around. We have focused on only one aspect of the solid waste problem, municipal wastes, and have left untouched such important components of the problem as industrial, mining and agricultural wastes, sewage, and a host of related pollutants. We believe that this has enabled us to do a more thorough literature review and to provide you with a more concise picture of what is, in many ways, the most visible aspect of this particular environmental problem and the one most suited for undergraduate study and community education programs.

Perhaps the most important "innovation" with this second packet, however, is the order blank enclosed. We are finding that the cost of producing the packets is somewhat greater than expected and, therefore, we will have to make a change if we are to produce the four more packets projected under this grant. We are encouraged in this by your response in the questionnaire; better than 90% of you indicated a willingness to pay an "at cost" charge.

The printing and mailing of the packets is costing us about a dollar a piece (this does not include the cost of research and production, etc.). We propose, therefore, after these two free packets, to offer <u>four</u> more packets at a total charge of $3.00. On the order blank enclosed we list the four topics within which we will be working. Three of these we have chosen based on your ranking of topics on the questionnaire: Noise (now well underway), Transportation (with a focus on urban problems) and Air Pollution (particularly that associated with the automobile). For the fourth topic, we would ask that you indicate your preference between the two possibilities listed: Natural Resource Management and Technological Assessment. We expect to finish two of the four by August and the remaining two by the end of October. If time and money hold out, we will then produce updated material for the Energy packet in order to learn what is involved in updating and to assess your response to it.

In order to take on these last four topics, we will have to see enough incoming orders to make the projection of a balanced budget a reasonable one. We will therefore greatly appreciate early receipt of your checks (payable to the University of Maryland, which is the fiscal agent for the project).

With the publication of these final four packets, we will be left, in our opinion, with a job undone. There will be several important topics with no packet: Water Pollution, Population, etc. Encouraged by your response to this project, we are beginning to make proposals to carry it on another year, planning not only to fill out our list of packets, but to try to update a few of the present ones. Such a proposal will be greatly strengthened if we can demonstrate that college science teachers are willing to share in the cost of producing these packets. For that reason also we ask for quick response to the order blanks.

Although we do not include a questionnaire with this packet, we remain eager for any feedback which will help us improve the quality of future packets. Please address your comments and criticism to Ms. Kathryn E. Mervine who, as Research Editor, has done the major work of literature review, summary and compilation for this packet.

John M. Fowler
Project Director

AC KNOWLEDGEMENTS

We want first to express our appreciation to the American Chemical Society for their permission to reprint "Solid Wastes", the review article that introduces this packet. Several people have been most helpful on the bibliographic section here: Ton. Quimby, of Resources for the Future, who provided suggestions for our "Economics" section; Bruce Hannon and Robert Grinstead, who reviewed a first draft of the bibliography and offered several useful suggestions; and Ron Ware, of the Bureau of Solid Waste Management Publications Office, who patiently guided us through the wealth of government documents available there. Finally, we are indebted to the many publishers and Congressional Committee personnel (particularly at the Senate Committee on Public Works) who responded so generously to our requests for complimentary copies of their publications.

KEM

Solid Wastes *

INTRODUCTION

The technology used to handle and dispose of solid wastes in the U.S. lags well behind that used to control air and water pollution. Less than 10 years ago, far fewer than half of the cities and towns in this country with populations of more than 2500 were disposing of community refuse by approved sanitary and nuisance-free methods (29). Municipalities have resorted primarily to open dumps, with relatively few using incinerators or improved disposal methods, such as sanitary landfills. Industry often has followed a like course.

As recently as 1965, the Federal Government was spending only an estimated $300,000 annually on research on solid waste disposal. In the few years since that time, and largely under federal stimulus, solid wastes management has come under increasing scrutiny, and the situation has begun slowly to change (16, 40, 44). The basic science of solid waste handling and disposal remains in relatively primitive condition, but advanced technology from other fields is being brought increasingly to bear on the many problems that must be solved. The need is clear. Even disposal methods that are now acceptable cannot be counted on to deal fully with the refuse from a growing industry and from 22 highly urbanized areas, containing some 240 million people, the situation expected in the U.S. by the year 2000.

BACKGROUND

Current estimates (Table 1) show that public and private agencies in the U.S. collect an average of 5.32 pounds per person per day of solid wastes, nationwide, or more than 190 million tons per year (3). By 1980,

Table 1

Average solid waste collected, pounds per person per day

Solid wastes	Urban	Rural	National
Household	1.26	0.72	1.14
Commercial	0.46	0.11	0.38
Combined	2.63	2.60	2.63
Industrial	0.65	0.37	0.59
Demolition, construction	0.23	0.02	0.18
Street and alley	0.11	0.03	0.09
Miscellaneous	0.38	0.08	0.31
Totals	5.72	3.93	5.32

SOURCE: Black, R.J., Muhich, A.J., Klee, A.J., Hickman, H.L., Jr., Vaughan, R.D., "An Interim Report. 1968 National Survey of Community Solid Waste Practices," presented at 1968 annual meeting, Institute for Solid Wastes, American Public Works Association, Miami Beach, Fla., October 1968. Bureau of Solid Waste Management, U.S. Department of Health, Education, and Welfare, Washington, D.C.

some 235 million people are expected to be generating 8 pounds per person per day of solid wastes or more than 340 million tons per year. These figures, moreover, cover only those wastes that are handled by collection agencies. Overall, the nation is generating today an estimated 10 pounds per person per day of household, commercial, and industrial wastes, or more than 360 million tons per year. In addition, about 7 million passenger cars, trucks, and buses are junked annually in this country. More than 80% of them may be salvaged in varying degree, but the excess contributes to an accumulation of abandoned vehicles that has been estimated at from 9 million to 16.5 million. The mineral industries alone in 1965 generated an estimated 1.1 billion tons of solid wastes in the form of mine waste, mill tailings, washing plant rejects, processing plant wastes, and smelter slags and rejects (but not including the overburden from surface mining).

The first federal effort to deal directly with the solid wastes problem was the Solid Waste Disposal Act of 1965. The act has two purposes: to start and accelerate a national research, development, and demonstration program on solid wastes; to give technical and financial support to interstate, state, and local agencies in planning, developing, and conducting solid waste disposal programs. The act authorized appropriations rising from not more than $10 million in fiscal 1966 to not more than $32.5 million in fiscal 1969. The money is divided between what is now the Bureau of Solid Waste Management in the Department of Health, Education, and Welfare, and the Solid Waste Research and Economic Resource Evaluation Studies Programs of the Bureau of Mines, in the Department of the Interior. Under the act, the Bureau of Solid Waste Management would receive 60 to 70% of the total when both agencies receive the maximum allowable appropriations.

MUNICIPAL REFUSE

Municipal refuse is a complex heterogeneous substance, both physically and chemically (Table 2). Measurements and standards that can be used to characterize municipal refuse do not now exist, and the Bureau of Solid Waste Management is working to establish suitable parameters. The bureau is also developing statistics on the use of different disposal methods (Fig. 1, page 168). Of the 5.32 pounds per person per day of solid wastes handled by collection agencies, about 8% is disposed of in some 300 municipal incinerators in the U.S. More than 90% goes to some 12,000 land disposal sites. Hog feeding and composting account for relatively small fractions of the solid waste disposal load. Of the 300 incinerators, only about 30% have adequate air pollution control devices. Of the 12,000 land disposal sites, only about 6% are sanitary landfills, defined as having daily cover, no open burning, and no water pollution problems. The remaining 94% of the land disposal sites are considered inadequate.

The aim of solid waste disposal processes is to reduce primarily the

Table 2

Sample municipal refuse composition—U. S. East Coast

Physical	Weight per cent	Rough Chemical	
Cardboard	7%	Moisture	28.0%
Newspaper	14	Carbon	25.0
Miscellaneous paper	25	Hydrogen	3.3
Plastic film	2	Oxygen	21.1
Leather, molded plastics, rubber	2	Nitrogen	0.5
Garbage	12	Sulfur	0.1
Grass and dirt	10	Glass, ceramics, etc.	9.3
Textiles	3	Metals	7.2
Wood	7	Ash, other inserts	5.5
Glass, ceramics, stones	10		100.0
Metallics	8		
Total	100		

SOURCE: Kaiser, E. R., "Refuse Reduction Processes," in "Proceedings, The Surgeon General's Conference on Solid Waste Management for Metropolitan Washington," U.S. Public Health Service Publication No. 1729, Government Printing Office, Washington, D.C., July 1967, p. 93.

volume and secondarily the weight of the refuse, so that it can be disposed of more readily, and to convert it to a less offensive form. Sanitary landfilling will reduce municipal refuse from an initial volume of about 7 cubic yards per ton to about a third of that volume. Incineration can reduce the volume 80 to 85% if the refuse is uncompacted and about 95% if cans and similar material are compacted. In composting, the organic matter in the refuse is reduced about 40% in weight by biological degradation and marketed as compost. If the uncomposted residue is used in landfill, the process achieves an overall volume reduction similar to that of incineration.

Composting involves the concept of cost recovery, since the compost itself is sold, and materials such as paper and rags may be salvaged and sold. The concept can also be applied to refuse incineration by using the heat produced to generate steam. There is very little evidence to suggest that cost-recovery will be a panacea. The importance of the concept lies in its recognition that municipal refuse can be treated as an asset rather than a nuisance, even though no net profit is realized, and this idea can be applied even in upgrading simple dumping to the sanitary landfill.

Sanitary landfill

Modern practice in sanitary landfill (Fig. 2, page 169) can be seen in those operated by the Sanitation Districts of Los Angeles County, Calif. (4). Refuse is spread in thin layers, and each is compacted by a bulldozer before the next is spread. When about 10 feet of refuse has been

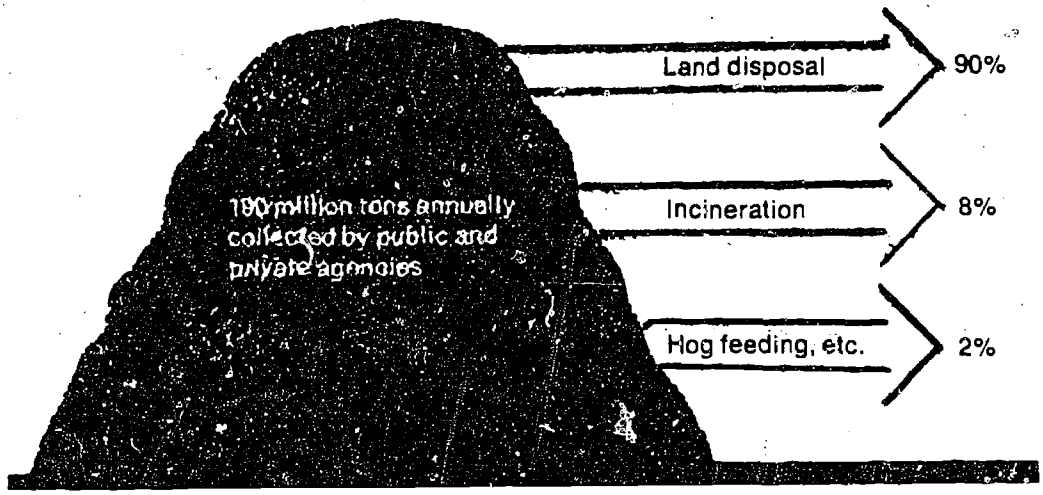

Figure 1

Methods used to dispose of solid wastes

Public and private agencies in the U.S. collect an average of 5.32 pounds per person per day of solid wastes, or more than 190 million tons annually. About 90% of the wastes collected go to some 12,000 land disposal sites, of which only about 6% are considered adequate sanitary landfills. About 8% is disposed of in some 300 municipal incinerators, of which only about 30% have adequate air pollution controls.

SOURCE: Black, R. J., Muhich, A. J., Klee, A. J., Hickman, H. L., Jr., Vaughan, R. D., "An Interim Report. 1968 National Survey of Community Solid Waste Practices," presented at 1968 annual meeting, Institute for Solid Wastes, American Public Works Association, Miami Beach, Fla., October 1968, Bureau of Solid Waste Management, U.S. Department of Health, Education, and Welfare, Washington, D.C.

laid down in this way, it is covered by a thin layer of clean earth, which also is compacted. The operation is repeated until the landfill has reached the desired depth. At the end of each working day the fill is sealed with a thin layer of compacted earth, and the completed fill is sealed with 2 or 3 feet of compacted earth. There is no burning and no serious problem with odors, flies, or rats. Water pollution is minimized by the small amount of rainfall.

Los Angeles County has used the landfill technique to reclaim land and convert it to parks, golf courses, and other types of recreational areas. The county has found that it can haul refuse for up to 50 miles in large trailers and bury it in landfills at costs competitive with those of operating municipal incinerators that would meet the local air pollution regulations. The 13 municipal incinerators that were operating in the county in 1955 have since closed down because they could not meet the regulations economically.

Air does not penetrate a well-compacted landfill to any extent, and oxygen inside the fill is utilized rapidly by aerobic microorganisms as they decompose organic matter. When the oxygen is depleted, decomposition

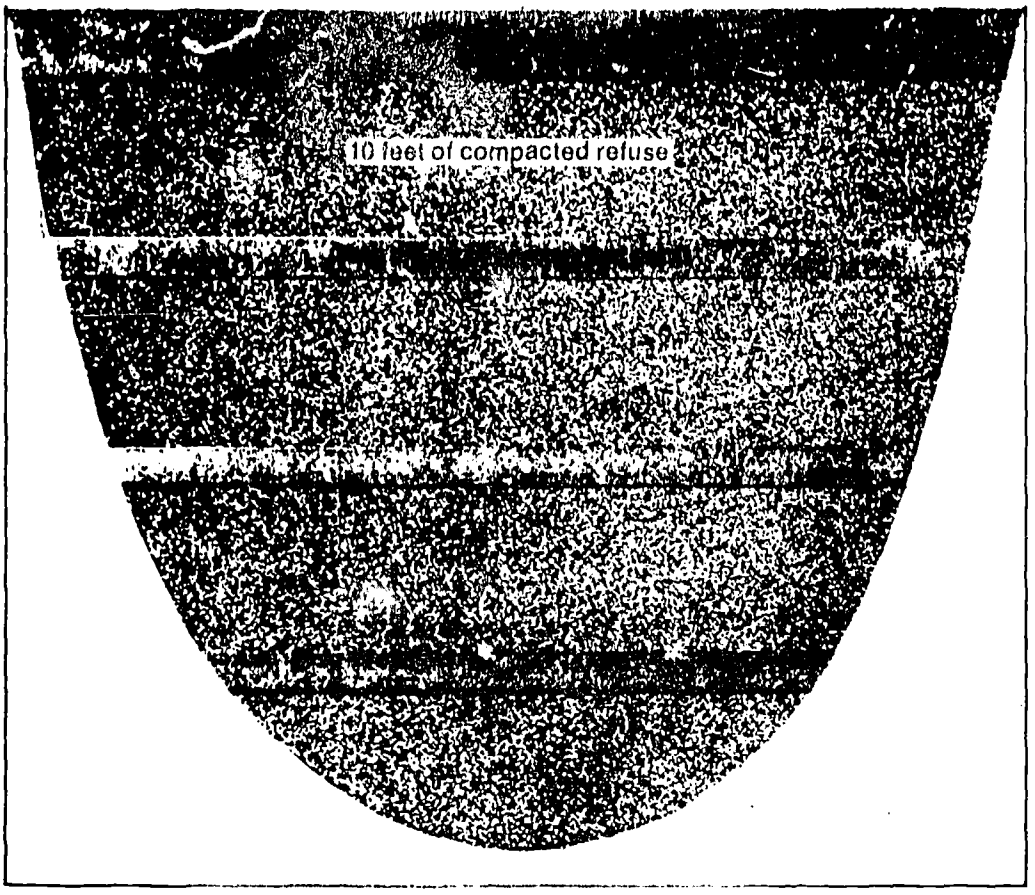

Figure 2

Modern practice in sanitary landfill

In a modern sanitary landfill, refuse is spread in thin layers, each compacted by a bulldozer before the next is spread. When about 10 feet of refuse has been laid down in this way, it is covered by a thin layer of clean earth, which is also compacted. At the end of each working day, the landfill is sealed with a thin layer of compacted earth, and the completed fill is sealed with 2 or 3 feet of compacted earth. An adequate sanitary landfill should have no burning and no serious problems with odors, flies, rats, or water pollution.

by anaerobic microorganisms begins and accounts for the degradation of most of the organic matter in the landfill. Methane and carbon dioxide are among the products of anaerobic decomposition. Methane tends to escape over the surface of the fill, but at rates that are not troublesome in open recreation areas. Buildings can trap methane, however, creating an explosion hazard, and this, plus settlement of the fill, are two factors of concern in erecting buildings on or next to sanitary landfills. Carbon dioxide produced inside a landfill can dissolve in ground water, making it weakly acidic. The water can then dissolve any limestone and other rock that it contacts, thus increasing the dissolved solids content of the water. For such reasons, sanitary landfills must be carefully

designed and operated to avoid difficulties with gases and ground water pollution. Current research is directed at upgrading the knowledge of the products of decomposition and improving methods of construction and operation. The movement of contaminants into ground water is also being studied, and further research is required on bacterial pollution of ground water.

Gas chromatographic analyses of the gases and acids produced by refuse decomposing anaerobically in steel cylinders indicate that the most pronounced changes in the organic materials occur in the first 60 days of decomposition (5). The accumulation of intermediate products of decomposition indicates further that the process is not complete even after two years. In addition to carbon dioxide and methane, decomposition produces hydrogen and organic acids of from two to six carbon atoms. Leachate created by percolating water through large concrete cylinders filled with anaerobically decomposing refuse was found to be rich in both organic and inorganic substances.

Other work is designed to demonstrate the feasibility of pumping air into a landfill and thus achieving aerobic instead of anaerobic decomposition of the organic matter (42). Previous study of aerobic landfills indicates that they might have several advantages, including more rapid settling than anaerobic landfills, and thus more waste disposal capacity; elimination of methane and hydrogen in explosive concentrations; and more rapid stabilization of the landfill, so that the land can be reclaimed more quickly for conventional construction.

Abandoned strip mines are being investigated as sites for sanitary landfills (1). This approach may have the additional advantage of reducing acid mine drainage in some cases.

Well-planned and well-operated sanitary landfill should offer at least a partial solution to the municipal refuse problem for some years to come. The method requires that suitable land be within economic range of the source of the refuse, however, and that the site be of such a nature that pollution of ground water can be prevented by application of the available technology. Where these requirements cannot be met, incineration will be most often the best alternative for disposing of municipal refuse, and use of incineration seems likely to grow.

Incineration

U.S. incinerator technology was largely empirical for many years, but it is moving now into an era of rapid evolution. The air pollution requirements that are beginning to appear for incinerators make scrubbers or electrostatic precipitators mandatory. The effect has been almost to double the cost of smaller units (from 240 to 450 tons of refuse per day) and to add up to 30% to the cost of larger units (500 tons per day and higher) (19). Other current developments include more sophisticated design, more careful examination of the economics of recovering waste heat, and an incipient trend toward large regional incinerators rather than small local units. U.S. practitioners also are looking more closely at

incinerator and other solid waste management practices in Europe (37, 41). Urban pressures there have compelled the application of technology that is available in the U.S., but is not yet used widely in this country for disposing of municipal refuse.

In modern U.S. incinerators, refuse burns on moving grates in refractory-lined chambers, and combustible gases and entrained solids burn in secondary combustion chambers or zones. Combustion is 85-90% complete for the combustible materials. Up to three times as much air is introduced into the incinerator as would be needed to supply the oxygen required to oxidize the refuse completely. The temperature in the bed of burning refuse may reach 2500° F. or more, and the excess air is required mainly to hold the temperature in the furnace at 1400° to 1800° F. Above 1800° F., slag formation in the furnace can become a problem. The incinerator produces the normal primary products of combustion, carbon dioxide and water, as well as oxides of sulfur and nitrogen and whatever other gaseous air pollutants might be generated (Table 3). It also produces fly ash, unburned solid residue, and the heat from combustion.

A large body of technology has grown up around this process, and a variety of mechanical designs is available in incinerators. The scientific principles that underlie this technology often are not well defined (12), partly because the heterogeneous nature of refuse and its variable moisture

Table 3

Typical products of incineration of municipal refuse

Stack gases:	Pounds per ton of refuse	Fraction by volume, dry
Carbon dioxide	1,738	6.05%
Sulfur dioxide	1	22 parts per million
Carbon monoxide	10	0.06%
Oxygen	2,980	14.32%
Nitrogen oxides	3	93 parts per million
Nitrogen	14,557	79.57%
Total dry gas	19,289	100%
Water vapor	1,400	
Total	20,689	
Solids, dry basis:		
Grate residue	471	
Fly ash	20	
Total, pounds per ton of refuse	21,180	

SOURCE: Kaiser, E. R., "Refuse Reduction Processes," in "Proceedings, The Surgeon General's Conference on Solid Waste Management for Metropolitan Washington," U.S. Public Health Service Publication No. 1729, Government Printing Office, Washington, D.C., July 1967, p. 93.

content make analysis of the combustion process extremely complex. For example, although useful combustion and heat calculations can be made, no scientific basis is yet available for estimating a refuse incinerator's maximum capacity in weight of refuse that can be burned per hour (13, 22). Progress might be made also in the chemistry of the slags that form in incinerators and their reactions with the refractories that line the combustion chambers (9).

Air pollution

The most immediate problem in municipal incineration today is control of air pollutants, chiefly fly ash (48). Odors caused by gaseous air pollutants can normally be prevented by proper furnace design and operation. Emissions of noxious gases such as oxides of sulfur and nitrogen are quite low compared with those from other sources, and do not appear currently to offer serious difficulty. Questions have been raised about incinerating plastics, whose concentration in municipal refuse now is estimated to be only 1.5%, but is growing (34). The widely-used packaging material polyvinyl chloride, for example, is about 50% chlorine, and that element is emitted as the toxic hydrogen chloride upon incineration. Very little data are available, however, on the overall air pollution potential of plastics incineration, although it might cause clogging and corrosion in the incineration equipment.

Emission of fly ash and other solid particles is more clear-cut. Typical practice in large municipal incinerators today produces up to 4 pounds of particulate matter per 1000 pounds of stack gas when the weight of the gas is adjusted to what it would be at 50% excess air instead of the 200 to 300% used normally. The regulatory trend in the U.S. today is to reduce particulate emissions to as low as 0.2 pound per 1000 pounds of stack gas. (In some parts of Europe, maximum allowable emissions of even less than 0.2 pound are in force.) Currently in this country there are three general levels of allowable particulate emission. These levels, the particle collection efficiencies that they require, and the collection capability of the available equipment appear in Table 4.

All of the devices shown in Table 4 are used routinely in industry. The devices used most commonly on municipal incinerators in this country are the settling chamber and wetted baffles. Cyclone collectors and direct impaction scrubbers have also been used, but to a lesser degree (14). The direct impaction scrubber is the least efficient device that is known to be able to meet better-than-intermediate particulate emission codes. The water used in the scrubber produces a stack plume, however, unless the gases are cooled to condense the water and reheated to make the dried stack gas sufficiently buoyant. Also, the scrubber uses a large amount of water, which can introduce a water pollution problem.

Of the two remaining devices, the electrostatic precipitator and the bag filter, the former is the more advanced for use on incinerators. Both devices require that the gases they treat be cooler than about 600° F., whereas uncooled gas from a refractory-lined incinerator may

Table 4

Particulate emission restrictions, required collection efficiency, collection efficiency of available equipment

Emission limit (lb. /1000 lb. gas at 50% excess air)	*Stringency of limit*	*Approximate collection efficiency required, %*
0.85	Nonexistent or lenient	74
0.65	Intermediate	80
0.20	Strict	94
Clear stack: refractory furnace	Strict	96-97
Clear stack: water-cooled furnace	Strict	98.5

Type of collector	*Maximum demonstrated efficiency, %*
Settling chamber	35
Wetted baffles	53
Cyclone collectors	75-80
Direct impaction scrubbers	94-96
Electrostatic precipitators	99+
Bag filters	99+

SOURCE: Walker, A. B., "Air Pollution Control Equipment for Incinerators," in "Incineration of Solid Wastes," Metropolitan Engineers Council on Air Resources, New York, N.Y., March 1967, p. 75.

range from 1200° to 1500° F. or higher. (It is now possible, however, to build electrostatic precipitators that will operate at considerably higher than 600° F.) The gas can be cooled by using a waste heat boiler, a water-wall (instead of refractory-lined) furnace and boiler, or by water sprays. Air cooling is uneconomical because of the large volume of air required. The bag filter has been tried to only a limited extent on municipal incinerators because of relatively high first cost and space requirements, and because the available filter fabrics had too short a life at the prevailing operating temperatures. Bag filters also might not withstand the flash high-temperatures that may occur when a batch of plastic or similar material enters the furnace. New materials might solve these temperature problems. Glass fabric filter bags, for example, have long life at 500° F., only about 100° F. below the temperature to which gases from refractory-lined furnaces are cooled by the normal means. Bag filters remain promising for use on incinerators, but require further research and development.

Water-wall incinerators

It appears today that to meet stringent particle emission codes for incinerators the U.S. will most likely follow the European practice of using electrostatic precipitators. These devices are performing at ef-

ficiencies of 99% or higher in Europe, but they are installed mostly on water-wall incinerators, which can produce steam and also produce a stack gas that is automatically preconditioned to enter the precipitator. Although large, steam-generating incinerators are operating in Europe (11), waste-heat recovery from municipal incinerators in the U.S. has been limited to relatively small, inefficient units that use waste heat boilers with refractory-lined incinerators. The water-cooled furnace wall is not a new concept, but for municipal incinerators it has been better adapted to conditions in Europe. Fuel is relatively costly there, which helps to justify the recovery of heat from incinerators. Also, urban pressures are greater in Europe than in the U.S., and the need is thus greater to convert refuse to the lowest-volume, most-readily-disposable form. This need is generally best filled by incineration, and, in addition, the auxiliary fuel used typically in heat-recovery incinerators can increase the efficiency of combustion of refuse to well over 90%.

The water-cooled furnace wall absorbs enough of the heat from combustion so that the incinerator can be operated at about 50% excess air, compared to the 200 to 300% used on refractory-lined furnaces. Gas handling equipment such as stacks and fly ash collectors can thus be much smaller. The heat of combustion also converts the cooling water in the water-wall furnace (with boiler) to steam, whose energy content can be recovered as heat or power. Stack gas from the water-wall furnace, moreover, is cool enough to enter the precipitator without further cooling. The water-wall furnace may cost more to build than the refractory-lined type, and the use of a boiler may require more highly-trained operators. Depending on the economic context, however, these costs can be offset by heat-recovery and lower costs for gas handling equipment and particle emission control. Another factor, if the heat recovered is to be used to generate power, is that a refuse incinerator is designed to operate 85 to 90% of the time, and a power plant is designed to operate 95 to 98% of the time. In any economic context, the difference must be reconciled. In any event, conditions in some parts of North America are beginning to converge with those of Europe, and European incineration practice is taking root on this continent.

Status of advanced incineration practice

The U.S. Naval Station at Norfolk, Va., started to operate a water-wall incinerator early in 1967 (28) (Fig. 3). It has a steam capacity of 100,000 to 120,000 pounds per hour, and the boilers can be fired with oil when the supply of refuse is inadequate. The new water-wall incinerator in Montreal, the first to be built by a municipality in North America, will be rated at 1200 tons of refuse per day and 400,000 pounds of steam per hour. It will use four electrostatic precipitators. The city of Chicago has contracted for a water-wall incinerator with a refuse capacity of 1600 tons per day. The plant will be rated at 440,000 pounds of steam per hour and will use electrostatic precipitators. Braintree, Mass., is building a water-wall incinerator with a refuse capacity of 240 tons per day.

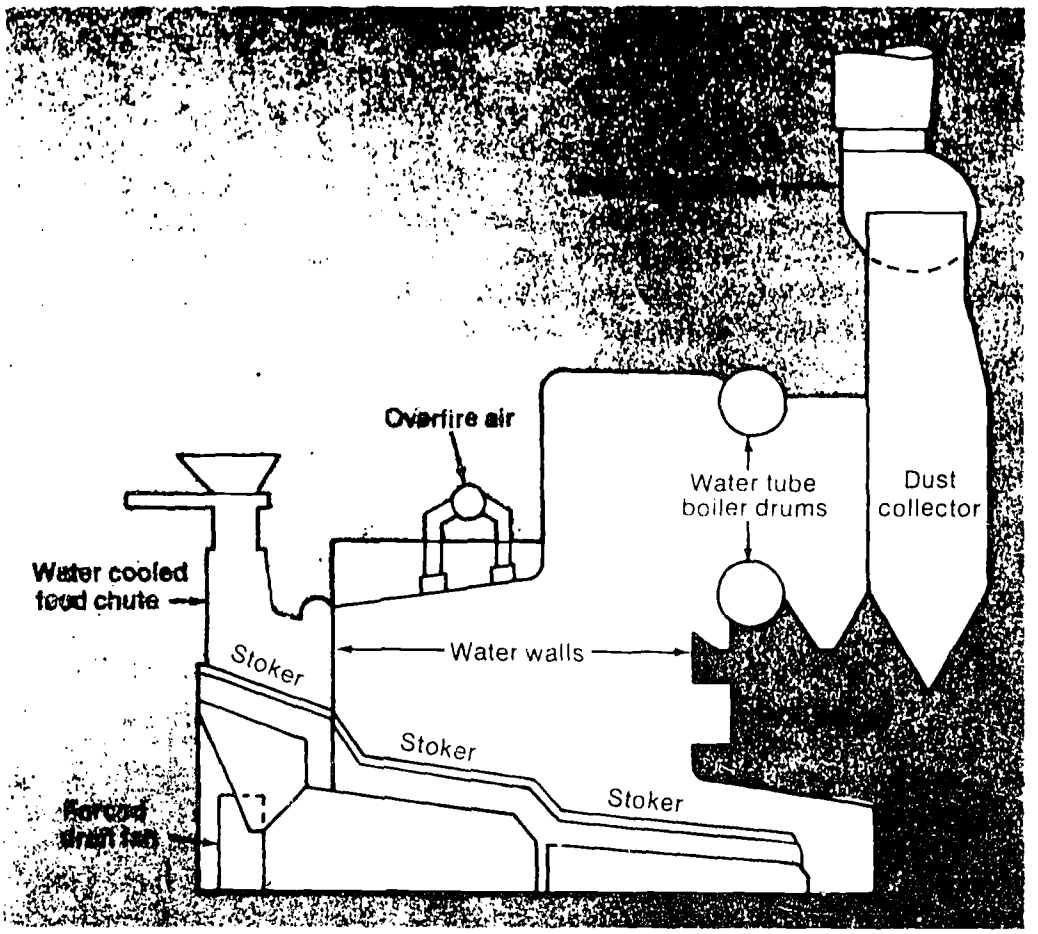

Figure 3

Water-wall incinerator at U.S. Naval Station, Norfolk, Va.

A water-wall incinerator, shown here in simplified form, has been used to burn refuse at the Norfolk Naval Station since 1967. The heat of combustion is recovered in cooling water and boilers to produce about 100,000 pounds of steam per hour at design conditions. Fuel oil can be used to augment the supply of refuse when necessary. Water-wall incinerators have been in use in Europe for some time, but are only just beginning to be used in the U.S.

SOURCE: Moore, H. C., "Refuse Fired Steam Generator at Navy Base, Norfolk, Va.," in "Incineration of Solid Wastes," Metropolitan Engineers Council on Air Resources, New York, N.Y., March 1967, p. 10.

The plant will produce 60,000 pounds per hour of steam and will use electrostatic precipitators. Two electrostatic precipitators are expected to come into operation on municipal incinerators in New York City in 1969.

Commercial buildings, apartments

Not all of the particulate control measures that might be used on big municipal incinerators can be applied to the smaller units used in com-

mercial buildings and apartment houses. Attempts to use dry collectors such as filters or cyclones have failed because the equipment is fouled rapidly by condensation of fats. However, proper incinerator design and use of a wet scrubber can reduce particle emissions by at least 90% (and noxious gas emissions by up to 60%). The problem is more economic than technical, particularly where old incinerators must be modernized. The capital cost of modernizing old equipment in New York City has been estimated at $1500 to $5000 per unit, depending on size. The New York City Housing Authority in early 1967 was experiencing an average unit cost of about $2000 for upgrading flue-fed apartment house incinerators.

Incineration research and development

Among the concepts being investigated for use in municipal incineration is the fluidized bed, which has long been used for a variety of purposes in the chemical and other industries and is being used successfully to incinerate sewage sludge (15). Refuse is fed into a bed of hot sand supported by an upward flow of air. The bed may be characterized as a violently agitated fluid, and the process provides both the heat transfer and gas-solid contact required for good incineration. A potential advantage of the fluid bed incinerator is that it may be able to operate with as little as 5% excess air, thus greatly reducing the size of the gas handling equipment required. Problems with the equipment include feed preparation and feeding, as well as ash removal. Considerable development remains to be done, but pilot-plant results to date suggest that the concept can be the basis of a compact incinerator for solid wastes with relatively clean stack gases.

Another concept that is being studied is to use hot gases from incineration to drive a gas turbine that generates electricity. Refuse would be shredded, dried, and burned under pressure, and the resulting hot gases would drive a turbocompressor and turbogenerator. A waste heat boiler would reclaim part of the heat from the turbine exhaust and generate steam that would drive an auxiliary turbogenerator. If the feasibility of process is demonstrated, a pilot plant could be operating sometime in 1971.

Incinerator residue. The chemical and physical nature of the residue from municipal incinerators is of interest for two reasons: The residue must normally be disposed of by landfill, where its stability, a function of carbon and hydrogen content, might be important; and the residue may contain salvageable material. Work is under way on the composition of incinerator residue, and means of characterizing it have been developed (25, 36). Analysis of residues from municipal incinerators in Washington, D.C., showed them to contain about 30% metals, mostly tin cans and other iron-based materials, 45% glass, 15% ash, 8% paper and charcoal, and less than 1% putrescible organic matter (Table 5). In-

cineration of a ton of municipal refuse produces up to 500 pounds of such residue. In Europe, the iron-based materials are sometimes salvaged from the residue, baled, and sold as scrap. The tin content usually makes such scrap unsalable in the U.S., although shredded, detinned cans find a limited market in the copper industry, where they are used to reclaim copper from dumps. There is reason to believe, however, that the use of plastic coatings and painted cans, plus lighter deposits of tin on cans, will increase the salability of iron scrap in incinerator residue.

The residue from the 300-odd municipal incinerators now operating in the U.S. can be viewed as a mineral resource, containing annually some 3 million tons of iron and 250,000 tons of nonferrous metals, including aluminum, zinc, copper, lead, and tin. The economic incentive to recover and recycle these metals does not exist today, but research is under way on the complex metallurgical problems that would be involved (33).

Composting

Composting municipal refuse to produce a soil conditioner and low-grade fertilizer has been generally unsuccessful in the U.S. Of nine composting plants built in this country in 1951-66, six were shut down or forced into intermittent operation, one important reason being in-

Table 5

Average composition of residues from five municipal incinerators in Metropolitan Washington, D.C.

Material[a]	Weight %, dry
Tin cans	17.2%
Mill scale and small iron	6.8
Iron wire	.7
Massive iron	3.5
Nonferrous metals	1.4
Stones and bricks	1.3
Ceramics	.9
Unburned paper and charcoal	8.3
Partially burned organics	.7
Ash	15.4
Glass	44.1

[a] Sample weighed 951.2 pounds, of which 33.4% was moisture.

SOURCE: Kenahan, C. B., Sullivan, P. M., "Let's Not Overlook Salvage," *APWA Rep.*, 34 (3), 5 (1967).

ability to sell the compost at a realistic price. Interest in composting appears nevertheless to be growing to a degree, partly because of the benefits that might be derived from the compost, partly because of the contention that the composting process is the best way to recycle the minerals and other resources in solid wastes.

Composting operations in the U.S. include three basic steps: refuse preparation; stabilization of organic material by aerobic microorganisms; and product upgrading (17). Refuse is presorted to remove noncompostible materials or those that might have salvage value, such as paper, cardboard, rags, metals, and glass. The refuse is then ground to improve the efficiency of the aerobic digestion process. The ground material is stacked in long, narrow piles (windrows) on the ground or placed in mechanical systems where it is degraded biologically to a humus (much like the organic portion of soil) that contains about 1% or less of the primary plant nutrients: nitrogen, phosphorus, and potassium. The finished product may be cured, ground, and bagged. Of the waste that enters a composting plant, more than 75% goes into the digestion process, and one third to one half of the latter amount becomes compost.

Windrow composting costs less than mechanical systems, but it requires six or seven weeks, compared with five or six days for mechanical systems. A windrow plant large enough to serve 100,000 people would require perhaps 30 acres, compared with 5 acres for a mechanical system.

The largest composting plant yet built in this country is a mechanical system that has been operating in Houston, Tex., since early 1967 (32). It is rated at 360 tons of municipal refuse per day, and the city guarantees the operator a delivery of 300 tons per day (Houston generates about 2000 tons of refuse daily). The plant was producing about 200 tons per day of compost in mid-1968, and its capacity was being expanded by 50%. Most of the compost is retailed in bags. Salvaged material, such as paper, rags, and metal, is available for sale.

In the spring of 1968, the Public Health Service and the Tennessee Valley Authority started to operate a windrow composting plant at Johnson City, Tenn. (38). The plant handles refuse mechanically, but composts it on a 7-acre area in long windrows 7 feet wide and 5 feet high. The PHS-TVA plant was designed to compost about 60 tons per day of refuse and produce about 25 tons of compost. Before composting, the refuse is mixed with sewage sludge, which supplies nutrients and the moisture required for optimum composting. The plant was designed basically to study the technology and economics of windrow composting, and TVA will work on the development of markets for the product.

Little is known about the chemical constituents of compost that might be essential plant nutrients, excepting the three primary nutrients. Furthermore, there is no agreement on the point at which degrading organic material becomes "compost." Research on the chemical and biological changes that occur in composting waste is being hampered seriously by the lack of a fully satisfactory method for determining the extent to which the waste has been degraded. Plant design is hampered

in turn, because logically it should depend on the degree of treatment that is being given to the waste.

New approaches to municipal refuse

A variety of unconventional means of using municipal refuse are being investigated, although few have moved out of the laboratory. Research is being done on transformation of organic material in solid wastes into sugars or protein. Heating of organic refuse out of contact with air to produce useful gases and liquids has also been studied (23). A plant is operating in Japan that compresses refuse into building blocks that can be sheathed in iron or other material, and the process is being investigated in this country. Another compression project under study will produce small bricks, for use as fill to reclaim submerged land, using a mixture of shredded refuse, fly ash, dried sewage sludge, incinerator residue, and river and lake dredgings.

Research and development on handling and disposal must take account of the fact that the nature of municipal refuse is changing. Per capita consumption of packaging materials, for example, is predicted to increase more than 25% in the decade 1966-76 (35). The growing use of paper is increasing the carbon content of municipal refuse, and this could have practical consequences in composting. The aerobic organisms use 30 to 35 carbon atoms for each nitrogen atom, and if excess carbon is present, the digestion process is delayed until enough nitrogen becomes available from dead microorganisms to support further growth. One of the potential benefits of adding sewage sludge to refuse before composting is that it will add enough nitrogen to maintain the ratio of carbon to nitrogen at the optimum level.

Collection and transportation. Collection and transportation of municipal refuse, which account for an estimated 75% of the total cost of handling and disposal, are the subjects of several studies. One of them involves the use of paper bags, instead of trash cans, by the householder. The bags have a capacity of about 30 gallons and, when full, are closed and placed at the curb. They speed the collection process because they can simply be thrown into the vehicle at curbside. They resist water, so that municipal incinerators need not cope with masses of wet paper. The bags keep out flies, resist rats to a fair degree, and minimize spillage in the streets.

Collection vehicles that operate more rapidly and do a better and less noisy job of compaction are desirable. Vehicles that are superior to U.S. models in these respects are available in Europe.

The efficiency of trash collection is susceptible to improvement by operations analysis of vehicle routes and schedules, and this approach is being studied in the U.S. Also under study are the transport of ground refuse as a liquid slurry in pipelines, and short-range transport of dry refuse in pneumatic tubes, a method developed in Sweden. The American Public Works Association is studying the use of unit trains to haul solid wastes from urban areas to disposal sites, such as land reclamation areas.

Recommendations: municipal refuse

Recommendation S1: *The appropriate federal, state, and local government agencies should press their efforts to define the nature and magnitude of the solid wastes problem both now and in the future. Education, research, and demonstration, and local and regional planning for solid wastes management, utilization, and disposal are all necessary for progress in this neglected area.*

Recommendation S2: *The use of known peripheral science and technology in developing improved methods for sanitary landfill and incineration should be encouraged and supported. Efforts to develop a more scientific basis for composting should also be supported, particularly in the area of the biochemistry and related aspects of the degradation process, so that the potential of the method, which appears to date to be quite limited, can be assessed more definitively.*

Recommendation S3: *Research and development on utilization and recycle of components of municipal refuse and incinerator residue should be maintained at a level that will insure that radically new approaches are not overlooked or inadequately investigated.*

Recommendation S4: *Continuing attention should be paid to collection and transportation of municipal refuse, both in the development of improved technology and in mechanisms for promoting the application of such technology by local agencies who are responsible for handling and disposing of municipal refuse.*

JUNKED AUTOMOBILES

Despite the backlog of unreclaimed junked automobiles that has accumulated over the years, a large fraction of junked cars actually is being processed by industry. A study of areas with a total junk car inventory of 510,000 vehicles showed that in 1965 about 73% of them were in the hands of auto wreckers and 6% in the hands of scrap processors (2). About 21% were in auto graveyards, abandoned on public or private property, or held on the owner's property. An investigation of problems in the iron and steel scrap business (21) showed that the gap between the number of cars junked and the number reclaimed was due in large measure to the difficulty of marketing scrap contaminated by nonferrous metals.

The discarded automobile typically goes first to the auto wrecker, who removes parts that can be sold for further use, sometimes after rebuilding. The scrap processor then may sell the battery for its lead content, the radiator, electric motors, and some other parts for their copper content, the engine block and other cast-iron components for use in foundries, and heavy components such as the frame for use as heavy melting stock. The remaining hulk, weighing 1000 to 1500 pounds, is cleaned of combustible or other nonmetallic material by hand stripping or burning and is then converted to scrap by baling, shearing, or shredding.

Traditionally, most auto hulks have been compressed into No. 2 bundles, which yield 85 to 90% iron and contain 0.5% copper, the most troublesome impurity. Another technique is to compress the hulk into a slab and shear it into sections of about 150 pounds each. Since about 1962, the shredding process has been gaining ground rapidly and in 1966 accounted for an estimated 16% of the 6.4 million cars that were consumed as scrap. In this process, the hulk is torn into small fragments by hammer mills, and ferrous material is separated magnetically from nonferrous and nonmagnetic material. The iron yield of shredded scrap ranges up to 97%, and copper content is 0.2% or less. A maximum of 0.15% copper is desirable, and one recent study concludes that that goal can be achieved consistently if the hulk is prepared properly before shredding and the shredder discharge is segregated carefully (7).

Auto scrap processors suffer from the cost of transporting hulks to processing points. They also have faced a generally lower demand for scrap, particularly impure automobile scrap such as No. 2 bundles, owing to the steel industry's adoption of the oxygen-enriched open hearth and the basic oxygen furnace. In addition, for auto hulk incinerators there is no effective smoke-control equipment whose cost can be borne by small auto wreckers and scrap processors (24, 31). Some authorities believe nevertheless that the junk car problem conceivably can be solved in perhaps a decade because of changes in steel-making techniques and the general upgrading of scrapping methods to yield a more salable product.

Research on scrap processing

The Bureau of Mines is seeking new ways to utilize automotive and other ferrous scrap using chemical and metallurgical methods as well as mechanical methods (10). At Salt Lake City, the bureau is working in two complementary areas: dismantling and chemically analyzing selected cars; and developing hydrometallurgical or chemical leaching methods for making clean scrap from cars or the by-products of scrap processing yards. One aim of this work is to develop less costly means of separating autos into light steel components, which could be shredded, and heavy components, which could be cut up and sold as heavy melting stock. Shredding only the light metal would reduce the cost of the required equipment. It might also allow the development of portable shredders that could be moved to rural areas to process auto hulks accumulated there.

A second aim of the work at Salt Lake is a system in which the stripped, incinerated hulk would be partly compacted and then leached with cupric ammonium carbonate or nitric acid to remove residual nonferrous metals. It would then be compacted further and sheared into slabs essentially free of impurities. Rough cost estimates for the process show that a plant handling 25,000 cars per year could produce scrap for $9.30 per ton minimum; at 100,000 cars per year, production cost would be $6.00 per ton. In August 1968, high-quality scrap of the type that would be made by this process was selling for about $25 per ton, and

No. 2 bundles for about $18. Costs other than production costs that would be incurred in using such a process have not been worked out.

In the Mesabi range in Minnesota, the Bureau of Mines had planned to operate a demonstration plant that would have processed a mixture of nonmagnetic taconite and automobile, refrigerator, and other kinds of ferrous scrap. In the process, the mixture is heated to about 1000°C. The iron oxide in the nonmagnetic taconite is reduced to the magnetic form, and the scrap is oxidized at the same time to the magnetic form (26). The discharge from the process is treated magnetically or by flotation to produce a concentrate containing 62% iron or more for use as blast furnace feed. By converting nonmagnetic taconite to the magnetic form, in which it can be converted to blast furnace feed by the normal means, the process would both increase the nation's iron resources and provide a use for scrap. The Bureau of Mines stopped work on the project in 1968 for budgetary reasons, but as of mid-1969 was hoping to resume the work as a joint government-industry effort.

Building blocks. A nonmetallurgical use of auto scrap would be as a core material in light-weight concrete building blocks. Prototype scrap-cored blocks have been made and show promise for use in light commercial buildings, bridge abutments and piers, foundations, and retaining walls. To make the blocks, the hulk is incinerated and the scrap is cut into sections, compressed, and encased in 2 inches of concrete, which is steam cured using the heat from the incineration process. The scrap accounts for more than half the volume of the block.

Vehicle tires

Of the 100 million vehicular tires that are discarded annually in the U.S., about 30% are reclaimed, and the remaining 70 million must be disposed of in some way. One potential method would be to grind up the tires, remove the cord, and incorporate the ground rubber in paving materials such as asphalt to improve such properties as resiliency and life. The use of various forms of rubber, including ground tire tread, in roads has a long history, particularly abroad (45), but it presents certain technical problems. Official specifications in the United Kingdom, for example, point out that the composition of ground tire tread is variable, and that the material is not recommended for use in roads unless its composition can be guaranteed. In this country, the Bureau of Solid Waste Management is supporting an intensive study of solid waste management in the rubber industry, including scrap and reclaim. One objective of the work is to determine whether changes in the distribution of facilities, or new processes or techniques, would improve the market for scrap rubber. Another is to identify all forms of scrap rubber that lend themselves to some form of reuse or that present a disposal problem.

Recommendations: junked automobiles

Recommendation S5: *Efforts by private industry to improve the economics of the auto scrap processing industry should be stimulated. The de-*

velopment of scrapping methods that would permit the use of less costly equipment, and of radically new scrapping methods, should be pursued at all levels. The development of new means of utilizing junked vehicles should also be encouraged and supported, with emphasis on methods of recycling the metals.

INDUSTRIAL SOLID WASTES

Industrial solid wastes differ sharply from municipal solid wastes in that they are much more varied, both chemically and physically. They are more likely to release toxic substances when burned, and their heating values may cover a much wider range. Industry, moreover, recycles large amounts of the materials of production, both in-plant and through the operations of the secondary materials industries. A distinction should be made between scrap, those solid materials that can be recycled at a profit, and solid wastes, those that are beyond the reach of today's technology.

Recycle by industry

The secondary materials industry includes roughly 9000 recognized establishments with total annual sales of more than $5 billion. In 1966, in the U.S., secondary aluminum accounted for about 20% of total consumption, secondary copper for about 42% of consumption, secondary iron and steel for about 45%, and secondary zinc for about 25% (Fig. 4, page 184). The rubber industry in 1966 consumed some 265,000 long tons of reclaimed rubber, or about 12% of total consumption of new rubber of all types. Paper and textiles are among other materials that are recycled in large volume.

Urban renewal, beautification programs, and other factors have been troubling the secondary materials industry in recent years (43), and one of the most difficult problems to be faced is air pollution: from smelters, from the burning of polyethylene and polyvinyl chloride insulation on copper wire, from incineration of auto hulks, and from a range of other sources. The equipment that is available to control such emissions is the same as that used elsewhere in industry. Technical problems exist in applying such equipment to some types of secondary operations, but the major difficulty is often cost. Members of the secondary materials industry have been estimated to have an average plant investment of only $1 million, and for units of that order of size the cost of air pollution control equipment can be burdensome or even prohibitive.

Solid waste disposal by industry

Most industrial solid waste is hauled to private dumps, usually by outside contractors, although some is disposed of by landfilling on the company site and some is burned in the plant and the residue hauled away. But cartage costs are rising, reflecting a growing scarcity of dumping sites and growing regulation of dumping practices, and the time may be coming when companies will find it more economical to burn more of their own solid wastes.

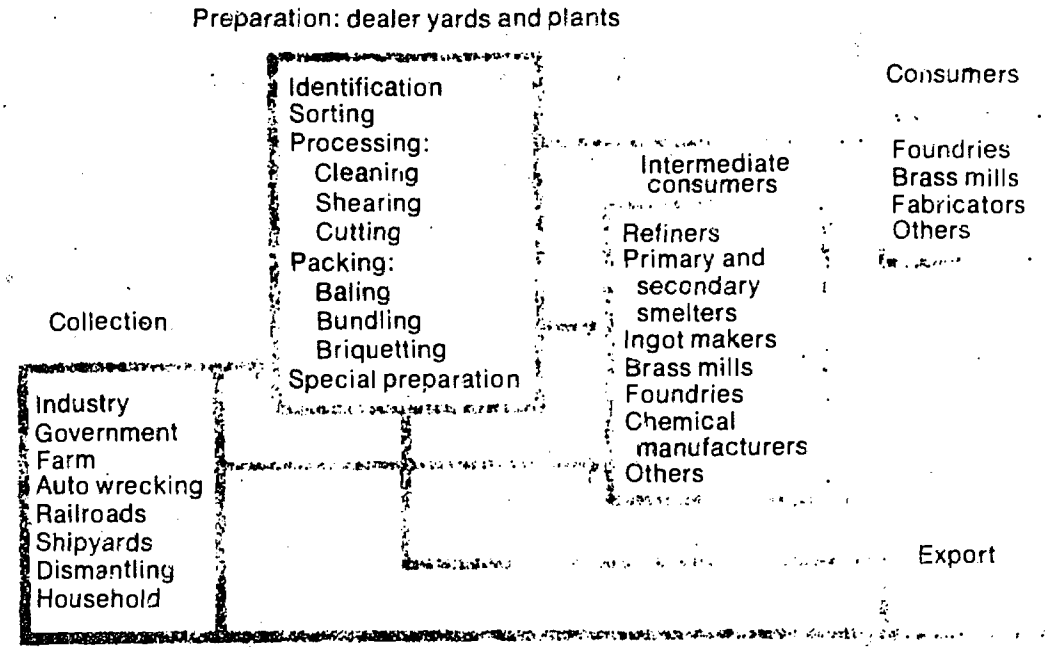

Figure 4

Flow chart of recycled nonferrous scrap metals

Large amounts of the materials of production are recycled via the secondary materials industries. In 1966, secondary aluminum accounted for about 20% of total U.S. consumption, secondary copper for about 42%, and secondary zinc for about 25%. Air pollution is one of the most difficult problems facing the secondary materials industries, partly because of technical problems, partly because of the cost of control equipment.

SOURCE: "A Study of Dislocation Factors: The Secondary Material Industries in a Changing Urban Society," National Association of Secondary Material Industries, New York, N.Y., 1965.

Until the past few years in this country, facilities for burning solid wastes were designed largely to accommodate municipal wastes of relatively low heating value. Design data are thus not extensive for equipment to burn the more refractory, high-heating-value industrial wastes. Designers have had to work with incorrect basic data on the wastes to be burned and have had to design units to operate properly over a wide range of wastes, heating values, degrees of impurity, and rates of disposal. The result sometimes has been equipment that operates at too high a temperature, costs more than it should to maintain, and causes additional pollution problems. More attention is being focused on such difficulties, and data and computational methods are available that can be used to make many of the required combustion calculations. When used with the computer these data and methods have proved to be a very useful design tool (27). Wider use of the computational facilities and thermodynamic data that are already at hand would be a step toward better

incineration. A national survey has been proposed to determine the chemical and physical analyses of industrial wastes in order to provide further data to support the conception and design of devices, including incinerators, for processing them.

Among the novel industrial incinerators that have been developed recently is the open-pit incinerator (39). Since the device has no top, heat can radiate to the sky, and the effect is to limit the temperature inside the unit to a level that causes negligible damage to the refractory lining. All of the air is supplied from above the combustion area through high-velocity nozzles, causing maximum turbulence and recirculation of the gases produced by combustion. The open-pit design has worked well on solids of high heating value and those that tend to melt, such as waxes, nylon, and polyethylene. Emission of particles can be a problem with some wastes, but a steel mesh screen placed on top of the incinerator can be used to reduce such emissions. The open-pit design has been investigated on a pilot-scale for use with municipal refuse. It was found to be inferior to the standard multiple-chamber design in emission of both particles and gaseous pollutants (6).

Heat recovery, central facilities

Industry recovers waste heat from the combustion of some solid wastes, such as bark, bagasse, corn cobs, and spent coffee grounds, but the total represents only a fraction of the energy available in solid industrial wastes. The desirability of recovering such energy, if feasible, and the apparent need for industry to burn more of its own wastes, suggest the use of a central facility to burn all combustible wastes, both solid and otherwise, on a given plant site (20). Air pollution control equipment should be less costly for a single large facility than for several small ones, and labor and other costs might also be lower. Such units would have to burn and recover heat from a variety of wastes: paper, wood, solid and liquid production wastes, waste treatment and production sludges. Automatic conveying, preparation, feeding, firing, and ash removal would be required. Facilities of this kind would often present severe engineering problems and might be difficult to justify economically even for a very large plant. At least one such unit is being designed, however, for a plant in the Northeast, and is scheduled to go into operation in 1970. The steam produced by heat from the combustion of the wastes will be fed into the plant's main steam system.

Recommendations: industrial solid wastes

Recommendation S6: *Efforts to improve the economics of recycle of solid materials by the secondary materials industry should be encouraged. A distinction should be maintained between solid materials that are recycled and those that are true solid wastes.*

Recommendation S7: *Studies should be made of the chemical and physical nature and the volume of industrial solid wastes, insofar as proprie-*

tory problems allow, in order to support the conception and design of equipment, including incinerators, for disposing of them economically.

MINING AND PROCESSING WASTES

Solid wastes from mining and processing are recycled to a degree, but the accumulated national total of such wastes has been estimated at around 21 billion tons, about 2 billion tons higher than in 1965 (47). Annual output by 1980 is expected to reach about 2 billion tons of mine waste, mill tailings, washing plant rejects, processing plant wastes, and smelter slags and rejects. About 60% of these wastes have economic value either for their mineral content or for use as aggregate and for similar structural purposes. About 37% of mining and processing wastes have no known economic value, but are public health and safety hazards, prevent the use of land they occupy for other purposes, or are an esthetic problem. The remaining 3% of mineral wastes are of small volume, have no value, and are remotely located and thus currently constitute no real problem.

Copper mining wastes

The copper mining industry in the western U.S. recovers several hundred tons of copper daily from mining wastes that are produced in volumes of several hundred thousand tons daily (18). In the process, the industry uses about 250,000 tons per year of incinerated or burned auto hulks and about 50,000 tons of detinned tin plate scrap.

To recover copper, dilute sulfuric acid is percolated through the waste dumps until it has dissolved equilibrium concentrations of copper and other soluble material. The leach liquor is then run through equipment that contains the scrap iron, producing iron (ferrous) sulfate and precipitating the copper, which is recovered by filtration. The volume of leach liquor available from this process at Bingham Canyon, Utah, is approaching 50 million gallons per day, and it has been found to contain 4 to 10 ppm of uranium, a slightly higher level of the metallic element yttrium, and 5000 to 10,000 parts per million of aluminum. Research has found that about 2 tons per day of uranium oxide may be recovered from the liquor by ion exchange, and calculated costs are lower than for any uranium extraction process used today. This work has shown also that the yttrium and aluminum may be recovered, and research on all three recovery processes was moving into the pilot plant stage in mid-1968.

Bauxite processing wastes

More than 5 million tons of red mud are produced annually in this country by plants that convert bauxite into aluminum oxide, from which aluminum is made electrolytically. The composition of red mud varies with the source of the bauxite and the processing method, but a typical analysis shows it to include about 20% aluminum oxide, 49% iron (ferric) oxide, and lesser amounts of oxides of silicon, calcium, sodium, titanium, phosphorus, and sulfur. Red mud also contains traces of a number of other elements.

Red muds have been investigated for use as thermal insulation, as an additive to concrete, and in such products as Portland cement and slag wool. Some such products have reached the commercial stage, but no consistent outlet has attained the scale at which it could consume the amount of red mud that is produced. One new approach that shows promise is to convert red mud slurries into porous structural blocks by a foaming process (46) Economic studies suggest a potential market of more than 1 million tons per year, enough to consume the annual red mud output of a large bauxite refining plant. The process is being pursued further with an aluminum company.

Phosphate mining wastes

A mineral waste problem that awaits improved solutions is the disposal and utilization of the colloidal clay wastes or slimes produced in phosphate mining operations in Florida (8). The slimes leave the processing plant containing 4 or 5% solids in water and about one third of the total phosphate mined (measured as bone phosphate of lime equivalent). Currently the slimes are pumped to huge settling ponds and, as the solids settle, clear water is drawn from the top of the ponds and returned to the process. The solids settle very slowly, and after years of settling the slimes may still have been concentrated to no more than 30% solids. The settling properties of the slimes thus impede the reclamation of land occupied by the ponds, and there is furthermore no economical means of recovering the phosphate in the slimes. The phosphate industry and others have expended considerable effort seeking means of improving the settling of slimes and of using them in some way or recovering the phosphate they contain. These efforts to date have not achieved significant success.

Recommendations: mining and processing wastes

Recommendation S8: *Research and development on processes for recovering various minerals from mining and processing wastes should be maintained at an adequate level against the day when changing economics warrant the recovery of such minerals. Work on other means of utilizing or disposing of these wastes should also be maintained at a steady level.*

EFFECTS OF SOLID WASTES

Among the obvious effects of solid wastes are the esthetics problem and the air and water pollution caused by unsatisfactory means of disposal. Solid wastes can prevent or control the use of the land they occupy and diminish the value of nearby land. They contain useful materials and energy, although in a form that makes their recovery by the available technology uneconomic in most cases today.

The scientific literature does not contain the data required to support quantitative estimates of direct relationships between solid wastes and disease. A thorough study of the literature (39) concluded among other

things that "It should not be surprising that so much opinion and so little data were discovered. . . ." The relationships are complex, disease pathways are obscure, reliable methods of study are scarce. The study concluded also that the circumstantial and epidemiological data support the conclusion that a relationship exists, although it is not well defined.

Flies are known carriers of disease, and they breed in large numbers in many types of solid wastes. A direct relationship between solid wastes and fly-borne disease in the U.S. has not been established, although the available knowledge of the dynamics of disease transmission, and related factors, can allow the conclusion to be reached that control of solid wastes can contribute to the prevention of fly-borne disease. Solid wastes appear not to be important in the transmission of disease by mosquitoes in the U.S. Very few cases of rodent-borne human diseases are being reported in this country, and the relationship of such diseases to solid wastes and their rodent population cannot be estimated. Evidence does exist that workers engaged in solid waste handling experience relatively high accident frequency rates, although definitive data are scarce. The occupation may be intrinsically hazardous, and there is in addition good reason to believe that some of the high accident rates that have been reported are due largely to poor or nonexistent safety programs.

Recommendations: effects of solid wastes

Recommendation S9: *The effort to upgrade solid wastes management, utilization, and disposal should be justified on the basis of esthetic values and control of air and water pollution.*

*Reprinted from Cleaning Our Environment: The Chemical Basis for Action (Washington: American Chemical Society) 1969. Complete copies of this valuable report, which also deals with air and water pollution and pesticides in the environment, can be obtained for $2.75 from:

American Chemical Society
Special Issues Sales
1155 Sixteenth Street, N.W.
Washington, D.C.

Availability has been a major criteria in selecting materials for inclusion in this series of packets and we were pleased to discover that much of the literature on municipal solid waste management is easily accessible, frequently at no cost.

All of the government reports included here should be available through the Regional Government Library in your Congressional district. Should you wish to obtain personal copies of the government materials reviewed here, there are three main sources:

1. The United States Government Printing Office. Orders may be sent by mail or, for quicker service, phoned in to the Order Desk. The mailing address is:

   Superintendent of Documents
   U.S. Government Printing Office
   Washington, D.C. 20402

   The phone number for the Order Desk is (202) 783-3238. Give as complete a reference as possible when ordering and enclose payment.

2. Congressional Committees. Several of the hearings documents included here were printed solely for distribution by the Committee concerned and are not available through the US GPO. Requests for these documents should be addressed to the Committee noted under "author" in the write-up.

3. Environmental Protection Agency (BSWMP). Entries noted under "publisher" in the write-ups as belonging to the Bureau of Solid Waste Management Publications (BSWMP) series are available free of charge from the EPA. Orders, limited to ten titles at a time, should be addressed to:

   Solid Waste Educational Materials Control Section
   U.S. Environmental Protection Agency
   Cincinnati, Ohio 45268

   The BSWMP Order Number should be included for each item requested. A full listing of documents available through this service is provided in Solid Waste Management: Available Information Materials (See Reference 1 in Appendix A).

Finally, should you have difficulty in obtaining copies of government reports, the Congressman for your district should be able to offer assistance.

1. BASIC GENERAL REFERENCES

1. RESOURCE RECOVERY ACT OF 1969

Author: Hearings Before the Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate, Ninety-first Congress, 1969 and 1970.

Publisher: USGPO, Washington, D.C. Parts 1 and 2, out of print (available through your Regional Government Library). Part 3 ($1.75), Part 4 ($1.25) and Part 5 ($1.75) available from the Superintendant of Documents, (Washington: USGPO), 1970.

Level: Popular, for the most part, with some semi-technical documents submitted for the record.

Summary: As is frequently the case with government hearings on a topic of national interest, these five volumes on solid waste disposal provide a convenient assimilation of some of the most useful documents in the literature. While most of the hearings took place in Washington and reflect the national scope of the problem, "on-site" sessions were held in four urban areas (Boston, Jacksonville, Detroit and San Francisco) in an effort to explore local problems.

Part I records testimony taken in Washington, Boston and Jacksonville and touches on several aspects of solid waste management and policy. Several interesting documents are included here: "Environmental Hazards: Urban Solid Waste Management", by Melvin First; the final report of an MIT "Summer Study on the Management of Solid Wastes", which deals on a technical level with incineration, pyrolysis, the hydrogenation of paper, and glass systems; "Availability, Utilization and Salvage of Industrial Materials", which provides a brief summary of factors affecting reuse and recycling; and "Towards a National Materials Policy", a report prepared by the Library of Congress Legislative Reference Service. A one-page fold-out diagram showing the involvement of the various Federal agencies in the national solid waste program is appended.

Most of the hearing testimony given by Federal agency representatives is included in Part 2 of the Hearings, and some rather revealing objections to the Resource Recovery Act are raised in their testimony. Again, there is no set order as to issues under discussion, but most of the major refuse problems crop up at least once for comment. There is particular emphasis here on the problems of scrap metal recovery and motor vehicle abandonment, most of it resulting from a one day Hearing held in Detroit. Three particularly important summary articles are excerpted in this volume: the "Eliassen Report" (see Ref. I-3); "Environmental Pollution" (Ayres and Kneese, 1968); and "Policies for Solid Waste Management" (see Ref. II-2). In addition, several specific waste problems not covered in this packet are discussed at some length: disposal of radioactive wastes (pp. 1029-1170), ocean dumping (pp. 1016-1028), hospital generated wastes (pp. 1269-1337) and military wastes (pp. 999-1013).

While Part 3 focuses initially on health related aspects of solid waste management, the bulk of the material here deals with metals recovery and the junked automobile dilemna. The testimony of Dr. Landsberg, of Resources for the Future, and that of Dr. Frey, of the National Academy of Sciences, deals with some of the fundamental policy questions affecting resource recovery and materials management. Dr. Frey's testimony provides a brief summary of an influential 1966 NAS study (Ref. I-4) which is included in its entirety, as is a useful policy document, "Research and Development for Better Solid Waste Management" (Ref. II-3). Technical and economic problems bearing on metals recovery are discussed by representatives of the Automobile Manufacturer's Association and the Reynolds Metal Company and several interesting papers on that topic are included. Some of the more useful are: "General Motor's Efforts in Junk Car Processing", "Materials Recovery and Reuse as an Approach to Solid Waste Management" and "Protecting Our Environment and Natural Resources in the 1970's." Some interesting data on materials consumption (in particular, paper and plastics) is appended to this volume.

1. RESOURCE RECOVERY ACT OF 1969 (cont'd.)

Testimony in Part 4 ranges over the technical and economic problems involved in paper recycling, in waste management in the food industry and related agricultural operations, and in the labor considerations associated with solid waste collection and transportation (see, in particular, "Personnel Safety in Solid Waste Management"). Sanitary landfills are dealt with at some length and two government documents on the topic are included: "Sanitary Landfill Operation Agreement" and "Recommended Standards for Sanitary Landfill Operations."

Several industry spokesmen discuss the problem of waste associated with mining operations (a very substantial part of the national problem) and the report, "Perspectives in the Secondary Materials Industry" is reproduced here.

The last volume, Part 5, contains testimony taken in Washington and in San Francisco. Much of it is concerned with the issue of ocean dumping and interesting data is provided on the New York Bight area and on the San Francisco Bay. Again, testimony on other issues weaves in and out of this central theme, so that glass disposal is covered rather thoroughly (pp. 2207-2214) and a particularly good and now out-of-print reference on plastics disposal, "Report on the Role of Plastics in Solid Wastes," has been reprinted here. In short, these five volumes are the stuff from which "instant experts" are made.

2. WASTE MANAGEMENT RESEARCH AND ENVIRONMENTAL QUALITY MANAGEMENT

Author: Hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works, U.S. Senate, Ninetieth Congress, Second Session, 1968.

Publisher: USGPO, Washington, D.C., 1968 (450 pp.; Not for Sale: Free upon request from the Committee on Public Works).

Point of View: "These hearings are intended to provide an initial look at current Federal research activities in waste management research. Testimony has been requested within a framework which emphasizes concepts of environmental quality management and the role of the Federal government in the development of control technology adequate to insure the implementation of pollution control legislation."

Level: Popular, for the most part; some semi-technical papers included.

Summary: The focus of these hearings is on the need to establish an environmental quality policy at the Federal level and to provide Federal support to research activities and strategies in air pollution control, water pollution control, and solid waste management. Testimony is presented from a variety of government agency representatives (AEC, OST, NAPCA, National Center for Urban and Industrial Waste, and the DOD Environmental Pollution Control Committee, etc.) spokesmen for the National Academy of Sciences, two well-known university professors (R. Buckminster Fuller and Rolf Eliassen) and Russell E. Train, then President of the Conservation Foundation. Taken together, their testimony provides an interesting overview of the technological, social, and managerial problems posed by the solid waste management issue and a useful summary of the Federal government's role in on-going programs and projects. Recycling and incineration are discussed at some length, as are the problems involved in locating and operating sanitary landfills and in affecting the role which packaging plays in solid waste production. Data on the national scale of the solid waste problem is scattered throughout the hearings, as are specific examples of local, mostly urban, facilities which have experienced either marked success or failure in managing solid wastes. Several government documents appear in the appendices to this hearing, including abstracts on solid waste demonstration projects funded by HEW under the 1965 Solid Waste Disposal Act, a table of state-interstate solid waste planning grants, and summaries of the Federal Research and Planning Grants in Solid Waste Disposal. This is as necessary reference for anyone seeking information on the Federal role in solid waste management, and an interesting one because of its detailed accounts of local experience and experiment.

3. SOLID WASTE MANAGEMENT: A COMPREHENSIVE ASSESSMENT OF SOLID WASTE PROBLEMS, PRACTICES AND NEEDS

Author: Prepared for the Office of Science and Technology (OST) by an ad hoc group of representatives from interested Federal agencies under the chairmanship of Rolf Eliassen, Prof. of Environmental Engineering, Stanford University.

Publisher: USGPO, Washington, D.C. May 1969 (110 pp.; $1.25).

Point of View: "This report was commissioned by the Director of the OST to provide a technical analysis that would be useful in responding to the Presidential directive ... to undertake a comprehensive review of solid waste disposal technology."

Summary: Frequently referred to as "the Eliassen Report", this document broadly surveys the entire waste management field and is a useful resource for anyone seeking a concise statement of the problems involved in solid waste management. Originally conceived as a background document for the Council on Environmental Quality, it is strongly oriented toward consideration of the government's role in dealing with the solid waste problem.

Part I, "Statement of the Solid Waste Problem", includes a brief look at several aspects which impinge on the problem (public health and ecology, natural resources, economics, technology, politics and administration) and a rather lengthy treatment of the sources of solid waste. A paragraph or two is focused on each of several sources: urban, residential, commercial, industrial (food processing, chemical, drug, rubber, automobile and household appliances), agricultural, mineral, and federal (mostly military-generated wastes). Background data, much of it from the 1968 National Survey of Solid Waste Practices (Ref. I-5), is provided in several graphs, tables and diagrams.

Part II, "Management of Solid Wastes", focuses on the problems of collection and transport, processing, and disposal (incineration, composting, utilization and salvage). Specific wastes and new technologies are discussed under each heading. The remainder of the report is concerned with the role the federal government might take in meeting the needs of solid waste management. Part III, "Current Federal Support of Solid Waste Research, Development and Demonstration", reviews several experimental programs and provides data on the scope of federal involvement prior to 1970. Part IV, "Interagency Responsibilities", is a brief policy statement calling for increased cooperation between agencies of the federal government in the formation of a national solid wastes R and D program. The last two sections provide an analysis of the proposed federal role and detail specific recommendations of the sorts of programs and research which the government might profitably support.

4. WASTE MANAGEMENT AND CONTROL

Author: A report to the Federal Council for Science and Technology prepared by the Committee on Pollution, National Academy of Sciences - National Research Council, under the chairmanship of Athelstan Spilhaus, University of Minnesota.

Publisher: Publication 1400, National Academy of Sciences, National Research Council, Washington, D.C., 1966. Copies available from: Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418 (257 pp.; $4.95).

Point of View: "The principal objective of the report is to set forth the nature of the pollution problem - descriptively, qualitatively, and comprehensively - in a useful perspective. It represents an effort to determine areas in which science and technology could effectively assist in reducing and controlling pollution."

Level: Non-technical; descriptive.

Summary: Published in 1966, this report of a two-year study into pollution, its origins, nature, effects, and potential constraints and controls, has become a classic reference in environmental literature. Its emphasis is on the complexity of the interactions among the many forms of pollution generated by man. To quote from the foreward to the report:

> [This report] details the interactions among the forms of pollution generated by man, the interactions between the polluted atmosphere, waters, and soils, which in turn affect living systems - the plants and animals that ingest them - and identifies and traces their origins, their movements, and their places of final deposit. It identifies the

4. WASTE MANAGEMENT AND CONTROL (cont'd.)

> geographic, social and economic factors that relate to the problem ... It further identifies a first strategy or framework, and priorities within that framework, that will allow a more coordinated attack and ... more efficient and economical means of dealing with the pollution problem ...

Structurally, the report is divided into an introductory summary report, and a section of eight appendices, each dealing with a separate facet of the pollution problem: 1) Pollution Processes in Ecosystems; 2) Criteria, Instrumentation and Monitoring; 3) The Transport System; 4) The Residue Situation - Current and Future; 5) Pollution - Abatement Technology; 6) Legal and Public Administration Aspects; 7) Public Policy and Institutional Arrangements; and 8) A Brief Analysis of Pollution in the Delaware Estuary. In three of these appendices, particular attention is focused on solid waste problems. Appendix 2 (pp. 83-88) deals with incineration problems and sanitary landfills, and contains a summary of the magnitude of community solid wastes and the problems encountered in dealing with them. Appendix 4 contains a discussion of the rate of growth of per capita refuse production and the need for recycling and reclamation (pp. 131-132), examination of the legislative and administrative controls which govern the land environment (pp. 148-150), and a set of conclusions summarizing the Committee's findings relative to the land environment (pp. 176-177). Finally, appendix 5 provides a brief look at the costs and technologies involved in various solid waste practices (pp. 196-199).

It is, however, an injustice to the report and to its thematic focus on the complex interactions of one form of pollution with another to extract only those sections which deal specifically with solid waste management. This is an extremely valuable document and one which should be read in its entirety as a basic reference to all the various forms of pollution. While students might find the appendices difficult reading, the initial summary section provides a helpful guide to the materials contained there and also presents the Committee's general recommendations as to programs which might be initiated as a first step toward "lowering the barriers that now inhibit the development of needed new technology and more effective and flexible institutional relationships." In summary, there is a wealth of information here which will provide a good introduction, not only to the problems of solid waste in the environment, but to the overall impact of pollution on the ecosystem.

5. 1968 NATIONAL SURVEY OF COMMUNITY SOLID WASTE PRACTICES

Authors: A.J. Muhich, A.J. Klee, and C.R. Hempel, Bureau of Solid Waste Management.

Publisher: Public Health Service Publication No. 1866 (Washington: USGPO) 1969. (Nine volumes; OSWMP Order Nos. 216-218).

Point of View: Presentation of data.

Level: Non-technical; there is no analysis here, just data print-out.

Summary: This survey represents the first attempt to compile and report solid waste information uniformly on a national basis. It consists of nine volumes, each presenting data on a specific geographic region. Information is presented on the types and amounts of solid waste collected, their disposition, and the resources (manpower, equipment, facilities, monies, etc.) required to carry out collection, reduction, and disposal activities. In addition to the inventory data on some 6300 communities (representing 46% of the US population), evaluations of existing reduction and disposal facilities (6000 land disposal sites and 450 facilities) are also provided. This is, to date, the most comprehensive source for data on community solid waste practices and runs to more than two thousand pages of computer print-out. It is useful to supplement this presentation with the statistical analysis papers which have been developed by the Bureau from this data (see Refs. I-6 and I-7).

6. PRELIMINARY DATA ANALYSIS: 1968 NATIONAL SURVEY OF COMMUNITY SOLID WASTE PRACTICES

Authors: Anton J. Muhich, Albert J. Klee and Paul W. Britton, Consumer Protection and Environmental Health Service, Environmental Control Administration, Solid Wastes Program.

Publisher: Public Health Service Publication No. 1867 (Washington: USGPO) 1968 (483 pp.; OSWMP Order No. 28).

Point of View: "Since the raw data is voluminous and requires basic statistical reduction to summarize it in a convenient and useful form, additional processing was performed on the ... computer to produce this report."

Level: Non-technical; simple presentation of data.

Summary: Of the three National Survey references noted here, this is by far the most useful and manageable. Some explanation as to the methodology of the Survey, the recording and processing of the data, sample size and the reliability of the data is provided in an introductory section. Sample questionaires are also included. Analysis of the response to each question is provided in terms of percent response, sample size, total, mean, standard deviation, 1967 population responding, and mean per thousand. Two main breakdowns are provided: national analyses are presented for community data, land disposal sites, and facilities; regional analyses are given for the community data and the land disposal sites. In addition, an urban-rural comparison is provided for the community data and all the data on incinerators is compiled and separately presented at the end of the report.

7. AN INTERIM REPORT: 1968 NATIONAL SURVEY OF COMMUNITY SOLID WASTE PRACTICES

Authors: Ralph J. Black, Deputy Chief; Anton J. Muhich, Chief, Systems and Operations Planning; Albert J. Klee, Chief, Operational Analysis, System and Operations Planning; H. Lanier Hickman, Jr., Chief, Technical Services; and Richard D. Vaughan, Chief, Solid Wastes Program, US Dept. of HEW.

Publisher: Papers presented at the 1968 Annual Meeting of the Institute for Solid Wastes of the American Public Works Association, Miami Beach, Florida, October 24, 1968 (Washington: USGPO) 1968 (55 pp.; OSWMP Order No. 26).

Point of View: " ... it must be concluded from examination of the 1968 National Survey data that present collection and disposal systems in this country are not really adequate."

Level: Popular; data displayed in charts and graphs.

Summary: These five talks, each prepared by a Federal Solid Wastes Program administrator, provide a popular summary of the major trends isolated in the 1968 National Survey. Topics addressed are: The Foundation Provided by the National Data, The Role of Facilities and Land Disposal Sites, The Challenge that the National Survey Presents, and National Solid Waste Survey: Report Summary and Interpretation. Several interesting numbers surface here: per capita waste production at 5.32 pounds per day; only 6% of the 6,000 sanitary landfill sites reported qualifying as "Sanitary"; 94% of all land disposal sites being utilized are characterized as "unacceptable" and "presenting disease potential"; an annual national solid waste expenditure of $4.5 billion per year, etc. In short, while this is the least complete and most descriptive of the Survey references noted here, it is perhaps the best source for quick access to summary and overview data.

8. SOLID WASTES

Author: Several; compilation of articles.

Publisher: An Environmental Science and Technology reprint book. Copies available from: Special Issue Sales, American Chemical Society, 1155 16th St., N.W., Washington, D.C., 20036 (87 pp.; $2.00).

8. SOLID WASTES (cont'd.)

Point of View: "This book contains 25 articles that originally appeared in Environmental Science and Technology from 1967 through March 1971. We believe that it covers all the major aspects of what has become a serious and in some ways intractable social problem."

Level: Popular; illustrated; diagrams, graphs and charts included.

Summary: ES and T consistently runs excellent short articles on current environmental topics and this compilation should, as the editor notes, "be helpful to teachers, students, and everyone who needs to be brought up to date in a hurry." The articles reprinted here are organized under six main headings (Overview, Government, Specific Solids, Mining, Sewage Sludge, and Technology) and, as can be expected from the magazine's orientation, the bulk of them are concerned with reviewing existing and evolving solid waste technology. There's something here on each of the most glaring solid waste problems, however, with particulary good presentations on auto scrap ("Auto Hulk Disposal"), packaging problems ("Throwaway Packages - A Mixed Blessing"; "Waste Recycling Really Works"), Incineration (several), and developing processing, disposal, and recycling technologies. This is not a complete "general" reference in itself as there are several important topics omitted (economics, legislation, collection and transportation, sanitary landfills, land composting), but it does provide a good, popular level introduction to the solid waste problem and one which might be particulary appropriate for a "non-specialist" audience.

9. WHAT'S AHEAD IN SOLID WASTE MANAGEMENT

Author: Several. This is a special single-topic issue with articles contributed by sixteen members of the Batelle Columbus Laboratories professional stafi.

Publisher: Batelle Research Outlook 3(3):3-29, 1971.

Point of View: "If this country is to sustain a reasonably esthetic environment, minimize health hazards, and conserve natural resources, this solid waste must be collected, processed, reclaimed, if possible, and ultimately returned to the environment in an intelligent manner."

Level: Popular; several graphs, diagrams and illustrations included.

Summary: This is a very readable summary covering six aspects of the solid waste problem: "Where Does It All Come From?", "Where is it All Going?", "Collection is the Key", "Emerging Technologies for Municipal Solid Waste", "Reclamation and Recycling: An Economic Overview", and "People and the Solid Waste Problem." No one topic is covered in much detail, but some of the most pertinent data from various government reports and statistical surveys is presented here and the general reader can at least get a good idea of the size of the problem and of the technical and managerial problems which complicate it.

"Where Does It All Come From" sets municipal solid waste in the context of the total solid wastes generated annually and briefly reviews some of the data on agricultural, mining and industrial wastes which, taken together, represent 90% of the solid wastes produced. As a rationale for focusing on municipal wastes, the authors note its visibility and several of the special problems associated with it.

"Where Is It All Going?" looks briefly at the various modes of refuse disposal (open dumps, sanitary landfills, incineration, and composting) and reviews the prospects and current practices associated with efforts to reclaim materials from waste. The third article, "Collection is the Key", is a particulary welcome one, partly because few popular level articles are written on this aspect, but more importantly because much of the relevant data from the National Survey (Ref. I-5) is summarized here. Also of interest is a scheme suggested here for applying a regional approach to collection systems.

The problems and potential of solid waste reclamation and reuse are discussed in "Emerging Technologies for Municipal Solid Waste." Several new

9. WHAT'S AHEAD IN SOLID WASTE MANAGEMENT (cont'd.)

developments in separation, size reduction, incinerator design, pyrolysis technology, composting, and fly ash utilization are examined. The pros and cons of sanitary landfills are summarized in "Returning Waste to the Land", and the final section examines the limits of technology in "solving" problems.

"Reclamation and Recycling: An Economic Overview" examines the practical maximum extent of recycling allowable when considerations of cost, environmental improvement, availability of resources, energy use, etc., are factored into the cost-benefit equation. Current practice in recycling is looked at along with some of the incentives and obstacles which affect its impact. Several criteria for recycling systems are suggested and "What's Ahead", the final section, focuses on two observable trends: Recycling will increase and social motivation for recycling will become more important relative to economic motivation.

The last article in the series, "People and the Solid Waste Problem", assesses the importance of human perception and attitudes in finding workable solutions to the solid waste problem. Several human factors that contribute to the problem are isolated and discussed: the "quick and easy culture", "out of sight, out of mind", "grit vs. glamour", "the myth of the virgin", "how gross the National Product", etc. The authors conclude by recommending that a public survey be taken to assess citizen attitudes toward solid waste and associated environmental problems. The sensitivity to environmental issues evidenced in all the articles here and the general tone and level of the writing combine to make this a particularly good reference for students or for a "general public" audience.

II. SOLID WASTE MANAGEMENT POLICY

1. RESOURCE RECOVERY ACT OF 1970: REPORT OF THE COMMITTEE ON PUBLIC WORKS

Author: Prepared by the Committee on Public Works, US Senate, to accompany S.2005.

Publisher: Report No. 91-1034 (Washington: USGPO), 1970. (41 pp.; Not for sale; free upon request from Committee on Public Works).

Point of View: "This legislation (Resource Recovery Act of 1970) is designed to develop systems which will change the present method of dealing with solid waste problems of communities, of farms, and of industries. The intent of this bill is to stimulate the development of resource recovery methods which will provide for more economic use of wastes."

Level: Non-technical.

Summary: When the Senate bill proposing the Resource Recovery Act of 1970 was submitted for consideration, this brief report was sent along with it as a rationale for the new legislation. While its main function was to gather support for the proposed Bill, in the process it manages to provide a useful analysis of the provisions and restrictions of previous legislation (the 1965 Solid Waste Disposal Act) and a brief delineation of the advantages of the proposed replacement. There are three "Titles" in the 1970 Act, and provisions under each are discussed separately. Title I, "Resource Recovery", is explained as containing provisions directed toward new research initiatives, expanded planning and training grant allotments, compliance of Federal agencies with the conditions of existing waste disposal statutes, and authorization for a "National Disposal Site Study" to "report and plan for the creation of a system of national disposal sites for the storage and disposal of hazardous wastes. The discussion of Title II presents the case for a "National Materials Policy Act" which would create a commission to "examine the broad subject of materials selection, treatment and use." Finally, Title III, "Resource Recovery Investigations", is described as legislation "designed to place special emphasis on the policy implications of a change from disposal to resource recovery." Although brief and necessarily biased, this is an invaluable guide, both to existing legislation governing national solid wastes policy and to the magnitude and the orientation of the Federal government's commitments in this area.

2. POLICIES FOR SOLID WASTE MANAGEMENT

Author: Prepared under a grant from the Bureau of Solid Waste Management by an ad hoc Committee on Solid Waste Management, Committee on Pollution Abatement and Control, Division of Engineering, National Research Council, National Academy of Engineering, National Academy of Sciences.

Publisher: National Academy of Sciences, Washington, D.C., 1969. (Reprinted in Ref. I-1, Part 3, pp. 1541-1614).

Point of View: " ... the principal solutions to solid waste management lie in providing operational systems that employ physical procedures rather than in regulation. Such handling, along with reclamation and reuse, as the solid waste management goal, offers the ultimate solution."

Level: Non-technical.

Summary: This is essentially a follow-up report which extends the 1966 NAS-NRC study "Waste Management and Control" (Ref. I-4) and seeks to blueprint the specific investigations and engineering activities which a coordinated attack on solid waste pollution would entail. There are six sections to the report: Introduction, Solid Waste as an Environmental Problem, Evaluation of Waste Management and Control, The Future, Priorities and Recommendations, and Recommended Funding Levels. Three appendices provide information on two on-going solid waste studies and a brief bibliography. A "Summary and Conclusion" section, which prefaces the body of the report, outlines the approach which the Committee used and states the four principal objectives which guided the study: 1) To improve the quality and coverage of the service; 2) To improve efficiency of operation

2. POLICIES FOR SOLID WASTE MANAGEMENT (cont'd.)

through increased mechanization and reduced labor requirements of the system; 3) To reduce the accident rate and improve the skills of operating personnel through manpower development programs; and 4) To economically recover and adequately process for recycle increasing portions of the solid waste stream. Various subsystems within the solid waste management area are then examined in some detail, including collection, transportation, processing (including incineration and separation) salvage and disposal.

The Committee notes the need for new technology and management concepts at all levels and recommends the initiation of a strong federal program which would disseminate information, encourage and support research, provide demonstration systems, and develop funding systems, personnel training programs, etc. The final section of the report, directed to the Bureau of Solid Waste Management, recommends suggested funding levels and types of programs to be funded.

3. R AND D FOR BETTER SOLID WASTE MANAGEMENT

Authors: Andrew W. Breidenback, Director, Division of Research and Development and Richard W. Eldredge, Director, Office of Program Development, Bureau of Solid Waste Management.

Publisher: Bioscience 19: 984-988, November 11, 1969. (Reprinted in Ref. I-1, Vol. III, pp. 1616-1620).

Point of View: "We believe that R and D efforts for better solid waste management need to be organized so as to attack the problem in segments that would form the basis for a research and development matrix."

Level: Non-technical.

Summary: This is a brief but useful introduction to the strategy underlying the national R and D program operating under authority of the 1965 Solid Waste Disposal Act. The legislative authority of the Act is outlined and a description provided of the role of each of the Federal agencies involved. As a guide to the strategy behind the Federal program, a "Research and Development Matrix" is provided along with a brief discussion of the problems associated with each of its six segments: Source Reduction, Storage, Collection and Transport, Volume Reduction Processing, Land and Sea Disposal, and Recycle, Salvage and Utilization. Under "Research Services", the authors note several basic questions which impinge on each of these areas: what are the characteristics of solid waste, what are the potential health hazards associated with a given solid waste system, etc. The remainder of the paper focuses on the four methods of accomplishing R and D that can be employed under authority of the Act: inhouse effort, contract effort, research grant contributions and demonstration grant activities. Several examples of on-going efforts under each category are described.

4. PROGRAMS IN SOLID WASTE MANAGEMENT AND NEEDED DEVELOPMENT

Author: Louis W. Lefke, Chief, Research Grants Section, Bureau of Solid Waste Management, US Public Health Service, Dept. of HEW.

Publisher: A paper in Proceedings of the 8th Annual Environmental and Water Resources Engineering Conference, June 5-6, 1969, Nashville, Tennessee, Technical Report No. 20, Vanderbilt University. Reprinted by HEW (Cincinnati: BSWM) 1970 (16 pp.; OSWMP Order No. 116).

Point of View: "The solid waste problem won't go away. It can't be flushed down the stream for someone else to be concerned about; it can't be belched out of a stack for dispersion over the next county. But, it can be managed so that it will not degrade our environment, endanger our health, or drain our natural resources."

Level: Non-technical.

4. PROGRESS IN SOLID WASTE MANAGEMENT AND NEEDED DEVELOPMENT (cont'd.)

Summary: Delivered prior to passage of the Resource Recovery Act of 1970, this is in some ways a dated paper. It does, however, summarize both the impact of the 1965 Solid Waste Disposal Act and several of the more successful programs funded under that original legislation. The R and D matrix developed by the Bureau (see Ref. II-3) is described in terms of the research grants awarded under each of the matrix segments and the level of progress in each area is briefly evaluated.

5. INITIATING A NATIONAL EFFORT TO IMPROVE SOLID WASTE MANAGEMENT

Author: Prepared under authority of Richard D. Vaughan, Deputy Assistant Administrator, for Solid Waste Management, US Dept. of HEW.

Publisher: An environmental protection publication in the solid waste management series (SW-14), US Environmental Protection Agency (Cincinnati: US EPA) 1971 (107 pp.; OSWMP Order No. 260).

Point of View: "This document is a report on accomplishments made by the Department (HEW) in its responsibilities under the Solid Waste Disposal Act of 1965."

Level: Non-technical.

Summary: Much of this report is concerned with documenting those activities in solid waste management which were supported by HEW grants between 1966 and 1970. Demonstration, research, and technical activities are discussed separately in terms of the scope, investment, and results associated with each of the programs supported in that category. Other sections deal with the organizational background of the solid waste program effort and provide a history of the Federal government involvement in the solid waste field. For the reader who concludes from all this that, despite the expenditure of $80 million, we are still far from "new frontiers" in solid waste technology, the report offers a final, conciliatory note:

> Although much has been accomplished since passage of the 1965 Solid Waste Disposal Act, the Bureau has long felt severe constraints imposed by budget and personnel limitations as it has been in the position of competing for limited resources with widely disparate programs of the Dept. of HEW. In an effort to make the most of inadequate resources, the Bureau has had to allocate much of its time and money to "putting out fires" -- to the refinement of proven techniques with immediate application -- and has devoted less time than it would wish to the exploration of new or undeveloped concepts, such as recycling and reuse ... The Bureau anticipates that placement in the US Environmental Protection Agency will provide a stability that has been lacking heretofore ..."

It is interesting to compare this evaluation with the statements from Mr. Hale, the new Deputy Assistant Administrator, as recorded in his 1972 interview with an ES and T (see Ref. II-6) reporter.

6. FEDERAL REDIRECTIONS IN SOLID WASTE

Author: Interview with Samuel Hale, Jr., Deputy Assistant Administrator of the Environmental Protection Agency, US Dept. of HEW.

Publisher: Environmental Science and Technology 6: 318-320, April, 1972.

Point of View: "We are undertaking a major redirection of our solid waste management activities. Between now and June 1973, we will be concentrating our energies primarily on taking what we know now and using that knowledge to get improvement now in local solid waste management practices, to demonstrate that many of the solutions already are well in hand and can be readily adopted at the local level without substantial federal financial assistance."

Level: Popular.

6. FEDERAL REDIRECTIONS IN SOLID WASTE (cont'd.)

Summary: This is a brief and optimistic evaluation of the potential federal impact on solid waste problems over the next fifteen months. Hale first deals with the realities of this year's reduced appropriations for EPA's solid waste program, maintaining that the reductions are not too serious as they will be supplemented with leftover monies from previous years. Perceived barriers to the adoption of progressive solid waste practices are discussed and Hale emphasizes the government's main concern, which is now resource recovery. Several on-going reclamation demonstration projects are briefly described and the EPA's major program thrust over the next few months is outlined. Particular emphasis is placed on the importance of Section 205 of the Resource Recovery Act which deals with product design and consumption behavior, two areas which, in Hale's words, describe "where the action is."

CROSS REFERENCES

1. Waste Management and Control (Ref. I-4), pp. 15-18, 24-27 and 203-235.
2. Solid Waste Management: A Comprehensive Assessment of Solid Waste Problems, Practices and Needs (Ref. I-3), pp. 73-111.
3. Solid Waste Management Act of 1972 (Ref. IV-1), Recommended legislation and policy pertaining to packaging materials.
4. Resource Recovery, Recycling and Reuse (Ref. x-3), Federal policy statement on recycling.
5. "Resources for Freedom" (summary of Volume I of the President's Materials Policy Planning Commission), pp. 1093-1738 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).
6. "Protecting Our Environment and Natural Resources in the 1970's" (a Resource for the Future paper), pp. 1846-1853 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).
7. Testimony of Donal N. Frey, National Academy of Sciences (review of NAS policy study), pp. 1528-1539 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).
8. "The Universities and Environmental Quality: Commitment to Problem Focused Education", pp. 611-812 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).
9. "Government", pp. 13-21 in Solid Waste (Ref. I-8).

III. ECONOMICS OF SOLID WASTE MANAGEMENT

1. COMPREHENSIVE STUDIES OF SOLID WASTE MANAGEMENT, FIRST AND SECOND ANNUAL REPORTS

Authors: C.G. Galucke, Chief Biologist, (Sanitary Engineering Research Laboratory) and P.H. McGauhey, Professor, Chief Biologist, University of California, Berkeley.

Publishers: U.S. Dept. of Health, Education and Welfare; Public Health Service. Publication, No. 2039 (Washington, D.C.: USGPO), 1970, (447 pp., $4.25); BSWMP No. 128.

Point of View: Comprehensive and academic; an attempt to produce a foundation for future studies and research.

Level: Variable; much of the report is easily readable by a non-specialist. The chapters on Operations Research and Planning and on Economics do introduce some specialized mathematics.

Summary: This volume contains the first and second annual reports of a large scale study of solid waste management conducted by the College of Engineering and the School of Public Health (Sanitary Engineering Research Laboratory), University of California - Berkeley, and the departments of Civil Engineering and Agricultural Engineering, University of California - Davis. The objectives of the study were to mount an interdisciplinary "operations research" attack on the problems of solid waste management and to undertake research with the goals of improving traditional techniques and developing new ones.

The First Annual Report, covering 1966-1967, is largely taken up with a literature study, information retrieval, and the gathering of background data on waste material. This latter category is very detailed but, for the First Report, is restricted to Santa Clara County and Berkeley.

The most useful portions of the First Report for the non-specialists are the four chapters: VI, Technology of Solid Waste Management, in which the major practices--incineration, composting, landfill, salvage--are defined and described; and Chapters VII, Anaerobic Digestion with Sewage Sludge; VIII, Wet Oxidation of Organic Wastes; and IX, Biological Fractionation of Organic Wastes, which deal with more sophisticated methods of handling wastes and describe research projects to be undertaken in each area.

The Second Annual Report, covering 1968 - 1969, focuses on much the same materials as the First Annual Report, but with more specific data. The Chapters in Planning (III) and Operations Research in Solid Waste (IV) develop sophisticated models for predicting waste generation and understanding waste flow patterns. Chapter V, Economics has data on the cost, economics of scale, etc., of all the various facets of collection, incineration, long-haul transportation, landfill, composting (and the various related activities--hauling, grinding, etc.), anaerobic digestion (costs and returns from sale of digester gases), biofractionation (costs and returns) and the costs, etc., for wet oxidation and pyrolysis. Further Chapters present research undertaken in the areas listed above, i.e., incineration, composting, etc. This is followed by a chapter on Public Health in which the relation of solid waste management to disease is discussed, research findings presented and further research needs outlined.

There are extensive appendices and a long list of references.

This volume contains much material which will probably not be used by the average college science teacher but its inclusiveness, its basic nature, and in particular its wealth of data, definitions and economic parameters make it a reference well worth having.

2. COMPREHENSIVE STUDIES OF SOLID WASTE MANAGEMENT, THIRD ANNUAL REPORT (FINAL) 69-70

Author: C.G. Galucke, Chief Biologist, Sanitary Engineering Research Laboratory, University of California - Berkeley.

Publisher: U.S.Environmental Protection Agency, PHS Pub. #1959 (Washington: USGPO), 1971, (201 pp.; $1.75);

2. COMPREHENSIVE STUDIES OF SOLID WASTE MANAGEMENT, THIRD ANNUAL REPORT (FINAL) 69-70 (cont'd.)

BSWMP #178.

Point of View: Systematic study of solid waste management.

Level: Variable, some specialized mathematics in modeling and planning but most material understandable by a college science teacher.

Summary: This final report deals with the same topics reported in the first two annual reports (see Ref. III-1). Chapter II reviews the work to date on planning and economics and includes summaries of the predictive models, of the surveys of costs, techniques, improvements, etc., in solid waste management. The section on economics contains estimates of costs and returns for products (where applicable) and a list of equipment needed for each of the conventional methods--landfill, incineration and composting--and for the experimental methods--compaction, wet oxidation. anaerobic digestion and biological fractionation. This long chapter also includes a thorough treatment of private and public expenditures in the solid waste industry.

Chapter III reviews the operations research analysis and Chapters IV-VII review the research undertaken by the grantees on anaerobic digestion, biological fractionation, incineration-pyrolysis-combustion, and wet oxidation.

The comments made at the end of the previous reference hold here: the report is such a basic document that it is an important reference even though it covers more material and at a greater depth than the usual college science teacher will require.

3. ECONOMICS AND THE ENVIRONMENT: A MATERIALS BALANCE APPROACH

Authors: Allen V. Kneese, Robert U. Ayres, Ralph C. D'Arge, Research Staff, Resources for the Future.

Publisher: Resources for the Future, Inc., Washington, D.C., Distributed by The Johns Hopkins Press, Baltimore, Maryland, 1970, (119 pp., $2.50).

Point of View: Analytical; an attempt to build economic models which take into account the resource value of air, water and land.

Level: Variable; it is written for the economist but only Chapter III contains specialized mathematics and economic models.

Summary: This book is, in the words of the preface: " ... an effort to break out of the traditional approach in pollution policy and research, which treats air, water, and solid waste problems as separate categories".

The authors approach the problem of residuals from a "materials balance approach", that is, they recognize that waste is conserved and that any thing that goes into the economic flow must come out of it. To this they then add the fact that air and water are no longer "free goods" but are in fact increasingly valuable resources providing "services" to the producer and consumer which must be paid for.

Chapter I provides an introduction and framework for their approach; Chapter II summarizes residuals from the three major categories: (1) Energy Conversion, (2) Materials processing and industrial production, (3) Final Consumption: Households. This chapter provides valuable data on overall input and output tonnages, efficiencies, etc. The data are generally from 1965 but newer data can be easily substituted. There are also several examples of alternative cycles with quite different residuals outputs.

Chapter III is of a highly technical level, presenting three different simple models for taking the costs of environmental services into account. The results are well summarized at the end of the chapter.

Chapter IV raises policy questions and provides a long list of areas in which further (largely economic) research is needed.

The book is an excellent reference for the natural scientist who wants a concise statement of the pollution problem in economic terms. In addition, the

3. ECONOMICS AND THE ENVIRONMENT: A MATERIALS BALANCE APPROACH (cont'd.)

breakdown of Chapter II will suggest a framework for presenting and evaluating the continuation of these problems into the '70's.

4. SOLID RESIDUALS MANAGEMENT: SOME ECONOMIC CONSIDERATIONS

Author: Walter O. Spofford, Jr., Research Associate, Resources for the Future.

Publisher: Natural Resources Journal II (3): 561-589, July 1971.

Point of View: The author takes the point of view of "welfare economics" and analyses materials reuse from a basis which includes all costs and benefits, market and non-market.

Level: The treatment is semi-quantitative but the level of mathematics is low (no calculus). The economics is sufficiently well explained to be useful to someone outside of that field.

Summary: The factors that contribute to a cost-benefit analysis which includes both market and non-market costs and benefits are presented in a general fashion. The interplay of these factors is then illustrated briefly in three examples: reuse of paper residuals, returnable versus non-returnable containers and municipal composting.

The example of reuse of paper residuals is then investigated more thoroughly to demonstrate schematically the computation of an optimal reuse ratio of paper from this "welfare economics" point of view. The "welfare economics" optimum reuse ratio is contrasted with that of traditional economics.

This article is useful for its demonstration of the interplay of the various cost-benefit factors and is clear and complete enough to form the basis for other similar considerations of optimal reuse ratios.

5. THE ECONOMICS OF RECYCLING WASTE MATERIALS

Author: Hearings before the Subcommittee on Fiscal Policy of the Joint Economic Committee.
Publisher: USGPO, Washington, D.C., 1972 (198 pp.; $0.75).

Point of View: Hearings on the necessity of and means of providing economic incentives for recycling.

Level: Popular.

Summary: This is a summary of two days of hearings. Testimony was delivered by, for instance, representatives of the salvage industry, by an independent economist and by representatives of New York City's Environmental Protection Agency and the Federal EPA.

The testimony provides data on the various problems that are reducing the economic importance of recycling; recycling was, in fact, decreased over the past few years because of such discriminatory practices as higher freight rates (as compared to virgin materials), depletion allowances, capital gains, tax privileges on timber, etc.

The prepared papers, which make up the bulk of the hearings, document taxes, discriminatory practices and their effects, and make some detailed suggestions for reform. The hearings contain some strong criticism of the ICC and the Federal Maritime Commission. The effect of the rulings of this latter group is strongly curtailing export of waste paper, for instance, and provides particularly interesting reading" ... The effective shipping rate, the conference rate of waste paper versus wood pulp is 75% higher. Of course those rates are subject to the Federal Maritime Commission. So, here is a case where all you are trying to do is export it overseas (to Australia) to get rid of the solid waste from the United States to a country overseas which wants to utilize it, but the freight rate is the big problem."

5. THE ECONOMICS OF RECYCLING WASTE MATERIALS (cont'd.)

As with many hearing reports, this one has much useful data in the prepared papers and the reprinted reports and articles. In addition to the heavy emphasis on wood products and waste paper, a statement from the used oil recycling industry is of particular interest in showing, again, how discriminatory taxes hamper the beneficial activities of this industry.

Case studies from New York City and Boston provide insight and data. There is also included a paper suggesting some of the advances to be expected from new technology.

These hearings concentrate on resource recovery and its potential contribution to the alleviation of solid waste problems. They are an excellent source of examples of the discouraging effects of Federal purchasing practices, discriminatory taxes and rulings by regulatory agencies.

6. SALVAGE MARKETS FOR MATERIALS IN SOLID WASTES

Author: Arsen Darnay and William Franklin, Midwest Research Institute.

Publisher: This is an environmental protection publication (SW-29C) in the EPA solid waste management series (Washington, D.C.: USGPO), 1972. (187 pp.; $2.75); BSWMP Pub. No. 293.

Level: Data presented in tabular or graphical form, the text accompanying is technical to the extent that it uses trade terms but most of these are defined implicitedly if not explicitly.

Point of View: This is a straight factual presentation of data from a sponsored study.

Summary: This report is a rich and authoritative source of data on almost any conceivable aspect of materials salvage. In it, the participants in the salvage operation (the salvage industry itself, the sanitation establishment, the industries which produce waste and consume the recycled materials, and the public) are described, their general attitudes, activities, and techniques summarized. The third chaper gives a thorough presentation of salvage operations and costs and includes a brief introduction to new technologies in this area.

The next six chapters treat in detail the most important components of salvage: paper, ferrous metals, non-ferrous metals, glass, textiles, and then other materials (rubber, plastic, etc.). The data is presented in many different ways, as historic trends, in terms of percentages, in flow diagrams, in geographic breakdown, in terms of consumption and production. It is difficult to find a category not included.

These chapters are followed by a useful survey of legislative and policy considerations which includes most of the present or potential issues. The next chapter, a very long one, presents a series of case studies of salvage experience in a broad geographic distribution of US cities. The final short chapter presents the results of a mail survey of municipal salvage programs. There is an appendix which gives a breakdown of composition and sources of waste and an extensive bibliography.

In summary, this report is a complete and very readable presentation of the salvage picture.

CROSS REFERENCES

1. "Current Federal Support of Solid Waste Research, Development and Demonstration", pp. 73-85 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).

2. "Factors Affecting Refuse Collection Costs" and "Financing Refuse Collection", pp. 78-102 and 268-296 in Refuse Collection Practice (Ref. VI-1).

3. "Reclamation and Recycling: An Economic Overview", pp. 20-25 in What's Ahead in Solid Waste Management (Ref. I-9).

CROSS REFERENCES (cont'd.)

4. "Environment and Packaging: An Economic and Legislative Analysis" in Solid Waste Management Act of 1972 (Ref. IV-1).

5. "Economics of Scrap Origination, Supply, and Demand", pp. 905-909 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

6. "Materials Recovery and Reuse as an Approach to Solid Waste Management: Economic Aspects and Implications", pp. 1811-1854 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).

7. Disposal of Junked and Abandoned Motor Vehicles (Ref. V-1).

8. "An Economic Analysis of the Junk Auto with Emphasis on Processing Costs" (Ref. V-3).

9. "Technical and Economic Impacts on the Paper Industry of Increased Recycling for Six Major Product Groups", pp. 76-118 in Paper Recycling: The Art of the Possible, 1970-1985 (Ref. X-7).

IV. SOURCES OF MUNICIPAL SOLID WASTE: PACKAGING AND DISPOSABLES

1. SOLID WASTE MANAGEMENT ACT OF 1972

Author: Hearings before the Subcommittee on the Environment of the Committee on Commerce, U.S. Senate, Ninety-Second Congress, Second Session, March 6, 10 and 13, 1972.

Publisher: Washington, D.C.: USGPO (Serial No. 92-60), 1972, (1024 pp.; $4.25).

Point of View: Testimony and supplementary documents included here have been drawn from representatives of the Federal government (EPA) and the packaging industry (bottlers, canners, paper manufacturers, etc.) and from several private citizens and university-based consultants.

Level: Popular.

Summary: Just about everything you might want to know about the role of packaging in solid waste management has managed to find its way into this Senate document. Ostensibly, it records three days of hearings on two bills: the "Mathias Bill" (S. 1377), which would bar soft drink and beer containers sold in interstate commerce on a no-deposit, no-return basis, and the "Proxmire Bill" (S. 3058), which would add a charge of "a penny a pound" to all packaging containers of the type that would not ordinarily be disposed of within ten years of the first sale. The record of the first day's hearings includes various arguments for one or both bills, with the testimony of Ellis Yochelson (pp. 63-77), particulary articulate and well-informed proponent of materials reclamation, recycling, and the returnable bottle, providing some especially interesting information. Testimony from the container manufacturers was taken on the second day of hearings and the record includes contributions from glass, can and paper manufacturers, and from a representative of the US Brewers Association. Their testimony is uniformly against both bills, with that of Norman Dobyus (pp. 77-101) perhaps best summarizing the industry's objections. Jerome Kretchner, an EPA administrator in New York City, takes exception to most of the industry objections and provides some useful data on the current magnitude and costs of packaging waste. The record of the final day of hearings provides a broader perspective as to the economics, legal, and systems implications of the proposed legislation. Russell Ackoff, Professor of Systems Sciences at the University of Pennsylvania, suggests an alternative to both bills. Samuel Hale, representing the EPA at the Federal level, essentially speaks against legislation at this time and calls for further study of the problem. Bruce Hannon, Assistant Professor of General Engineering at the University of Illinois - Urbana, disousses his investigation into the energy costs of various container systems, and William Rodgers, Professor of Law at the University of Washington, reviews several of the legal aspects involved and provides some interesting details regarding the strength and tactics of the container manufacturer lobbyists. All of this testimony comprises only 300 pages of the report; the bulk of information here is provided through the reprinting of related reports, studies, newspaper and journal articles, and correspondence. Among the most useful are the reprints of several "Keep America Beautiful" studies, which came under heavy criticism in the testimony of several non-industry people: "Environment and Packaging: An Economic and Legislative Analysis", which includes some very interesting data on the costs of packaging to the consumer; and "System Energy and Recycling: A Study of the Beverage Industry", a reprint of Bruce Hannon's study into the energy costs of various packaging practices. Perhaps what this document best provides, however, is a clear look into the difficulties encountered when the Federal government attempts to push a powerful industry in a direction that it does not want to go.

2. THE ROLE OF PACKAGING IN SOLID WASTE MANAGEMENT, 1966-1976

Authors: Arsen Darnay and William E. Franklin, Midwest Research Institute, Kansas City, Missouri.

Publisher: Public Health Service Publication No. 1855 (Washington, D.C.: USGPO), 1969, (205 pp., $2.25; BSWMP Pub. No. 44).

2. THE ROLE OF PACKAGING IN SOLID WASTE MANAGEMENT, 1966-1976 (cont'd.)

Point of View: "To a large extent the aims of packaging and of solid waste disposal are mutually exclusive. The packager wants--and technology is developing--a container that won't burn, break, crush, degrade, or dissolve in water. The waste processor wants a package which is easy to reduce by burning, breaking, compaction, or degradation. The final objective of solid waste management is to reduce the total quantities of solid waste and unsalvageable materials through recovery and reuse. In an ideal system, packaging materials would never be discarded--they would be reprocessed by industry and made into new packages or other products."

Level: Semi-technical; numerous charts, tables, and graphs.

Summary: Data on just about every aspect of packaging has been assimilated here, much of it displayed in easy-to-read charts and graphs. For that reason alone, this is a valuable reference. The text is very straight-forward and, while no attempt has been made to make this a particularly readable report, it is well worth the effort to become familiar with the material contained here. Perhaps the best way to summarize the contents of this report is to simply quote from the abstract which accompanies it:

> Packaging materials are increasing in quantity much more rapidly than the population, primarily because of the continuing rise in self-service merchandising. Per capita consumption, which was 404 lb. in 1958, is expected to be 661 lb. in 1976. The goals of waste processors and packagers obviously differ: the packaging industry seeks durable container material that will be unimparied by external factors. Until recently, no systematic analysis of the relationship between packaging and solid waste disposal has been undertaken. This three-part document defines these interactions, and the differences, with possible solutions, are explored.
>
> Part I discusses packaging materials, consumption data from 1959 to 1966, and the outlook for the period from 1966 to 1976. Part II, concerned with disposability, analyzes the collectability, the resistance to disposal and processing, and salvageability and reuse of packaging materials. Part III explores mechanisms to mitigate the problems that arise from this type of waste: how research, education, incentive programs, taxes, and regulations can reduce the quantity and reduce the processing difficulties of this disposed material, yet save the natural resources from which packages are made.

3. SOLID WASTE DISPOSAL PROBLEMS ARISING FROM THE PROJECTED OUTPUT OF CONTAINERS

Author: N. Russell Wayne.

Publisher: Chapter 13 (pp. 313-342) in Environmental Side Effects of Rising Industrial Output, Editor, Alfred J. Van Tassel (Lexington, Massachusetts: Heath Lexington Books), 1970, ($19.50).

Point of View: "A significant portion of the solid waste problem stems from packaging residues, specifically containers ... But the fact of increased overall container output is only one facet of the problem. Another is the use of the one-way, no deposit, no-return beverage bottle. This outgrowth of the throw away spirit is punctuating the countryside from coast to coast, incuring a mammoth litter collection bill."

Level: Non-technical.

Summary: This is a fairly concise, well documented agrument for establishing waste prevention as a central criteria in the design of packaging. Data from a 1963 Resources for the Future Study (Resources in America's Future) is examined in the first section which deals with the impact of packaging on the overall solid waste problem. The discussion focuses on "Resource Consumption for the Production of Containers" and includes several tables summarizing historical, current, and projected data. The viability and accuracy of RFF projections are then analysed and the various factors influencing the assumptions behind

3. SOLID WASTE DISPOSAL PROBLEMS ARISING FROM THE PROJECTED OUTPUT OF CONTAINERS (cont'd.)

them are discussed. "Packaging and Society", the next section, deals with the impact of rising affluence, the trend toward disposability, the littering problem, and cost factors relating to the issue of returnable vs. non-returnable bottles. (It is interesting to compare some of the data here with that given by industry representatives in Ref. IV-1). Trends in packaging design and disposal methods (landfill, incineration, composting, naturally degrading containers, etc.) are briefly reviewed in terms of the technology associated with them and the observed external effects (resource waste, decreasing landfill space, environmental problems, etc.) which accompany them. The discussion of incineration is particularly useful and provides a quick summary of several design improvements under development here and in Europe. The final section, "A Projection of the Magnitude of the Solid Waste Problem to the Year 2000", includes a discussion, both of the national problem (with data on population and personal expenditure consumption) and of the special problems faced by the cities.

4. THE ROLE OF NONPACKAGING PAPER IN SOLID WASTE MANAGEMENT, 1966-1976

Authors: Prepared by William E. Franklin and Arsen Darnay, Midwest Research Institute, under a grant from the Solid Waste Management Office, US Environmental Protection Agency.

Publisher: Environmental Protection Publication SW-26c (Washington: USGPO), 1971, (76 pp.; $.75; OSWMP Order No. 170).

Point of View: Report of a study "to determine what portion of the non-packaging grades of paper and paperboard would be a part of the solid waste stream in two base years: 1966 and 1976."

Level: Semi-technical; numerous tables, graphs, etc.

Summary: This companion study to Ref. IV-1 focuses on the other half of the paper problem: newsprint, writing paper, sanitary tissue, construction board, etc. Like the earlier document, it reports a survey study undertaken for the EPA by the Midwest Research Institute. It is organized around four basic tasks: 1) development of the historical consumption of nonpackaging paper and paperboard from 1958 to 1966; 2) analysis of the techno-economic factors that influence the consumption of nonpackaging paper and paperboard; 3) forecasting of the consumption to 1976 for each grouping of nonpackaging paper and paperboard; and 4) estimation of the proportion of paper and paperboard tonnages that reached solid waste disposal facilities in 1966 and that will probably reach disposal facilities in 1976. The report itself is divided into three sections: a brief introduction, "The Outlook for Nonpackaging Paper, 1966 to 1976", and "The Impact of Nonpackaging Paper on Solid Wastes". The introduction simply outlines in a few paragraphs the objectives of the study and the organization of the report. Part II then deals with the methodology employed in arriving at the 1976 consumption forecast figures and discusses each of the major grades of nonpackaging paper in terms of the techno-economic factors that influences its consumption. A discussion of the disposal characteristics of the various paper grades is provided in Part III, along with estimates of the amount of such paper which reached disposal facilities in 1966 and which will reach them in 1976. A number of useful tables and graphs are scattered throughout the report and a helpful bibliography is appended.

5. PACKAGING INDUSTRY LOOKS AT WASTE UTILIZATION

Author: John A. Abrahams, Jr., Glass Manufacturing Institute, Inc.

Publisher: Compost Science 10: 13-19, Spring/Summer 1969 (Reprint available from: Glass Container's Manufacturing Institute, Inc., 1800 K St., N.W., Washington, D.C. 20036).

Point of View: "Experience has shown that people responsible for disposal cannot transfer their problems to others through restricting non-returnable containers, for example ... Further, taxing the non-returnable containers by some arbitrary means of a "disposability index" still results in the consumer paying the price as another hidden tax."

Level: Popular.

5. PACKAGING INDUSTRY LOOKS AT WASTE UTILIZATION (cont'd.)

Summary: The packaging industry position as to the sources and solutions of the national solid waste program are carefully set forth here. Abrahams first reviews the current and predicted packaging trends, noting in particular the continued and growing demand for the non-returnable container:"... the increasingly high cost of recovery and cleaning and the resistance on the part of consumers and retailers to returning and handling the empties has resulted in the rapid growth in non-returnable containers." He then turns to what he views as the real root of the solid waste disposal problem, not packaging but "the outdated system of managing solid waste throughout most of the municipalities in this country." The shortcomings of several disposal methods (incinceration, sanitary landfill, composting) are described and the argument for attacking the problem by denying disposable packaging put to rest with the conclusion that " ... discarded package remains gradually decomposing may be more difficult and costly to pick up than present packaging, and may present a health problem." In "Recycling of our Natural Resources" the problems associated with the reclamation and reuse of glass are detailed. Abrahams notes that there are logistical problems (separating waste at the source, sorting glass by color, etc.), as well as economic problems ("There is today only a small market for waste glass ...") involved in reclaiming packaging materials but that the glass container industry and the government are seeking solutions to them. He concludes by arguing against schemes that suggest taxing or restricting non-returnable containers and recommends instead that industry " ... actively help to convince the public of the growing needs in residential solid waste disposal and assist the municipal waste disposal people to obtain the necessary tax dollars to meet these needs."

6. DESIGN OF CONSUMER CONTAINERS FOR REUSE OR DISPOSAL

Author: Proceedings of the Solid Waste Resources Conference on Design of Consumer Containers for Reuse or Disposal, Co-Sponsored by Batelle Memorial Institute - Columbus Labs and the U.S. EPA, May 12 and 13, 1971 and compiled by George F. Sachsel.

Publisher: An environmental protection publication in the solid waste management series (SW-3p) published jointly by the Office of Solid Waste Management Program and the National Environmental Research Center (Washington, D.C.: USGPO), 1972. (330 pp.; $1.75) OSWMP Order No. 261.

Point of View: Proceedings of a state-of-the-art symposium.

Level: Varies from paper to paper but, for the most part, non-technical, with data displayed in graphs and tables.

Summary: Of the eighteen papers prepared for this Solid Waste Resource Conference, four provide an overview of packaging and its environmental impact and the remainder are evenly divided between four areas: plastics, composites and paper, glass containers and metallic containers. In a sense, they are all summary papers, designed to quickly survey one area or aspect of a specific type of packaging or packaging problem. The first paper, "Packaging and Solid Waste Management" is particularly useful as it summarizes much of the appropriate data and data projections on packaging trends and costs. The argument of "design for self-disposal" versus "design for reclamation" runs through most of the papers. Among the specific technologies treated are thermoplastics in waste recycling, returnable plastic container systems, glass containers and self-disposal, glass separation techniques, metallurgical aspects of reclaming container scrap and recovery and utilization of aluminum. In short, this is a good source for a quick survey of the most recent packing industry thinking and technology.

7. BOTTLES, CANS, ENERGY

Author: Bruce M. Hannon, Assistant Professor of General Engineering, University of Illinois, Urbana.

Publisher: Environment 14: 11-21, March 1972.

Point of View: "Returnable Bottles are cheaper in dollars and scarce energy resources than throwaways, even when the best available recycling technology is used.

Level: Popular. Illustrated. Several tables. Bibliography.

7. "BOTTLES CANS, ENERGY" (cont'd.)

Summary: Decisions as to the packaging medium for beer and soft drinks impact strongly both on waste disposal and resource utilization questions. Hannon here presents a careful analysis of the cost-benefit issues involved in the choice between three types of containers: throwaway bottles, returnable bottles, and cans. The magnitude of the packaging problem is described first in terms of direct and indirect consumer costs. Two physical laws are then proposed as yardsticks by which to measure recycling efficiency: the law of conservation of mass and the law of conservation of energy. The rising cost of energy is briefly discussed and related to the need for developing minimum energy consumption packaging systems. In "The Origin of Throwaways", Hannon details the advantages which the disposable bottle container system holds for inner city shoppers and retailers and for the manufacturers themselves. "Remelting and Recycling" then deals with the process by which household and commercial waste is sorted into recyclable components. As a means of comparing the value of recycling via returnable bottles with "recycling" via remelting, Hannon presents a rather detailed energy analysis of the two systems. Several tables provide data on energy resources needed for each step in the manufacturing, distribution, and return or disposal of glass soft drink containers. It is shown that, "from dollar cost and energy cost standpoints, returnable bottles are preferable to cans or throwaway bottles."

8. BOTTLENECKS

Author: Robert R. Grinstead, Research Chemist involved in solid waste, water pollution and resource recovery programs at the Western Division Research Center of the Dow Chemical Company.

Publisher: Environment 14: 2-13, April 1972.

Point of View: "Solid wastes that go at low cost into municipal landfills contain valuable raw materials which technology is not equipped on a large scale to sift, sort, separate, transport, process, produce, package and market. Identifying the key stumbling blocks may help divert the flow of wastes to useful purposes rather than into permanent burial sites."

Level: Popular. Illustrated. Several tables. Bibliography.

Summary: This first article in a two-part series (see Ref. IX-6 in part 1) deals with the status of both the technology of recycling and the problems of disposition of the reclaimed resources. "Bottlenecks", difficulties which interfere with the balance between reclamation and reuse, are identified for each major "trash resource" and each is discussed in terms of the value of the products involved and their marketability. Separate sections concentrate on iron and steel, aluminum and other metals, glass and paper. In each instance, data is presented as to the percentage occurance of each material in trash, its recycled value per ton, the variables which affect and determine that price, current and potential percentage re-used and likely developing uses.

Three methods of converting organic solid wastes to useful products are then examined singly: composting, hydrolysis and fermentation, and the recovery of heat energy for fuel during the incineration of trash. In each instance, the methodology involved is described and the economics and potential end-use of the products discussed. Finally, the problem of plastics in trash is addressed and the severe difficulties involved in reclaiming plastics products are reviewed. A table on the "Potential Value of Resources Recoverable from Trash" presents data as to the value of the virgin material and the expected value as it is reclaimed from trash. A brief discussion of the economic realities suggested by the data in the tables concludes the article.

9. NO DEPOSIT, NO RETURN: SOLID WASTES, TRASH PAPER, PACKAGING TRENDS

Author: Robert R. Grinstead, Research Chemist involved in solid waste, water pollution and resource recovery programs at the Western Division Research Center of the Dow Chemical Company.

Publisher: Environment II: 17-23, November 1969.

Point of View: "Taken together, the empty cans, bottles, boxes and bubble-packs that we discard are creating a mountain of trash which is beginning to exceed the available space for disposal."

9. NO DEPOSIT, NO RETURN: SOLID WASTES, TRASH PAPER, PACKAGING TRENDS (cont'd.)

Summary: Several of the major issues associated with packaging wastes are discussed in this brief acticle which reports the First National Packaging Wastes Conference held in 1969. Representatives from government, industry and academia met for two and a half days to explore the various facets of the packaging waste problem. Their discussion and suggestions are summarized here under five headings: The Bulk of Cities Trash; Who Will Pay the Costs?; Packaging Industry Developing Solutions; Squeeze or Burn?; and Trends.

The size and character of the packaging disposal problem are briefly outlined in the first section and summary cost data presented. "Who Will Pay the Costs?" presents the standard controversy: industry thinks the consumer should pay, the consumer thinks the packaging industry creates too much wasteful packaging, and the government seeks to encourage the packaging industry to design more easily disposable packages or face government intervention.

Several design solutions developed by the packaging industry are cited, but Grinstead notes that "most of the developments, under close scrutiny, struck some observers as nibbles at the problem of packaging waste disposal". In "Squeeze or Burn?", several promising approaches to compaction and incineration are noted, including brief mention of the Japanese building blocks of compressed garbage. Noting the problem of achieving any kind of consensus opinion at a conference of this size, Grinstead isolates three areas in which there seemed to be at least general agreement: 1) "the individual consumer appears to be a very key factor in finding solutions to the waste problem" 2) "considerable effort is still needed in the technical front"; and 3) "both the private and the public sectors of the economy must work together".

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1. Waste Management Research and Environmental Quality Management (Ref. I-2), pp. 105, 114, 141, 148, 188, 213 and 230.

2. "Report on the Role of Plastics in Solid Waste", pp. 2227-2517 in Resources Recovery Act of 1969 (Ref. I-1, Part 5).

3. "Use and Disposal of Single-Use Items in Health Care Facilities", pp. 1269-1332 in Resource Recovery Act of 1969 (Ref. I-1, Part 2.

4. Testimony of Leonard S. Wegman, pp. 1854-1866 in Resource Recovery Act of 1969 (Ref. I-1, Par. 3).

5. Testimony of Edwin A. Locke, Jr., pp. 1867-1897 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

6. "$Cp + D \stackrel{?}{=} P$" ("Does Packaging Convenience Plus Disposability have to Equal Pollution?"), pp. 1929-1936 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

7. "Throwaway Packages: A Mixed Blessing" and "Waste Recycling Really Works", pp. 28-34 and 83-85 in Solid Wastes (Ref. I-8).

8. "The New Resource" (Ref. X-5).

V. SOURCES OF MUNICIPAL SOLID WASTE: THE AUTOMOBILE

1. DISPOSAL OF JUNKED AND ABANDONED MOTOR VEHICLES

Author: Hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate, Ninety-First Congress, Second Session, August 19 and 26, 1970.

Publisher: USGPO, Washington, D.C., 1970. (417 pp.; No charge; free upon request from Committee on Public Works).

Point of View: These hearings were called to discuss two bills: S. 4197, the Motor Vehicle Disposal Assistance Act, and S. 4204, the Motor Vehicle Disposal Act. Testimony is presented by representatives from the federal and local government and from the industries involved.

Level: Non-technical.

Summary: As both Acts under discussion in these hearings represent proposed federal intervention in two sensitive areas, private property and private enterprise, the testimony here tends to be particularly narrow and self-serving. At the risk of over-simplification, much of the debate revolves around the advantages and disadvantages of two approaches to solving the abandoned car problem: the "punitive" approach, involving fines and taxes on the automobile owner to insure disposal of his car, and the "reward" approach, involving "bounties" and other incentives to the autowrecking and dismantling industries to encourage the processing of junked autos. While several interesting numbers suggesting the scope of the problem came up in this testimony, the real value of this volume lies in the papers which have been included to supplement the testimony. By far the most readable and comprehensive paper is "What Wisconsin Can Do to Get Rid of Junked Cars", a report prepared by the Wisconsin Cooperative Extension Service. The magnitude of the problem and the various economic and logistical factors affecting each step in the junk car cycle are briefly reviewed and several alternative solutions are considered, including the so-called "Maryland Bounty" and "Vermont" plans. It is interesting to note that this paper is one of the few places where the concept of attacking the junk car problem at the design stage is considered as a positive and viable step. Other useful papers reprinted here include "Proceedings: Landscape 1970, National Conference on the Abandoned Automobile", "The Auto Wrecking/Dismantling Industry", a preliminary draft of a U.S. Department of Commerce paper, and "The Automobile Cycle: An Environmental and Resource Reclamation Problem", prepared by U.S. Bureau of Solid Waste Management. The latter is a particularly good source for data on the scope of the problem, the resource investment involved and the economics of dealing with the problem. Several "model acts", representing alternative legislation to that under discussion, are included in the hearing record. In short, this volume provides a most valuable introduction to the problem of abandoned automobiles by including, not only much of the basic data available, but an interesting record of the government and industry attitudes which impinge on the problem.

2. THE AUTOMOBILE CYCLE: AN ENVIRONMENTAL AND RESOURCE RECLAMATION PROBLEM

Author: Revision of a study made by the Federal solid waste management program for the President's Council on Environmental Quality.

Publisher: An environmental protection publication (SW-80ts) in the solid waste management series (Washington, D.C.: USGPO), 1972. (115 pp.; $1.25)·OSWMP No. 275.

Point of View: "The fundamental concern of this report is the production - consumption cycle of the automobile industry ... this study was initiated to determine the extent of the problem and to provide a framework by which potential government actions can be effectively evaluated."

Level: Non-technical.

Summary: The approach here has been to model the various interrelationship of the industries involved in the junk car cycle and to extrapolate from that model the kind of policy decisions which might encourage improved recycling efforts. Each major segment of the cycle is examined separately in the four chapters which make up the body of the report: motor vehicle manufacturers, abandonment, dismantling industry, and scrap end-use. The discussion under each of these headings is broken into several components, including a general background description, a discussion of the resource conservation and environmental danger implications involved, and an outline of the key decision areas. The scope of operations and available technology within each segment is detailed in a flow

2. THE AUTOMOBILE CYCLE: AN ENVIRONMENTAL AND RESOURCE RECLAMATION PROGRAM (cont'd.)

chart which also includes a delineation of the key decisions and barriers which affect recycling within each area. Several possible tactics for improving recycling efforts are described in an appendix and the report concludes with a discussion of strategies and suggested methods for selecting the best course of action. It is a useful report, both for the summary data (size, costs, rate of growth, etc.) it provides for each segment of the cycle and for the insight it provides into the complexity of decision-making in a complicated, multi-industry enterprise.

3. AN ECONOMIC ANALYSIS OF THE JUNK AUTO WITH EMPHASIS ON PROCESSING COSTS

Authors: Robert L. Adams and Sylvia E. Milanese, staff economists, Bureau of Mines, US Department of Interior.

Publisher: Proceedings of the Third Mineral Waste Utilization Symposium, Jointly Sponsored by the U.S. Bureau of Mines and IIT Research Institute, Chicago, Illinois, 14-16 March, 1972. To be published by the USGPO, Spring 1973.

Point of View: "The main concern of this paper is to present some of the economic aspects of the junk auto problem and to show how the model can work. In doing this, the relationship between the changing technologies of preparation, transportation, and processing of auto hulks will be discussed, as well as their implications for governmental policies and programs."

Level: Non-technical. Some basic understanding of economic theory is assumed.

Summary: Several important economic aspects of junk automobiles are examined in this brief summary of a doctoral thesis submitted by Adams to the University of Illinois - Urbana. Noting the lack of data and reliable information on the various stages of the junk auto cycle, Adams undertook to develop "an analytical model capable of estimating the impact of the technological changes upon auto hulk values while, at the same time, developing the model in such a way as to be usable with minimum data outputs". Variables discussed in this summary include costs in shredder and baling operations, cost of flattening auto hulks via a portable flattener operation and calculation of maximum transportation distances. Adams notes that, "While the (potential) economic incentive to eliminate excessive auto wrecker inventories appears to be more than sufficient, this is not necessarily true for the auto abandonment problem". The economic incentive to the last owner of an automobile to deliver one auto every two or three years is briefly discussed and several alternative mechanisms for encouraging proper disposal are suggested. The author concludes: "While changes in technology and market values will certainly help the movement towards a solution, it simply does not appear that the market place, by itself, will solve the auto abandonment problem".

CROSS REFERENCES

1. "Motor Vehicle Abandonment in US Urban Areas", pp. 929-980 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

2. "Disposal of Automotive Scrap", pp. 579-580 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

3. Testimony and materials submitted by Thomas B. Mann, pp. 1637-1676 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).

4. "Suggested State Legislation on Abandoned Motor Vehicles", pp. 1640-1649 in Resources Recovery Act of 1969 (Ref. I-1, Part 3).

CROSS REFERENCES (cont'd.)

5. Testimony of Richard Burlingane, pp. 1368-1377 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

6. "Scrap Tires" and "Auto Hulks", pp. 22-26 in Solid Wastes (Ref. I-8).

7. " ... Only the Giant Car-Eater Can Save Us", pp. 1684-1687 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).

VI. COLLECTION AND TRANSPORTATION OF MUNICIPAL SOLID WASTE

1. REFUSE COLLECTION PRACTICE

Author: Prepared by the Committee on Solid Wastes, American Public Works Association.

Publisher: Public Administration Service, 1313 East Sixtieth Street, Chicago, Illinois 60637, 3rd edition, 1966 (525 pp.; $10.00).

Point of View: This is the third edition reporting the continuing APWA program "to provide authoritative reference volumes on the operation and management of municipal refuse collection practices for city officials and others seeking information on modern methods and practices. The data that served as the basis for this edition was obtained by means of a comprehensive study conducted by the APWA in cooperation with the United States Public Health Survey."

Level: Non-technical. Illustrated; numerous tables.

Summary: In 1941 the APWA published the first edition of what was to become the "definitive American publication" on refuse collection practice. This is the third edition of that report and it remains the most comprehensive and well-documented waste collection reference available. There are sixteen chapters, each dealing with a separate facet of the problem: The Refuse Collection Problem, Refuse Materials, Preparation of Refuse for Collection, Factors Affecting Refuse Collection Cost, Refuse Collection Methods, Refuse Collection Equipment, Planning Refuse Collection Systems, Supplemental Transportation of Refuse, Special Refuse Collection Problems, Municipal, Contract or Private Collection, Financing Refuse Collection Operations, Organization, Personnel, Equipment Management, Reporting, Cost Accounting and Budgeting, and Public Relations. The four appendices provide information on typical refuse collection ordinances, criteria for planning a refuse collection systems, collective data from several hundred cities and a selcted bibliography. There is so much information here that it can be a bit overwhelming. Fortunately, each chapter is sufficiently self-contained to allow for selective reading. Two chapters might be of particular interest to the general reader: Chapter one, which provides an overview of the refuse collection problem, and chapter 4, which presents a careful, well-documented overview of the economics of collection. Quick access to the data and various specialized discussions is provided by a very thorough index and table of contents.

2. A STUDY OF SOLID WASTE COLLECTION SYSTEMS COMPARING ONE-MAN WITH MULTI-MAN CREWS

Author: Prepared for the Bureau of Solid Waste Management by Ralph Stone and Company, Inc., Engineers, Los Angeles, California.

Publisher: U.S. Dept. of HEW, Public Health Service Publication No. 1892 (Washington, D.C.: USGPO), 1969. (175 pp.; $2.25); OSWMP No. 65.

Point of View: "Approximately 75 percent of the cost of solid waste management is attributable to the collection process ... this study was funded for the purpose of examining one means for reducing collection costs and improving the level of community sanitation services."

Level: Non-technical. Illustrated; numerous tables and graphs.

Summary: This is the report of an investigation undertaken to define the nature of the possible savings due to a one-man crew; to compare the efficiency of one man crews with two- and three-man crews; and to project the future use of the one-man system for refuse collection. Analytical techniques applied in the study include comprehensive field surveys, nationwide survey data analysis, time and motion studies, and mathematical modeling. Extensive data is provided on the various factors influencing collection costs and efficiency: ordinances governing refuse collection, man-hours, tonnage collected, injury rates, etc. Further analysis is based on a limited mathematical model, developed to enable projections of refuse collection system performances for alternative crew sizes, collection methodologies, truck sizes, haul distances, and labor and equipment costs. Many useful tables and graphs are included in the report, along with a fairly comprehensive bibliography and a section on equipment available in the U.S. and in Europe.

3. "SATELLITE VEHICLE WASTE COLLECTION SYSTEMS"

Author: Summary of a comprehensive report by Ronald A. Perkins prepared by James E. Delaney.

Publisher: An environmental protection publication in the solid waste management series (SW-82 ts.1), EPA (Washington, D.C.: USGPO), 1972. (14 pp.; $0.20), OSWMP No. 262.

Point of View: An investigation into the cost-efficiency potential of using "satellite" vehicles, small, 3 or 4 wheeled vehicles that shuttle between dwelling unit storage points and a packer truck, to improve "backyard" collection systems.

Level: Non-technical.

Summary: The "backyard" system of refuse collection, used in approximately one third of all U.S. communities, is the most convenient and the most costly system for the homeowner. In an attempt to alleviate some of the problems associated with backyard collections, several communities have experiemnted with the use of "satellite" vehicles. This is a brief summary of an extensive evaluation which the EPA made of the satellite system. It provides data on daily crew costs, crew efficiency, collection costs and efficiency, annual cost per dwelling unit, etc., for a system which seems particularly suited to low-to-medium density housing areas where single-family houses predominate. While the quantative evaluation is inconclusive, qualitatively, in terms of sanitation, efficiency, crew morale, etc., the satellite system is given a favorable review.

4. SELECTED SHORT ARTICLES FROM AMERICAN CITY MAGAZINE

Author: Several, as noted.

Publisher: American City, magazine of municipal management and engineering, issued monthly by Buttenheim Publishing Corporation, Berkshire Common, Pittsfield, Massachusetts.

Point of View: Substantial articles on collection and transportation of municipal solid waste rarely appear in the more accessible journals. American City, found in most university and many public libraries, frequently runs short articles focusing on a particular city's experiences with collection and transport problems. Several articles are summarized here as examples.

Level: Popular. Many American City articles are submitted by local government officials.

Summary: "Computers Put Efficiency in Refuse Collection" (September 1972) reports the success of the Nashville, Tennessee sanitation department in achieving particularly good equipment and labor savings by computer routing their residential refuse pick-up trucks. Route simulation by mathematical modeling is used to determine efficient sizes of vehicle and crews.

"One Man Refuse Collection" (July 1972) boosts this system as one which saves costs, improves service and increases collection workers' pay. Several modifications in route, containers, trucks, point of pick-up and incentive to collectors are noted as necessary to implement this collection method.

"One Man Mechanized Refuse Collection" (January 1972) reports a program in Texas which relies on the "Mechanical Bag Retriever" (MBR) collection system. The author notes that "bag collection systems have already shown that they can lower refuse collection costs as well as eliminate many hazards and objectionable features of the collectors' work."

"We Cut the Refuse Work Load" (April 1972) presents results of an experiment in Wisconsin to modify collection schedules and procedures for better efficiency. Collection problems are noted and ordinances developed to help solve them are briefly discussed.

"Rail Haul Refuse Disposal ..." (August 1968) notes the availability of this alternative transportation system and discusses the various questions involved in moving to such a system.

CROSS REFERENCES

1. "Are Pipelines the Answer to Waste Collection Dilemna?", pp. 52-57 in Solid Wastes (Ref. I-8).

2. "Collection is the Key" in What's Ahead in Solid Waste Management (Ref. I-9).

3. "Collection and Transport", pp. 42-48 in Solid Waste Management (Ref. I-3; also appears in Ref. I-1, Part 2, pp. 743-749.

4. "Comparison Between Alternative Collection Methods", Appendix E, pp. 132-136 in Resource Recovery Act of 1969 (Ref. I-1, Part 1).

5. "Bagged Refuse Brings Better Service", pp. 1893-1897 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

6. Testimony and correspondence submitted by Leo Weavers, pp. 1945-1970 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

7. "Personnel Safety in Solid Waste Mangement", pp. 1970-1974 in Resource Recovery Act of 1969 (Ref. I-1, Part 4.

8. Chapter 7 in Third Pollution (Ref. XII-3).

9. Preliminary Data Analysis (Ref. I-6).

VII. MUNICIPAL SOLID WASTE PROCESSING: INCINERATION

1. "CENTRAL INCINERATION" AND "ON-SITE INCINERATION"

Author: Committee on Refuse Disposal, American Public Works Association.

Publisher: Chapters 5 and 6 (pp. 140-231) in Municipal Refuse Disposal (Chicago: Public Administration Service), 1966. (528 pp.; $15.00).

Point of View: "In recent years, incineration design has been markedly influenced by the need for more efficient operation and lower costs... These new developments have made possible installation of large incinerators with a lower potential for creating nuisances and the advantages of lower operating costs."

Level: Non-technical. Illustrated; numerous graphs and tables.

Summary: These two chapters combine to provide a very thorough treatment of modern incineration and its place in municipal refuse disposal. "Central Incineration" deals with "the method used by either a municipality or a private company to dispose of refuse at a plant to which refuse is brought." A brief history of incineration is presented and a listing of advantages and disadvantages provided as a guide to evaluating incineration as a disposal method. Costs are then examined and comparative data is provided on construction and operation expenses for various types of incinerators in different geographical locations. A brief section on determining plant location and size includes a discussion of the problems of public acceptance of the "neighborhood incinerator". Incineration technology is then examined in some detail with separate sections on facilities for handling refuse, combustion of refuse, refractories, chimneys and residue handling. Each section includes a summary of current technology, comparative cost-efficiency data and a brief discussion of associated problems or deficiencies. "Architecture and Construction" examines criteria for plant buildings and furnace construction and is followed by a short section on "Operation and Maintenance". Finally, the problem of air pollution is discussed in terms of smoke, with an explanation of the "Rigelman Chart for Grading Density of Smoke", and fly ash, with some useful, but dated, data on particle size and chemical analysis of emission.

"On-Site Incineration" deals in much the same way with domestic, commercial, and institutional incinerators. The pros and cons of on-site systems are examined, the various types of incinerators briefly described in terms of the technology involved, criteria for evaluation is provided and various cost factors are briefly examined. A final section on "The Future of On-Site Incineration" deals with municipal air pollution ordinances and the place of this type of disposal in the overall waste management scheme.

2. INCINERATION

Author: Richard B. Engdahl and staff of the Battelle Memorial Institute, Columbus Laboratories.

Publisher: A section in Solid Waste Processing: A State-of-the-Art Report on Unit Operations and Processes, Report (SW-4c) in the Bureau of Solid Waste Management Series, U.S. Department of HEW, Public Health Service, Publication #1856, 1969. (72 pages; $0.75), OSWMP No. 114, Second Printing, EPA, 1971.

Level: Non-technical.

Summary: This is a short review of the material in the chapter on incineration in Municipal Refuse Disposal (Ref. VII-1) and the authors have simply excerpted the more pertinent descriptive material and cost data and summarized them under five headings: General Characterics of the Incinerator Process, Kinds of Furnaces, Industrial Incineration, Capital Costs and

2. "INCINERATION" (cont'd.)

Operating Costs. Only minimal information is provided as to the technology involved in incineration and all of the practical guides as to construction, operation, and maintenance problems have been omitted. Several cost tables are included, however, and, while this in no way compares to the usefulness of the original reference, it does provide a quick summary of incinerator cost data. A bibliography is appended to the report.

CROSS REFERENCES

1. "Incineration", pp. 50-54 in Solid Waste Management (Ref. I-3; also appears in Ref. I-1, Part 2, pp. 751-754.

2. "Incineration - A Practical and Scientific Approach", pp. 59-70; "Ingenuity and Incinerators", pp. 70-72; "Fluid Bed Incinerators Studied for Solid Waste Disposal", pp. 75-78, in Solid Wastes (Ref. I-8).

3. "Incineration", pp. 12, 16-18 and 20-24 in Comprehensive Studies of Solid Waste Management: Third Annual Report (Ref. III-2).

4. "Incineration", pp. 81-86, 93-100 and 155-164 in Comprehensive Studies of Solid Waste Management: First and Second Annual Reports (Ref. III-1).

5. "National Analysis: Incinerators Only", pp. 471-483 in Preliminary Data Analysis (Ref. I-6).

6. Chapter 8 in Third Pollution (Ref. XII-2).

7. "Disposal by Incineration", pp. 222-224 in Waste Management Research and Environmental Quality Management (Ref. I-2).

8. "The Role of Facilities and Land Disposal Sites", pp. 27-43 in An Interim Report (Ref. I-7).

9. Testimony of Mr. Arpin ("Montreal's Incinerator") pp. 1961-1964 and of Mr. Leonard (Synthetic fuels; fly ash) pp. 2057-2064 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

10. "Incineration", pp. 93-100 and "Incineration" (Appendix B), pp. 115-125 in Resource Recovery Act of 1969 (Ref. I-1, Part 1).

11. "Combustion Power Unit - 400 - CPU 400", pp. 535-550 and "Solid Wastes Pile Up ...", pp. 376-383 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

VIII. MUNICIPAL SOLID WASTE PROCESSING: COMPOSTING

1. COMPOSTING OF MUNICIPAL SOLID WASTES IN THE UNITED STATES

Author: Prepared by members of the Federal solid waste management research staff under the direction of Andrew W. Breidenbach, Director, Office of R and D, Office of Solid Waste Management Programs.

Publisher: An environmental protection publication in the solid waste management series (SW-47r), Environmental Protection Agency. (Washington, D.C.: USGPO), 1971. (103 pp.; $1.00) OSWMP No. 212.

Point of View: "Composting, properly practiced, can be a nuisance-free way to recycle organic solid wastes without significantly polluting water and land resources. Composting municipal refuse is technically feasible, but it costs more than sanitary landfilling and can cost more than incineration. The problems that have prevented composting from becoming an accepted method of solid waste treatment relate primarily to the inability of local governments to accept the concept that the process should be properly supported by adequate municipal funds, as are incineration, sewage disposal and water treatment."

Level: Non-technical. Data Presented in charts and graphs.

Summary: Several unique features of this report make it a particularly useful basic reference on composting. It contains both a general discussion of the American and European composting experience (with comparative data and descriptions on some 30 systems) and a specific reporting of two federally sponsored projects designed to investigate and demonstrate the economic and technical feasibility of composting municipal refuse. A very good, although now somewhat dated, bibliography, is appended, interesting tables and graphs appear throughout the report, and a brief "summary" section at the beginning provides a concise review of the author's major conclusions. The report itself is divided into six sections: "Background", "Composting Municipal Refuse: Processes and Types of Plants" (including a section on some recent applications of composting), "Engineering, Chemical, and Microbiological Aspects of Composting" (including a discussion of environmental aspects), "Economic Considerations" (Capital cost, operating cost and partial recovery of costs), "Agricultural and Horticultural Utilization of Municipal Compost", and "Potential of Municipal Refuse Composting in the United States." This latter section is particularly interesting as it reiterates the EPA theme that environmental impact must be weighed against "actual" costs if the true economics of a system are to be examined.

2. COMPOSTING

Author: Prepared by the American Public Works Association with assistance from the U.S. Public Health Service.

Publisher: Chapter 9 (pp. 279-316) in Municipal Refuse Disposal, American Public Works Association (Chicago: Public Administration Service), 1966. (528 pp.; $15.00).

Point of View: " ... experience in Europe and with experimental operations in the United States indicate that capital and operating costs of a compost plant may, under favorable conditions, be similar to costs for an incinerator. The major advantage of the process appears to be that it produces a potentially marketable and useful product. However, unless some economically beneficial use is actually made of the end product, composting will be of limited value as a means of municipal refuse disposal."

Level: Non-technical. Illustrated; numerous graphs and tables.

Summary: This APWA chapter on composting begins on the above cautionary note and so shares the "economic deterrent" philosophy that is frequently cited in arguments against composting of municipal wastes. While there are those who argue that market considerations should not be the controlling criteria in choosing between alternative waste treatment methods (see Refs. VIII-I

2. "COMPOSTING" (cont'd.)

and 5) this article provides a clear statement of the economic realities faced by municipal engineers and government officials. Some historical perspective is provided in an opening section which reviews composting efforts in Europe and Indian and briefly summarizes several American studies undertaken in the 1950's. Several references to more recent American developments are provided. The pros and cons of composting as a municipal waste treatment method are then examined, and the authors quickly deal with several factors of the problem, including compost as fertilizer and its competitive position with on-going farming practices (chemical fertilizer, "green manure", etc.). The section ends with a concise table of advantages set against disadvantages. The bulk of the chapter, however, is concerned with the technology and mechanics of composting as an engineering process. "Fundamentals of Composting" reviews the numerous components of the process: types of biological decomposition, raw materials, particle size, moisture and liquid content, aeration, temperature control, acidity and alkalinity, microorganisms, changes during composting, concentration of volatile acids, and public health aspects. Operational considerations such as practical methods of composting, mechnical systems, modified windrowing and area methods and capital and operating costs are discussed briefly and a rather lengthy section is directed to "Plant Design and Operation". The question of end-product marketing is again addressed and the authors suggest the following: "Initially, a large amount of compost must be sold to farmers at about the cost of production. A realistic analysis of a compost plant must be based on this premise, although better markets may develop later ... Retail sales and distribution of compost can probably best be done by private enterprise ... Ultimately, commercial fertilizer companies will probably be the main distributors of compost."

3. SOLID WASTE MANAGEMENT/COMPOSTING: EUROPEAN ACTIVITY AND AMERICAN POTENTIAL

Author: Samuel A. Hart, University of California, Dept. of Environmental Engineering.

Publisher: Report (SW-2C), U.S. Dept. of HEW, Public Health Service Publication #1826, Consumer Protection and Environmental Health Service, EPA Solid Waste Program (Washington, D.C.: USGPO), 1968. (40 pp.; $0.50) OSWMP No. 55.

Point of View: "Rough-quality compost, cheaply produced, without grinding or fine screening, has real potential for the reclamation of spoiled lands (as from mining), for the prevention of erosion, for reduction of the volume of material going into a landfill, and as a cover material for above-ground landfills. A further and even more favorable avenue of composting practices will be to consider land as an acceptor of compost rather than compost as a benefit to the land."

Level: Non-technical; illustrated.

Summary: Western Europe has long had a reputation for success in the composting of refuse and this study was undertaken in the hopes of learning from that experience applications which might strengthen American composting efforts. As two short introductory chapters point out, however, the European system is not without its problems. Most serious are reliance on a very limited market, luxury agriculture, and high production costs. Fourteen plants, most of them in Germany, were visited and a brief operational description of each is provided. The real focus of the report, however, is on compost utilization and that is the topic of the next three chapters. The first of these, "Compost Utilization in Europe", provides a discussion of existing compost markets and presents data on sales distribution and end-use in Holland and Germany. "European Research in Compost Manufacture and Use" summarizes several German programs dealing with different facets of composting: engineering technology, public health problems, mineland reclamation, vineyard soil erosion prevention, and compost utilization in basic agriculture. Data on each experiment is provided in graphs and tables. Many of the conclusions and recommendations in the last two chapters are then extrapolated from the European program and research implications. "The Potential for Composting and Compost Utilization in the U.S." suggests three specific areas in which composting has potential in the U.S. and then examines two "conditions", "Compost for luxury agriculture" and "Compost has Value and Economics do Not Control" which impinge on the success of any American large-scale composting effort. A final section, "Recommendations for U.S. Composting Research" suggests six specific areas for research (marketing research, composting cost studies, wasteland reclamation research, pesticide degradation in organically enriched soils, pathogen survival research, and the land as an acceptor of wastes) and provides a summary section

3. SOLID WASTE MANAGEMENT/COMPOSTING: EUROPEAN ACTIVITY AND AMERICAN POTENTIAL (cont'd.)

briefly detailing the major conclusions of this study, among them the finding that "compost utilization in the U.S. appears to have limited potential".

4. RENEWING THE SOIL

Author: Judith G. Meyer.

Publisher: Environment 14 (2): 22-24, 29-32, March 1972.

Point of View: "In addition to the agricultural benefits, composting offers an attractive way to reduce pollution by making ecologically sound use of ... wastes ... The difficulty is that composting for application to the soil costs more than alternative methods ... The experience in industrialized countries has been that compost cannot compete economically with chemical fertilizers".

Level: Popular; illustrated, several tables.

Summary: This is a concise, thoughtful statement of the environmentalist's agrument for composting: environmental costs must be weighed in with traditional market costs when evaluating alternative waste treatment methods. Incineration and landfill, although now "cheaper" by traditional standards, pose long-term pollution and resource-depletion problems. Composting, although now prohibitively expensive to most communities, presents the most environmentally sound method of waste treatment. As a basis for this argument, Meyer first explains how compost is formed and its value as a soil conditioner. Several problems with compost are then touched on as reasons for its not being adopted in the U.S.: high production cost, limited sales market, presence of heavy metals in some composted wastes, etc. Despite these drawbacks, municipal refuse composting has had some trial in Europe and the Middle East and the problems and successes there are briefly reviewed. Again, most of the problem is economic and a quick look at the composting process itself is provided to explain some of the costs. Eight steps are delineated: aerobic or anaerobic decomposition, magnetic separation of salvagables, shredding or grinding, carbon-nitrogen chemical interaction, moisture control, aeration, stacking, and curing and/or drying. Ecological effects are then examined and the benefits of compost are contrasted with the drawbacks associated with incineration, landfill, and chemical fertilizers. Several existing and proposed composting programs are described with particular emphasis on Ecology, Inc., the successful Brooklyn composting facility. Finally, the essential dilemna, actual costs versus environmental value, is again examined and Meyer concludes: "The lack of immediate financial return on composting is not a justification for withholding individual, municipal, state or federal support ... support of compost production and utilization could, in the long run, prevent and reverse environmental damage wrought by presently economical soil-treatment and waste-disposal methods".

5. GARBAGE AS YOU LIKE IT

Author: Gerome Goldstein, executive editor, Rodale Press, and author of numerous books and articles on environmental problems.

Point of View: "Of all alternative methods for treating municipal wastes, compost is the only process that creates a potentially-useful material. It conserves as it treats, as opposed to a process that destroys as it treats. Compost is an optimistic practice, conserving wastes in the belief that future researchers will develop uses for waste. And, compared to other treatment methods available to cities, composting wastes is economical".

Level: Popular; illustrated.

Summary: This is very much the citizen's Bible on composting, with little in the way of unbiased factual information and a lot in the way of an ecological call-to-arms. But, with that limitation understood, it's a very readable and thorough attempt to state the case for composting municipal solid wastes. There are some twenty chapters in all, dealing with everything from the composting process itself (see, in particular, the appendix, "Technical and Mechanical Aspects of Composting") to the "collect and destroy philosophy"

5. GARBAGE AS YOU LIKE IT (cont'd.)

in American solid waste management and the need for new marketing strategies ("Selling Composted Garbage Like Toothpaste"). Several on-going programs are examined and the role of existing Federal legislation is reviewed. Goldstein concludes that one thing that is badly needed is new legislation based on a new assumption: "We must get our officials to stop looking at compost as if this were a new way to make money and begin to look at it as a new, less expensive, more beneficial way to treat waste." Among the more unique benefits Goldstein explores in some detail are those to the urban poor ("Anti-Poverty and Anti-Pollution or Add a C to the Old CCC") and those to the recipients of American foreign aid ("How to Beautify the Ugly American"). Finally, in "Technology versus Man (Can Man Win)" and "Creative Conservation and the Compost Philosophy "the theme of man's responsibility to the environment is reiterated and several spokesmen for the environmental movement are quoted. The message is clear: "We must create resources, not dumps. Then and only then will we achieve genuine creative conservation. Then and only then will we achieve the goal of improving the world around us."

6. SAMPLE ARTICLES FROM COMPOST SCIENCE

Publisher: Compost Science is published bi-monthly by Rodale Press, Inc., 33 Minor Street, Emmaus, Pa. 18049.

Point of View: "Compost Science reports the entire field of large scale composting and recycling of organic wastes. It provides the technical, scientific and practical information to enable the composting process to achieve its fullest state of development as a means for conversion of municipal, agricultural, and industrial wastes into useful products."

Level: Varies from popular "how-to" type articles to fairly sophisticated reporting of scientific experiments.

Summary: This is a very useful journal for anyone wishing to keep current with developments in large scale composting and with related advances in recycling and landfill technology. There are numerous articles in issues from the last two years that would be appropriate to this packet. To cite just a few as examples: "Composting Perspectives - Progress Since 1950" (July/August 1972) provides a quick summary of the direction in which compost technology has been moving and the kind of acceptance and resistance its adoption as a municipal process has met; "The Economics of Composting Municipal Wastes" (July/August 1972) deals first with the limitations of classical economics in evaluating social value programs and then provides some interesting cost data from existing U.S. composting plants; "Controlling Environmental Parameters for Optimum Composting" (January/February 1972) is the first in a series of papers reporting the results of experiments carried out over a four year period to investigate several variables in the composting process. This paper deals specifically with temperature effects and provides some interesting data to support the more efficient composting rate achieved in the experiment: "Four Leaf-Composting Communities" examples the "how-to" type articles which appear in the journal and reviews the experiences of four communities with leaf-composting projects. Special attention is paid to the operational details of the projects and to problems the communities encountered so as to provide a guide for other communities considering such projects.

CROSS REFERENCES

1. "Composting", pp. 89-91 and 100-104 in Comprehensive Studies of Solid Waste Management, Third Annual Report (Ref. III-2).

2. "Composting Conversion Processes", pp. 55-66 in Recovery and Utilization of Municipal Solid Waste (Ref. X-1).

3. "Composting", pp. 54-55 in Solid Waste Management (Ref. I-3).

CROSS REFERENCES (cont'd.)

4. "Air Classification for Reclamation of Solid Wastes", (Ref. XI-4).

5. "Composting Conversion Processes", pp. 55-66 in Recovery and Utilization of Municipal Solid Waste (Ref. X-1).

IX. MUNICIPAL SOLID WASTE PROCESSING: SANITARY LANDFILL

1. SANITARY LANDFILLS

Author: Prepared by the American Public Works Association, with assistance provided by the U.S. Public Health Service.

Publisher: Chapter 4 (pp. 89-140) in Municipal Refuse Disposal (Chicago: Public Administration Service), 1966. (528 pp.; $15.00).

Level: Non-technical. Several illustrations and engineering drawings.

Point of View: "Recently, use of the sanitary landfill method has had to be curtailed in a number of large cities ... because of the difficulty of finding suitable sites within economic haul distances and the need to preserve sites for disposal of non-combustibles .... Nonetheless, the sanitary landfill method of refuse disposal will continue to find users among small cities and, for that matter, some large cities, at least until a more economical and sanitary method is devised".

Summary: Six major aspects of the sanitary landfill method of solid waste treatment are examined in this chapter: Site Selection, Site Preparation, Equipment and Personnel, Costs, Special Problems, and Use of Completed Landfills. Throughout, the discussion is objective and factual, aimed, as is this whole volume, as a user's manual for municipal engineers and officials. Site selection, described as "the most important pre-operational step in developing a satisfactory landfill program", is discussed in terms of the criteria which determine the suitability of a geographical area for use as a sanitary landfill site. These include the following, each of which is briefly but separately discussed: public health and safety, land requirements, topography, availability of cover material, proximity to residences and industry, accessibility, drainage, zoning regulations, etc. Once these requirements are met, the site must be "prepared" and the next section provides guidelines for such operations. First, an engineering survey is recommended, with careful attention to such details as topography and volume requirements. Suggestions are then provided for the construction of access roads, fencing, facilities for personnel and equipment, weighing facilities, and the type of cover material to be used. Special requirements for landfills in dry areas (both "area" and "depression" types) and in wet areas (swamps and marshes, tidal areas, ponds, quarries, and standing water depressions) are detailed separately. Under "Equipment and Personnel" various types of equipment are evaluated in terms of size, special features, etc. and data, extrapolated from APWA surveys, used to estimate the number of men needed to operate various size fills. Costs are treated very briefly and the reader is referred to a later chapter, "Management of Disposal Facilities" for additional data and details. Some idea of the potential environmental problems associated with sanitary landfills emerges in the next two sections, "Special Problems" (dust, odors, ground and surface water pollution, etc.) and "Settlement and Decomposition". All but the latter are dealt with as minor problems that can be engineered away and, although the serious aspects of explosions due to decomposition are eventually noted, a rather remarkable paragraph introduces the section, describing how workers at one site tapped into a decomposing section to get a gas flame for heating coffee. The following chapter, "Uses of Completed Landfills", notes the suitability of such sites for parks, playgrounds, golf courses, parking areas, landing fields, and light industrial or commercial buildings. Guidelines as to the special care in engineering needed to assure the safety of these structures are provided. Finally, "Landfills in Small Towns" points out the economic advantages of the fill method for towns of 5,000 and less population.

2. SANITARY LANDFILL: DESIGN AND OPERATION

Authors: Dirk R. Brunner and Daniel J. Keller, U.S. EPA, Solid Waste Management staff.

Publisher: An environmental protection publication in the solid waste management series, SW-65ts (Washington, D.C.: USGPO), 1972, (60 pp.; $0.65), OSWMP No. 287.

Point of View: "An acceptable alternative to the present poor practices of land disposal is the sanitary landfill ... A sanitary landfill is not only an acceptable and economic method of solid waste disposal, it is also an excellent way to make otherwise unsuitable or marginal land valuable".

2. SANITARY LANDFILL: DESIGN AND OPERATION (cont'd.)

Level: Semi-technical. Numerous drawings, diagrams and tables.

Summary: This is a thorough and up-to-date review and evaluation of sanitary landfill technology. It is much more detailed than the APWA study (Ref. IX) and has the added advantage of drawing directly on the results of several EPA supported research activities. Its focus, however, is slightly different and this is not so much an engineering manual as a technical assessment of all the various facets involved in fill design and operation. The first half of the report deals with design factors and separate chapters are assigned for discussion of "Solid Waste Decomposition" (leachate, contaminate removal, decomposition gas), "Hydrology and Climatology" (surface water, groundwater), "Soils and Geology" (soil cover, land forms) and "Sanitary Landfill Design" (volume requirements, site improvements, control of surface water, groundwater protection, gas movement control, sanitary landfilling methods, summary of design considerations). Within each chapter, data and research findings are cited to support the author's conclusion and recommendations. When appropriate, drawings and tables are provided. Chapters 6 through 9 deal with operational factors in landfill technology and again the discussions are quite detailed. "Sanitary Landfill Operation" provides guidance in everything from suggested laws of operation and methods of weighing solid waste to recommendations for handling specific wastes (dead animals, pesticide containers, etc.) and general maintenance procedures. The chapter on "Equipment" follows and is divided into sections on equipment functions, types and characteristics (with illustrations, table of performance characteristics and horsepower needs) and costs. Two final chapters examine the uses and management of completed sanitary landfills. Problems of decomposition, varied density, settlement, bearing capacity, landfill gases and corrosion are briefly outlined and several uses for the fill are noted: green areas, agricultural construction (here the costs and potential problems are well delineated) and recreation (ski slopes, golf courses, etc.).

3. ROLE OF SANITARY LANDFILLING IN SOLID WASTE MANAGEMENT

Author: Ralph J. Black, Assistant Director for State and Local Affairs, Environmental Protection Agency, Solid Waste Management Office.

Publisher: Waste Age, September/October 1972. (Reprinted for distribution by EPA Solid Waste Management Office).

Point of View: "At present, more than 90% of our Nation's solid waste is disposed of directly on land. Since sanitary landfilling is the only acceptable method of disposing solid waste on land, the Federal solid waste management program ... will continue to promote its use and to seek ways of improving sanitary landfill technology".

Level: Popular. Illustrated, bibliography.

Summary: This is a short paper addressed to the realities of sanitary landfill as a municipal waste disposal method: lack of public acceptance, difficulty in finding suitable sites, high operating costs of modern equipment, and environmental problems inherent in the process itself. With all those negatives one might expect a rather discouraging portrayal, but to the contrary, the EPA here takes the position that landfill is here to stay and what is needed is continued research for improved technology. Each objection to the process is answered in turn. Black notes that: "It is possible to win public support, even enthusiasm, for sanitary landfills" and cites evidence from the Southern California experience. As to the difficulty in finding suitable sites, several EPA projects aimed at demonstrating the use of such new sites as abandoned strip mines, gullies (a Nebraska experiment) and high water-table site alternatives like the trash mountain constructed in Virginia Beach are cited. Under "Equipment" several new machines are described and, although their operating costs are noted as quite high, it is suggested that "they may prove feasible and economically practicable under conditions where established sanitary landfill techniques cannot be used". Finally, "What Happens in a Landfill" looks at a rather serious problem: "Even after they have been buried in a sanitary landfill, wastes can damage the environment and affect the ultimate use made of the completed site". Black notes the continued EPA support of projects concerned with this aspect of sanitary landfills and cites the results of several such experiments: a West Virginia University project to study the microbiology of sanitary landfills, a demonstration project in Santa Clara, California, to study the aeration process, etc. In addition, he addresses the problem of water pollution associated with sanitary landfills, notes several EPA projects looking into this aspect, and suggests that: "The possibility of such pollution can be normally eliminated by proper planning and site selection, combined with good engineering design and careful operation". Several recommendations along those lines are suggested. Finally, in "Long-Term

3. "ROLE OF SANITARY LANDFILLING IN SOLID WASTE MANAGEMENT" (cont'd.)

Planning", Black deals briefly with the problem of financing purchase of sites for future use and points out data suggesting that a $5 million investment in land can provide the same disposal capability as a $300 million investment in incinerators. He concludes:

" ... we feel that most of the United States has no choice but to use the land for disposal. In the process, the land can be despoiled, or it can be protected and enhanced. Sanitary landfill techniques make the difference."

CROSS REFERENCES

1. "Sanitary Landfill", pp. 86-89 and 104-105 in Comprehensive Studies of Solid Waste Management, First and Second Annual Reports (Ref. III-1).

2. "Landfill", pp. 12, 16, 19 in Comprehensive Studies of Solid Waste Management, Third Annual Report (Ref. III-2).

3. "Sanitary Landfill Operation Agreement and Recommended Standards for ... Design and Construction", pp. 1997-2033 and "An Accounting System for Sanitary Landfill Operations", pp. 2023-2040 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

4. "Solid Wastes Pile Up ...", pp. 376-383 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

5. "The Role of Facilities and Land Disposal Sites", pp. 27-43 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

6. Chapter 8 in Third Pollution (Ref. XII-2).

X. SOLID WASTE RECOVERY: SALVAGE, RECYCLING, AND REUSE

1. RECOVERY AND UTILIZATION OF MUNICIPAL SOLID WASTE: A SUMMARY OF AVAILABLE COST AND PERFORMANCE CHARACTERISTICS OF UNIT PROCESSES AND SYSTEMS

Authors: N.L. Drobny, H.E. Hull, and R.F. Testin, Batelle Memorial Institute, Columbus Laboratories. Prepared under a grant from the Solid Waste Management Office, U.S. EPA.

Publisher: An environmental protection publication (SW-10c) of the Solid Waste Management Office, available also as Public Health Service Publication No. 1908 (Washington, D.C.: USGPO), 1972. (118 pp.; $1.75)OSWMP Order No. 177.

Point of View: "Based upon information collected, it is considered that solid waste recovery may never become economic in the engineering sense, but that the external diseconomics and social costs associated with the disposal-oriented methods of solid waste management may provide a strong motivation for continued development of solid waste recovery techniques".

Level: Semi-technical; illustrated, numerous graphs and tables.

Summary: This is an extremely thorough and careful analysis of all available cost and performance characteristics of unit processes that are, or might be, employed in solid waste recovery and utilization. Three main areas are covered: size reduction, separation, and recovery. The primary information source for the study was contact with more than 200 operators of existing processing systems, equipment manufacturers, and selected experts. The first three sections provide a brief overview, setting recovery of wastes in the context of current waste management practice and providing a quick look at the recovery potential of solid waste. The authors then examine the principles of size reduction (tension and compression forces, shear forces, theoretical power requirements), current equipment designs, and existing and estimated performance and cost data, etc. In "Separation", the discussion is subdivided into two sections, one on unit processes for separation. The bulk of the report, "Recovery and Utilization" is then focused on selected treatment processes: composting conversion, heat recovery and chemical conversion. The technology and economics of fly-ash utilization is examined and a final sub-section examines separately the salvage process and potential associated with each of several items: tin cans, glass, plastics, rubber, rags and incinerator residues. The concluding section begins by noting the need for more data and recommends that the Bureau of Solid Waste Management fund both experimental studies and full-scale operations so that "reliable and meaningful" data can be obtained. Two major conclusions are then put forward: one, that "In the area of recovery and utilization of mixed solid waste, by-product recovery appears to have significantly greater economic potential in the classical sense than does salvage and should be given priority for R and D"; and the other, that, even though "recovery and utilization of municipal solid waste may never become generally economic in the classical sense", development of the techniques for the recovery of material from solid waste "must continue to be explored".

2. RECYCLING: ASSESSMENT AND PROSPECTS FOR SUCCESS

Author: Arsen Darnay, Director, Resource Recovery Division, Office of Solid Waste Management, U.S. EPA.

Publisher: An environmental protection publication (SW-81) in the solid waste management series (Washington, D.C.: USGPO), 1972. (14 pp.; OSWMP Order No. 286).

Point of View: "Recycling today is declining in importance in the market even as interest in resource recovery is rapidly increasing. Resource recovery is not viewed as a particulary attractive solution to the solid waste problem in the short term, except possibly the recovery of energy from mixed combustible wastes. In the long run, resource recovery will become a necessary part of our materials-use practices; this will be brought about by the creation of new incentives".

2. RECYCLING: ASSESSMENT AND PROSPECTS FOR SUCCESS (cont'd.)

Level: Popular; illustrated.

Summary: This is a clear, concise statement of recycling as perceived by the Director of the government agency responsible for carrying out the directives outlined in the Resource Recovery Act of 1970. While it is a discouraging assessment in many ways, it is a most realistic one in terms of the Federal government's attitude and commitments. Darnay begins with a brief look at "philosophical perspectives", pointing out the imbalances and waste of post-industrialized modes of behavior and the need for new perspectives on resource utilization. In "Recycling Today" Darnay examines several facets of the problem: the materials cycle, the interrelationships between resource recovery, pollution and energy use, resource recovery technology and incentives, and the relationship between recycling and solid waste management. The focus in this section is on the need for incentives: " ... incentives must be created or, to put it bluntly, recycling must be subsidized for whatever period is needed to wean the Nation from a nearly exclusive reliance on virgin resources". This theme is then elaborated in terms of the prospects for recycling. General program directions are outlined and a clear look at the EPA program is provided. Of particular interest here is the EPA checklist of requirements and criteria which "if adhered to, should result in economically healthy resource recovery facilities". The justification for these creiteria is explained in terms of the U.S. experience with compost plants and Darnay notes that a similar "history of failure" and "dismal record" must be carefully guarded against. He concludes by noting the current decline of recycling importance in the market and calling again for the creation of new incentives.

3. RESOURCE RECOVERY; RECYCLING AND REUSE

Author: Citizens' Advisory Committee on Environmental Quality.

Publisher: A section (pp. 33-41) in the Annual Report to the President, and to the Council on Environmental Quality for the Year Ending May 1972 (Washington, D.C.: USGPO), 1972, (10 pp.; OSWMP Order No. 307).

Point of View: "To deal with the anticipated increase in solid wastes and to conserve our vital natural resources, this country must implement now a policy of maximum resource recovery, recycling and reuse".

Level: Popular.

Summary: This brief summary highlights recommendations from a special report sent by the Citizen's Advisory Committee on Environmental Quality to the president in December 1971. The focus here is on isolating those mechanisms available to the Federal government which would effectively encourage resource recovery, recycling and reuse. The report reviews proposed national policy, governmental and private sector responsibilities, the need for full-scale demonstration facilities, federal tax and purchasing policies, new market incentives, freight rates, citizen action, and the special problems of reclaiming lubricating oil and tires. The Committee concludes that "the Federal commitment is inadequate" and details the scale of Federal solid waste expenditures in relation to those for air and water pollution. Allocation of Federal funds for demonstration projects is sharply criticized and the report notes that in several important areas, not a dollar of allocated funds has yet been spent. A number of Federal tax incentives, disincentives and government procurement policies are recommended as means to provide economic incentive to private industry, to stop practices which needlessly intensify the solid waste problem, and to conserve natural resources. The need for the development of new markets for salvage materials is emphasized, and the report points out those ways in which the Federal government, through its massive purchasing power, could stimulate various salvage markets. The ICC freight rates, which have effectively discouraged recycling by making it cheapter to ship virgin products than reclaimed ones, are isolated as an example where policy change is badly needed and where the government could demonstrate its commitment to conservation of resources. In brief, this is a very useful introduction to the ways in which Federal policy has worked to impede recycling efforts and a clear statement of the ways in which Federal policy change could bring real incentive to a national recource recovery effort.

4. SALVAGE AND RECLAMATION

Author: Prepared by the American Public Works Association with assistance provided by the U.S. Public Health Service, Dept. of HEW.

Publisher: Chapter 10 (pp. 316-331) in Municipal Refuse Disposal (Chicago: Public Administration Service), 1966. (528 pp.; $15.00).

Point of View: "Salvage and reclamation as a disposal method should be carefully considered and a decision made on the basis of engineering and cost studies .... Perhaps the most serious problems in using salvage and reclamation even as a partial disposal method are the lack of stable markets and reasonable prices for salvage materials".

Level: Non-technical; illustrated, several tables.

Summary: The first half of this chapter examines the market and cost factors which affect the economic potential of salvage as a waste treatment alternative. Not surprisingly, the data suggests very little future in reclamation as a "principal disposal method". Price fluctuation data for salvage goods such as rags, paper and paper products, tin cans and bottles and rubber are provided for comparison and a few comments are offered on the technological impediments to greater salvage utilization. A number of plants designed for salvage operations are briefly examined and evaluated as to the operational and economic problems encountered. A section on "Partial Salvage" then looks at the areas in which most current salvage operations are involved. This is broken down into seven subsections: salvage at the source, at incineration plants, fly ash, waste heat, salvage at landfill sites, rendering, dehydration of garbage and automobile salvage. None of these aspects is examined in much detail, but the scale of operation is outlined. The chapter concludes: "The record indicates that although paper, cardboard and rags will continue to find their ways to mills, most cities do not find it aesthetically or economically practical to use salvage as a principal means of disposal. The trend is toward partial salvage".

5. THE NEW RESOURCE

Author: Robert R. Grinstead, research chemist, Western Division Research Center, Dow Chemical Company.

Publisher: Environment 12: 3-17, December 1970.

Point of View: "The flood of trash which threatens to engulf us can be a source of valuable materials ... the biggest problem, waste paper, is also the most valuble new resource".

Level: Popular; illustrated, several tables and a brief bibliography.

Summary: Defining recycling simply as "returning the wastes to the economy in a way that will provide some utility in any form", Grinstead provides here an overview of current waste reclamation practice and a brief look at the potential of several developing technologies. The rationale for recycling is summarized under three aspects: the reduction or elimination of waste material, potential credit toward the cost of managing waste material, and reduced pressure on the corresponding virgin material. Under "What's in Trash", the components of typical trash are analyzed as to their value as bulk material and their potential value of these materials (scrap iron, aluminum, scrap glass, clear wastepaper, etc.) could be recycled into specified forms. Several additional yardsticks for evaluating proposals for recycling trash are then presented, ranging from the costs of separating out the various materials to the costs of disposing of the final residue. In "Current Recycling Methods" existing trash disposal practices are reviewed in terms of the uses to which paper waste are put in each process. Metal and glass in trash are dealt with separately in "The Indestructable Pair" and product yields and potential value of developing technologies for trash recycling are described briefly. Finally, Grinstead notes that one of the major problems to be faced is that of extending our materials technology to include production of materials from waste sources. A brief review of government

5. THE NEW RESOURCE (cont'd.)

involvement in recycling is provided and Grinstead concludes with a call for two changes in official attitude: "First we need to treat waste material industries on at least an equal basis with virgin material industries and, second, we need to establish some sort of feedback between the disposal process and the material manufacturing process".

6. MACHINERY FOR TRASH MINING

Author: Robert Grinstead, research chemist, Dow Chemical Company.

Publisher: Environment 14: 34-42, May 1972.

Point of View: "The technology for profitable recycling of municipal trash is being developed, and the era of the incinerator and landfill may be ending. Recycled paper sales will probably be the most important factor".

Level: Popular. Illustrated. Bibliography.

Summary: This second (See Ref. X-5) and briefer article of a two part series on urban trash recycling deals with the technology by which various materials are recovered and provides an assessment of the current status of a number of systems.

Incineration is discussed as a resource recovery system in terms of its heat recovery or fuel potential. Several conventional incinerator systems where trash is used as fuel are described along with two rather innovative systems: the fluidized bed incinerator and the U.S. Bureau of Mines residue fractionating system. Cost data and discussion of operational considerations are provided for each system.

Pyrolysis is briefly described and compared as to its advantages over existing incineration techniques. The Monsanto Landgard system and the Garrett process are compared and described and brief note is given to several emerging systems: one at the Northern Recycling Corporation Queens, New York plant and the announced Union Carbide pure-oxygen system. The purported economic advantages of pyrolysis over conventional incineration are noted and some speculation provided as to the slow acceptance of pyrolysis in actual urban situations.

Composting is dealt with much more briefly. The process itself is described in a few lines and the remainder of this section focuses on existing and proposed composting plants and their economics and difficulties.

"Cellulose-Fiber Recovery" reviews the problems in recovering paper for recycling. Several existing processes are described, including the Metro Waste Corporation system and the Black Clawson process. The limitations, both technical and economic, on these and a number of other processes (including the Rust process) are reviewed. The general approach of "dry sorting systems" is then discussed and some detail provided on the vertical air sorter system commonly in use and a new system involving a ballastic principle.

A table on "Economics of Trash Recycling Systems" serves as the focus for a concluding section which summarizes the status of recycling technology and attempts to predict where we are going and when or whether we will get there. Several conclusions based on the figures for net costs of the various systems are discussed and their potential for the future evaluated. Finally, "The Big Bottlenecks" deals with those problems which are impeding the spread and development of recycling technology: lack of Federal demonstration grants, the absence of significant amounts of recycled materials which such plants could produce and market for evaluation, the absence of Federal support of research into cellulose fiber recovery, the absence of a link between the producing and disposal sections of the economy and, finally, the bottleneck of encouraging consumer demand for recycled materials.

7. PAPER RECYCLING: THE ART OF THE POSSIBLE

Author: William E. Franklin, Senior Environmental Economist, Midwest Research Institute.

Publisher: The American Paper Institute, Inc., New York, New York, March 1973. (181 pp.; $25.00).

Point of View: "The forces that led to the declining rate of waste paper recycling - availability of vast forest resources, unfavorable economics, competitive virgin fiber product specifications and performance, and more efficient pulpwood technology - still generally prevail. The importance of the forest as a fiber resource is likely to increase in the future. However, external forces should provide incentives and create new demand for recycled products, reversing the current trends in resource/use patterns and leading to a recycling rate of about 26 percent by 1985, compared to 20.5 percent in 1970".

Level: Non-technical; numerous graphs and tables.

Summary: This study is an examination of the resource/use patterns of the paper industry and the requirements for fiber resources, especially those derived from waste paper, to 1985. By design, the study focused on three objectives: 1) To evaluate future requirements for fibrous raw materials in the paper industry - with particular attention to the role recycling of waste paper will play; 2) To put in perspective the utilization patterns of raw materials resources - especially waste paper - that external economic and political forces will shape by 1985; and, 3) To determine the impacts on the paper industry of changes in resource utilization patterns - with a particular view to the development of the most productive actions that would meet both paper industry fiber resource/use requirements and related solid waste management objectives. A very useful summary of the report is provided in an introductory section that notes each of the report conclusions and details the data behind them. The body of the report is broken down into eight chapters: An Overview of Paper Industry Fiber Use Patterns, Forecasts of Paper Demand to 1985, External Factors Affecting the Paper Industry, Availability of Forest Resources to Meet Paper Demand, Availability of Waste Paper for Recycling, Technical and Economic Impacts on the Paper Industry of Increased Recycling for Six Major Product Groups (Linerboard, Corrugating Medium, Folding Boxboard, Newsprint, Printing and Writing Paper, Tissue), Analysis of Resource Use Patterns to 1985, and Alternatives to Recycling for Paper in Solid Waste. Five appendices include data and discussion on production and comsumption of paper from 1960 to 1971, effects of recycled fibers on quality of printing and writing papers, and waste paper collection and use in foreign countries. In short, this is a very clear and comprehensive statement of the paper industry's position toward recycling of waste paper and an invaluable data resource on U.S. paper production, consumption, and reuse.

8. RECYCLING OF PAPER

Author: J.J. Forsythe, assistant to the manager of Northern Division Research for International Paper Company.

Publisher: TAPPI (Journal of Technical Association of the Pulp and Paper Industry) 55: 679-690, May 1972. (Reprints available at $3.00 each from: TAPPI, Dept. E, 1 Dunwoody Park, Atlanta, Ga. 30341).

Point of View: "Until the late fourties recycling of waste paper was a fairly simple and straightforward recovery process. However, technological advances in adhesives, paper coatings, printing inks, polymer coatings, and other materials difficult to eliminate have created many problems in reusing waste paper today".

Level: Semi-technical; bibliography, several tables of data.

Summary: The major focus of this paper is on the factors involved in industrial recycling of paper. A brief section, however, is concerned with "fiber recovery from solid waste" and it is clear that many of the problems inhibiting industrial recycling will also bear on the potential of recycling paper from municipal wastes. There is much useful data in here on the current scope of waste paper usage and attention is given to each of several restrictions which limit the reuse of waste paper: grade quality, contaminants, mill equipment aesthetic factors, economic factors,

8. RECYCLING OF PAPER (cont'd.)

and availability of pulpwood supplies. The advantages of recycled fibers, mostly economic, are briefly noted. Processing of waste paper is then described under two categories, mechanical treatment and chemical treatment. The state-of-the-art in equipment and in process requirements for pulping, cleaning and screening, water removal, flotation, bleaching, asphalt dispersion, and waste disposal is briefly defined. Finally, the author briefly discusses fiber recovery from solid waste and describes the wet process system now in use. He concludes: "The economic aspects of recovering fiber from solid waste are presently not fully establishes .... The joint value of conservation of resources and a solution to municipal solid waste problems, however, justify continued research and development in this area".

9. RECYCLING CONTAINER GLASS - AN OVERVIEW

Author: John H. Abrahams, Jr., Manager, Environmental Pollution Control Programs, Glass Container Manufacturers Institute.

Publisher: A paper in the Proceedings of the Third Mineral Waste Utilization Symposium, Jointly sponsored by the U.S. Bureau of Mines and IIT Research Institute, held in Chicago, Illinois on March 14-16, 1972. To be published by the USGPO in Spring, 1973.

Point of View: "Recent studies have shown that as soon as collection and separation systems are developed to provide a continuous reliable source of waste container glass, there are potential uses for every bit of it available in the country now or in the foreseeable future".

Level: Popular.

Summary: This is the text of a state-of-the-art paper delivered at a Mineral Waste Utilization Symposium. To quote from the abstract: "Recycling of salvageable materials from municipal refuse is seen to be the long range solution to present solid waste problems. A major problem, however, is the collection, separation, and transportation of waste glass and other waste products. A number of separation systems for municipal wastes are being developed but few, if any, currently produce a pure and color sorted glass fraction that can be used in large quantities in glass furnaces. Container glass is shown to be about the most recyclable of all packaging materials. The highest level of use of waste container glass is believed to be back into glass furnaces to make new containers. Studies are continuing in order to increase the use of municipal waste glass in glass furnaces, and to determine the limits of its use. To obtain this waste glass, GMI is developing a subsystem designed to remove the glass fraction from the glass-rich mixture which will be discharged by the various proposed wet and dry systems for separating municipal refuse. Optical sorting completes the refining process by producing a metal-free color sorted glass sample. Glass-rich fractions which are only partially processed can be used in the manufacture of secondary products for road or building construction. In most cases, glass imparts a useful and beneficial property to the product. Almost all of these advances in technology are the result of accelerated industrial interests for proper management of solid wastes and the utilization of waste products".

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1. "Salvage", pp. 105-117 in Comprehensive Studies of Solid Waste Management, Third Annual Report (Ref. III-1).

2. "Reclamation and Recycling: An Economic Overview", pp. 20-25 in What's Ahead in Solid Waste Management (Ref. I-9).

3. "Report of the Autowrecking and Dismantling Industry", pp. 137-235 in Disposal of Junked and Abandoned Motor Vehicles (Ref. V-1).

CROSS REFERENCES (cont'd.)

4. "Reclaiming Solid Wastes for Profit", pp. 81-83; "Waste Recycling Really Works", pp. 83-85; and "Aluminum Scraps Find Second Life", pp. 26-28 in Solid Wastes (Ref. I-8).

5. "Bottles, Cans, Energy" (Ref. IV-7),

6. Design of Consumer Containers for Reuse or Disposal (Ref. IV-6).

7. "Availability, Utilization and Salvage of Industrial Materials", pp. 384-404 and Testimony of Victor Brown, pp. 331-337, in Resource Recovery Act of 1969 (Ref. I-1, Part 1).

8. "Summary of Investigation and Research by the Dept. of Mines ... on Extraction of Mineral and Energy Values from Solid Waste", pp. 577-580 and "Iron and Steel Scrap Consumption Problems", pp. 877-936 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

9. "Materials Recovery and Reuse as an Approach to Solid Waste Management: Economic Aspects and Implications", pp. 1811-1854 in Resource Recovery Act of 1969 (Ref. I-1, Part 3).

10. "Environmental Management Through Secondary Materials Utilization", pp. 2167-2177 and Testimony of Leon J. Coslor, pp. 2109-2122 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

11. "Report of the Role of Plastics in Solid Waste", pp. 2227-2260 in Resource Recovery Act of 1969 (Ref. I-1, Part 5).

XI. THE FUTURE IN MUNICIPAL SOLID WASTE MANAGEMENT

1. FUEL FROM WASTES: A MINOR ENERGY SOURCE

Author: Thomas H. Maugh II.

Publisher: Science 178: 599-602, 10 November 1972.

Point of View: "It is clear that, while conversion of organic wastes to fuels is an ideal way to dispose of the wastes, it is probably not a feasible method of averting an energy crisis".

Level: Non-technical.

Summary: This is a brief but useful summary of the potential evergy recoverable from the conversion of solid wastes to synthetic fuels. Three major conversion routes are examined: hydrogenation, pyrolysis and bio-conversion. Hydrogenation, because it is the most promising process, is described in some detail as to the chemistry of the process, the products yielded and its economic feasibility. The Garrett pyrolysis process is then described in similar detail. The final section of the article focuses on a RANN project at the University of Pennsylvania's Center for Energy Management to study the feasibility of converting urban waste to methane. The role which supplemental algae might play in such a conversion is briefly examined.

2. ENERGY CONSERVATION AND WASTE RECYCLING: TAKING ADVANTAGE OF URBAN CONGESTION

Author: Eugene Kramer, Urban Planner.

Publisher: Science and Public Affairs, (Bulletin of the Atomic Scientists) 29 (#4): 13-18, April 1973.

Point of View: "If our central cities are to survive . . . it will be necessary to develop systematic approaches for exploiting urban concentration and its inherent advantages".

Level: Popular.

Summary: The author points out the inherent advantages of urban concentration for energy conservation and waste disposal. For the former, the shorter distances to move people and energy (especially "waste" heat) should be utilized. While recognizing the disadvantages of locating large power plants in a city, Kramer urges use of the heat from existing urban power plants and more use of "total energy stystems"--small power plants with heat recovery--for apartment complexes, mass housing projects, etc. Generally, he urges an "integrated utility system" approach in which, for instance, waste heat from power plants would be used in liquid waste treatment, dried sewage sludge would be used as power plant fuel, etc.

In the treatment of waste materials, Kramer urges increased recycling and the locating of reclamation plants in the city to reduce transportation costs. He proposes an "Environmental Industrial Park", a complex located in a central city, producing electric power, heat and cooling water, salvaged materials, etc., and cites some examples of trials of this idea.

The paper is stimulating in its central idea and is also a useful summary of some of the beginning efforts of urban areas to carry out the implications of that idea.

3. AIR CLASSIFICATION FOR RECLAMATION OF SOLID WASTES

Author: Richard A. Boettcher, Program Manager, Solid Waste Technology, Stanford Research Institute.

Publisher: Compost Science II: 22-29, November-December, 1970. (Reprinted and distributed by the Office of Solid Waste Management Program, US EPA).

Point of View: "Preliminary research on air classification, as investigated with the zigzag air-classification unit developed by Stanford Research Institute, has indicated the feasibility of using this method of separation to process several types of solid waste mixtures".

Level: Semi-technical; illustrated.

Summary: Separation engineering has considerable bearing on the potential for the future success of reclamation and recycling efforts. In this article, a waste separating system is described which, because it is mechanized, continuously operative, and non-labor intensive, promises to be a potentially important process for the separation of selected salvage materials. Much of the initial discussion focuses on three criteria which must be met for satisfactory separation under this system: suitable feed preparation, control of particle dimensions, and the requirement that the particles flow in a granular fashion when fluidized by air. The laboratory unit used in this study is described and diagrammed in some detail. Separate sections deal with the unit's potential application in processing several items: compost from municipal refuse, auto body waste, wastepaper and glass and metal. Additional specialized applications are briefly noted. The authors conclude that the "zigzag" method detailed here has potential in the recovery of paper and of nonferrous metal from shredded auto body waste and that it can be a low cost process for increasing the marketability of compost. Design requirements for processing solid wastes with a full scale commercial unit are discussed and required supplemental equipment (shredders, screens, etc.) described. Cost estimates are provided and the article concludes with a brief listing of the findings of the study and of the limitations of the process.

4. GRANTS ENCOURAGE NEW WASTE DISPOSAL METHODS

Author: Anton J. Muhich, Director, Division of Demonstration Operations, Bureau of Solid Waste Management.

Publisher: Journal of Environmental Health 32(5): 572-578, March/April 1970. (Reprinted and distributed by Bureau of Solid Waste Management: OSWMP Order No. 121).

Point of View: "Our existing technology is adequate to permit the collection, handling, disposal, and perhaps even recovery of many of the materials in solid wastes in a more efficient and acceptable manner".

Level: Popular.

Summary: Several projects under grants from the Bureau of Solid Waste Management are outlined here. The descriptions are quite brief, but Muhich succeeds in at least painting a general picture of what improvements are in the immediate future for solid waste management. Studies described include those aimed at collection and transportation, recycling and reuse, land disposal, composting, and thermal reduction. Reiterating the Bureau's belief that the technology for improvement is here now, Muhich concludes: "Although our nation's solid waste load may be increasing, technologies and innovations pertinent to the total waste disposal problem are undoubtedly available well beyond our current utilization of them".

5. ST. LOUIS POWER PLANT TO BURN CITY REFUSE

Author: F.E. Wisely, Consulting Engineer, G. Wayne Sutterfield, St. Louis Refuse Commissioner, and David L. Klumb, Engineer.

Publisher: Civil Engineering 41 (1): 56-59, January 1971. (Reprinted and distributed by Bureau of Solid Waste Management: OSWMP Order No. 180).

Level: Non-technical; illustrated

Summary: The fuel potential of municipal waste has been discussed for some time and several incineration pilot projects have been undertaken here and abroad. This article very briefly reports the engineering and organizational steps involved in designing a waste

5. ST. LOUIS POWER PLANT TO BURN CITY REFUSE (cont'd.)

burning pulverized-coal boiler for the city of St. Louis. Several potentially attractive features of the process are enumerated and the theory behind it is briefly explained. Cooperation between the boiler manufacturer, the Bureau of Solid Waste Management and the National Air Pollution Control Administration in funding the project is described. A catalogue of potentially adverse effects and their resolution is provided along with a discussion of the attractive economics for long-range applications.

6. GLASS RECYCLING MAKES STUDIES

Author: Prepared by the magazine staff.

Publisher: Environmental Science and Technology 6 (12): 988-990, November 1972.

Point of View: "Container glass, when properly handled, is not a problem in municipal waste disposal system .... It can ideally be landfilled or incinerated, recycled into new packaging materials, or be reused as raw material for manufacturing secondary products".

Level: Popular; illustrated.

Summary: Asserting that "waste" glass is good for anything from road paving to chicken "grit", the glass industry here suggests several beneficial uses which glass will or might have in the future. None is very thoroughly explored, but the article does provide a catalogue of some of the interesting alternatives to the current "burn or bury" pattern. In "back to the furnace", some of the difficulties in using cullet are examined, particularly when foreign or colored glass is introduced. Various separation systems currently under study are briefly reviewed and several "secondary products" which might incorporate waste glass are noted. Particular attention is paid to the potential road and building construction applications of waste glass, ranging from "glassphalt" and reflective paints to mosaic tiles and cement building blocks. In fact, the author concludes that: "Ground glass could potentially replace cement in concrete and improve its properties and workability".

CROSS REFERENCES

1. "The Future", pp. 26-44 in Policies for Solid Waste Management (Ref. II-2; also Reprinted in RRA of 1969, Ref. I-1, Part 3).

2. "Emerging Technologies for Municipal Solid Waste" in What's Ahead in Solid Waste Management (Ref. I-9).

3. "Are Pipelines the Answer to Waste Collection Dilemna", pp. 52-58; "Plants Burn Garbage, Produce Steam", pp. 72-75; "A Solid Waste System for All Municipalities", pp. 78-81 and "Converting Solid Wastes to Electricity", pp. 85-87 in Solid Waste (Ref. I-8).

4. "Solid Waste Disposal Problems Arising from the Projected Output of Containers" (Ref. IV-8).

5. "Packaging for Food Systems of the Future", pp. 49-69; "Reclamation of Plastic-Paper Composites", pp. 121-135; "Paper Industry Plans", pp. 135-155; "Techniques for Self-Disposal", pp. 210-231 and "Design Trends in Glass Containers", pp. 171-185 in Design of Consumer Containers for Reuse or Disposal (Ref. IV-6).

6. "An Ideal Posture for Materials in the Year 2000", pp. 399-403 in Resource Recovery Act of 1969 (Ref. I-1, Part 1).

CROSS REFERENCES (Cont'd.)

7. "The Fusion Torch: Closing the Cycle from Use to Reuse", pp. 1075-1165 and "Navy Steam Generating Refuse Disposal Plant", pp. 227-228 in Resource Recovery Act of 1969 (Ref. I-1, Part 2).

8. Testimony of Joseph Leonard (synthetic fuels, fly ash, etc.), pp. 2061-2064 and of Richard Smith (burning wastes for fuel), pp. 2077-2109 in Resource Recovery Act of 1969 (Ref. I-1, Part 4).

9. Testimony of Richard Chevey (glass wool, bricks, beads, glasphalt, etc.), pp. 2211-2215 in Resource Recovery Act of 1969 (Ref. I-1, Part 5).

10. "Streets of Glass" (July, 1970); "Promising Future for Underground Incinerators" (May, 1970); and "An Amphitheatre Rises From Refuse" (December, 1969) in American City (Ref. VI-4).

XII. SUGGESTED STUDENT READING

1. SOLID WASTES

Author: Laurent Hodges, Dept. of Physics, Iowa State University.

Publisher: Chapter 13 (pp. 211-228) in Environmental Pollution (New York: Holt, Rinehart and Winston) 1973. (370 pp.; $7.95)

Point of View: "The real reason for the phenomenal growth of solid waste tonnages in the United States has been the trend to the "throw away" society .... Until people realize that apparent conveniences involve less apparent inconveniences, present and future, and espouse a program of environmental stewardship, the solid waste problem will continue to increase".

Level: Textbook; written for undergraduate, liberal arts students. Illustrated; numerous tables and graphs and a brief bibliography.

Summary: Several factors combine to make this a most valuable reference for students. It is clear that Hodges has read carefully in the literature of solid waste management and has applied his background as a physicist and teacher to provide a well-organized, carefully documented summary of the physical and chemical principles involved in solid waste management. The chapter is full of useful data, both historical and current, all converted into metric units to facilitate comparisons. Six main topics are examined: type, character and quantities of solid wastes; current disposal methods (open dumps, sanitary landfill, incineration, composting, etc.); the costs of solid wastes; packaging; junked automobiles; and better solid waste management (utilization, recovery, recycling, avoidance of waste). In short, this is a very readable, carefully prepared summary and should serve as a useful introduction for undergraduates.

2. THIRD POLLUTION: THE NATIONAL PROBLEM OF SOLID WASTE DISPOSAL

Author: William E. Small, editor of Biomedical News, former staff member, Senate Committee on Public Works and scientific information officer for Pennsylvania State University.

Publisher: (New York: Praeger Publishers) 1970. (173 pp.; $6.95).

Point of View: "Today there is general recognition that solid wastes are a cancer growing on the land, awful in themselves and awful in the way they further foul the already polluted air and waters near them ..."

Level: Popular.

Summary: Very little of the solid waste problem has been left untouched in this extremely readable, well-documented account of the national struggle against the "third pollution". Small's background with the Senate Public Works Committee is clearly evidenced by his extensive quoting from hearings, testimony and government reports. He has been carefully selective, however, and the data and report excerpts presented here manage to convey the magnitude and immediacy of the solid waste problem without overburdening the reader. Most of the focus is on municipal solid waste management, although separate chapters deal briefly but well with agricultural and mineral wastes. The impact of packaging on the growth rate and character of modern refuse is well documented as is the issue of automotive scrap and its recycling potential. Short sections on the relationship between disease and solid wastes and on the various disposal techniques (landfill, incineration, etc.) provide a good introduction to some of the technological and research needs in the solid waste field. Two final chapters, "When People Speak" and "City of Dreams" focus on the policy and technological questions which impinge on the solid wastes problem. Small's congressional background proves particularly useful in his examination of the Federal government's role and effectiveness in environmental issues. In summary, this is an excellent introductory reference, for both a "general public" and a "general student" audience.

3. SOLID WASTE DISPOSAL

Author: Melvin A. Bernarde, Associate Professor, Dept. of Community Medicine, Hahneman Medical College and Hospital, Philadelphia, Pa.

Publisher: Chapter 9 (pp. 151-170) in Our Precarious Habitat (New York: W.W. Norton and Company, Inc.), 1970. ($6.95; paperback: $2.95).

Point of View: "There was a time when people or communities could always find someplace to throw their trash. This is no longer possible. That "someplace" has been or is rapidly becoming urbanized. In addition, both the quantity and the variety of solid wastes generated by today's urban communities are cause for concern".

Level: Popular; written both as an environmental text for "non-biologists" and as a general introduction for a popular audience. Illustrated; numerous tables and graphs.

Summary: This is a particularly interesting reference as it is written from the perspective of environmental health and so takes a slightly different cut through the usual background material. In addition, Bernarde has aimed his book at both a text and trade audience and so takes particular care to write readable prose, unencumbered by involved explanations or extensive data. Inevitably, this results in some over-simplification, but not enough to detract from the book's usefulness. Several newspaper-type accounts of recent community solid waste problems are presented to introduce the magnitude and immediacy of the problem and the various types of waste are classified. The discussion of waste treatment processes (dumps, landfills, incineration, etc.) focuses on the environmental health drawbacks associated with each. Composting is described as "the most controversial, but potentially the most desirable method of solid waste disposal" and some detail is provided on the chemical composition process. The chapter concludes with a brief comment on the "throw away" philosophy that has so increased America's solid waste problem. All in all, this is a readable and, as far as health aspects are concerned, informative look at the solid waste problem.

4. NOT SO RICH AS YOU THINK

Author: George R. Stewart, author and ecologist.

Publisher: A Signet Book from New American Library (New York: New American Library, Inc.), 1970. (176 pp.; $0.95).

Point of View: "... the American people are not taking care of the waste that they create, and it is catching up with them. Our civilization is going to have to come to a working agreement with the environment, or it is going to become such a disagreeable civilization as hardly to be worth living in if, indeed, anyone can live in it at all. To come to some kind of balance with the environment is going to cost a great deal of money".

Level: Popular.

Summary: This is an extremely readable, common-sense look at the whole range of solid waste problems, from sewage and litter to smog and atomic wastes. It is necessarily a bit simplistic and, in some instances, overly optimistic, a tendency the author himself acknowledges. But these are minor flaws in an otherwise impressive book which manages to provide a consistently balanced and thoughtful analysis of the origins, causes, and potential solutions to the ever growing solid waste burden. The chapters on garbage, junk and litter are particularly applicable to this packet, but the whole is so thoroughly integrated as to make the others equally necessary reading. These include chapters on sewage, factory effluents, agricultural refuse, mineral refuse, smoke, smog and CO_2 and atomic wastes. In the final three chapters, Stewart treats the more subtle but increasing prevalent products of our industrialized society--heat, noise, and light--and attempts to deal with the sociological and psychological factors which affect our behavior and its impact on the environment. He concludes with a call for increased education, more research, not only into engineering problems, but into the "rather simple matters of statistics," and considerable reorganization at the political or administrative level. The final chapter, "In Praise of Shiva", looks at the peculiarities of the American experience and the implications of our "production" and "throw-away" ethics.

5. THE DIRTY ANIMAL

Author: Henry Still.

Publisher: Hawthorn Books, Inc., New York, 1967. ($6.95).

Point of View: "Hunger for affluence, shortsightedness and greed--all emerging to some extent from the same intelligence--have blinded all but a few to the vast residue of filth we leave behind us as we pass .... If massive, coherent, intelligent--and vastly expensive--steps are not taken to clean up our air, our water and our land, we'll choke to death or drown in our filth".

Level: Popular.

Summary: Solid waste is but one component of the man-made pollution discussed here that seems to justify Still's title epithet, "the dirty animal". Only two chapters, "Littered Land" and "New Brooms", deal with solid waste in the perspective of this packet, but is is extremely helpful to see the problem set so clearly in the context of all the other pollutants man has generated. There are, however, two minor criticisms to be made of this as a student reference: one, that it was published in 1967 and so is a bit dated and two, a more serious flaw, that the author sometimes slips into the "environmental panic" voice, speaking in aphorisms (i.e., "The only thing wrong with the world is the fact that people live on it) which, while perhaps true, aren't particularly helpful to someone seeking a realistic assessment of the problems. Fortunately, the positive aspects of the book far outweigh the drawbacks. On one level, Still has provided an excellent historical summary of man's origins and success as a pollutor. There are fascinating sections describing the magnitude and impact of pollution on civilizations from that of early Rome to modern day New York and Calcutta. Each account is carefully documented with quotations from the literature of the day, government records, legislation, Presidential addresses, etc. On another level, it is a convincing, humanitarian book, clearly written by a concerned and informed spokesman and easily carrying a kind of common sense prodding that makes the seeking of solutions to these problems seem a reasonable and altogether necessary task. In the end, what distinguishes this book from the others recommended here is that the perspective is global, the problems associated with the various pollutants are set in the context of one another, and the historical background is carefully drawn.

6. MAN AND HIS ENVIRONMENT: WASTE

Author: Wesley Marx.

Publisher: Harper and Row, New York, 1971 (179 pp.; $6.00; paperback: $3.25).

Point of View: "Our ability to abuse our environment with our wastes dogs every progressive steps we make, as if mocking our own shrewdness .... We must shape our style of materials and energy conversion to the needs of the environment as well as material comfort. The ability of the natural environment to assimilate wastes is as finite as our ability to process wasteloads".

Level: Popular; illustrated.

Summary: This is one in a series of Harper and Row books being published under the general title, "Man and His Environment". Waste is taken here to include everything we throw away, from disposable diapers and auto hulks to auto emissions, DDT, sewage and oil spills. Obviously, there is far too much here to be treated deeply and well in a few hundred pages, but several interesting aspects of the nation's solid waste problems are touched on and a useful, briefly annotated bibliography is provided at the end of each chapter.

APPENDIX A

Suggested Bibliographies

1. Solid Waste Management: Available Information Materials, Report SW-58.17, U.S. Environmental Protection Agency, (Washington: USGPO) January 1973.

2. Accession Bulletin (Franklin Institute) Solid Waste Information Retrieval System Accession Bulletin, 1(1-12): 1-266, Jan-Dec, 1970; 2(1-8): 1-205, Jan-Aug, 1971. (Washington: USGPO) 1971-1972.

3. Solid Waste Management: Abstracts and Excerpts from the Literature, C.G. Golueke, Public Health Service Publication No. 2038 (Washington: USGPO) 1970.

4. The Environment Index (New York: Environment Information Center) Annual volumes in print, 1971 to date.

5. Applied Science and Technology Index (New York: H.W. Wilson Co.) Annual volumes in print, 1958 to date (also Monthly issue).

6. Science for Society: A Bibliography (Washington: American Association for the Advancement of Science) Annual volumes in print, 1970 to date.

7. Selected U.S. Government Publications (Washington: USGPO) issued bi-monthly at no charge by the U.S. Superintendent of Documents.

8. Books in Print, a Xerox Education Co. Publication (New York: R.R. Bowker, co.) Published yearly in two volumes: Title and Publisher Index and Author Index.