Recycling from Municipal Refuse: A State-of-the-Art Review and Annotated Bibliography

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Integrated Resource Recovery

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INTEGRATED RESOURCE RECOVERY SERIES

GLO/80/004

Number 1

This is the first in a series of reports being prepared by the Resource Recovery Project as part of a global effort to realize the goal of the United Nations International Drinking Water Supply and Sanitation Decade, which is to extend domestic and community water supply and sanitation services throughout the developing world during 1981 to 1990. The project objective is to encourage resource recovery as a means of offsetting some of the costs of community sanitation.

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Remanufacturing
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Ultimate (marine) Disposal

and a series of case studies of various projects throughout the world.

Series cover design (clockwise from top): Aquaculture using wastewater yields about 8 tons of fish per hectare per year in India. Biogas is produced from organic wastes in India. Sullage from a shower is used to irrigate a garden in the Sudan. The original value added to aluminum is captured by using waste oil to melt scrap and then pouring new ingots in Egypt. A "state-of-the-art" plant, built to demonstrate the pyrolysis of garbage to make fuel oil, has been shut down temporarily because of excessive operation and maintenance costs in the United States. Paper is recycled in a factory of the Shanghai Resource Recovery and Utilization Company in China.

This report is printed on recycled paper.

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Recycling from Municipal Refuse

A State-of-the-Art Review and Annotated Bibliography

Sandra Johnson Cointreau, Charles Gunnerson, John M. Huls,
and Neil N. Seldman
with the assistance of
Phillip Mitchell, Lee Jackson Long, and Elissa Courtney Bellassai

The World Bank
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ABSTRACT

This report is in two parts: a concise state-of-the-art overview of recycling from municipal refuse, focusing on techniques and conditions germane to developing countries; and an annotated bibliography with abstracts of more than 200 published references on recycling. It was prepared as part of a global research, development and demonstration effort of the United Nations Development Programme and the World Bank.

Recycling is used in its broadest sense, encompassing the full range of resource recovery and reuse techniques, including repair, remanufacture, materials recovery and energy conversion of refuse materials, broken machine parts, and discarded consumer products. The philosophy behind the report is that some of the value added from production activities, such as agriculture, mining and manufacture, is retained when a "waste" is recycled. Thus, through recycling, more sustainable economies, for countries and cities, are achievable.

The state-of-the-art overview contains numerous case examples of recycling efforts throughout the world. It provides insight into the informal network of relationships and incentives that affect recycling. Techniques of recycling are arrayed, focusing on those of limited mechanization that better meet the needs for job development and constraints on foreign exchange in developing countries. Strategies which several countries have used to encourage recycling are highlighted, showing the needs for public education and government support in linking macroeconomic benefits and microeconomic costs.

The annotated bibliography, with selections from a world wide search in which several thousand documents were collected and reviewed, covers a wide spectrum of published references providing technical, economic, institutional, environmental and cultural information about recycling.

CONDENSE

Le présent rapport comprend deux parties : un examen concis de la situation actuelle du recyclage des déchets urbains, principalement les techniques et la situation dans les pays en développement, et une bibliographie annotée portant sur plus de 200 ouvrages de référence sur le recyclage qui ont été publiés. Il a été préparé dans le cadre d'un effort global de recherche, de développement et de démonstration auquel ont participé le Programme des Nations Unies pour le développement et la Banque mondiale.

Le terme recyclage est ici utilisé dans son sens le plus large, et recouvre toute la gamme des techniques de recouvrement et de réutilisation des ressources, notamment réparation, réfection, recouvrement de matériaux et conversion pour produire de l'énergie, portant sur les déchets, pièces d'outillage cassées et produits de consommation jetés. L'idée directrice du rapport est qu'une partie de la valeur ajoutée par les activités de production telles que l'agriculture, l'extraction minière et la fabrication, est conservée lorsqu'il y a recyclage d'un "déchet". En conséquence, le recyclage des déchets devrait permettre aux pays et aux agglomérations urbaines de mieux soutenir le niveau de développement économique atteint.

L'analyse de la situation actuelle contient de nombreux cas de recyclage pris dans le monde entier et examine le réseau informel de relations et de motivations affectant le recyclage. Les différentes techniques de recyclage sont présentées, particulièrement celles qui s'appuient sur une mécanisation réduite et qui par conséquent favorisent particulièrement la création d'emplois et ne font pas beaucoup appel aux ressources en devises limitées des pays en développement. Le document présente les stratégies utilisées par plusieurs pays pour encourager le recyclage en mettant l'accent sur le soutien indispensable du Gouvernement et sur l'éducation de la population dans les efforts déployés pour lier les avantages macroéconomiques et les coûts microéconomiques.

La bibliographie annotée, choisie parmi plusieurs milliers de documents rassemblés dans le monde entier, couvre une gamme étendue d'ouvrages de référence publiés et fournissant des renseignements techniques, économiques, institutionnels, écologiques et culturels sur le recyclage.

EXTRACTO

Este informe consta de dos partes: una reseña concisa de la tecnología actual del reciclaje de los desechos municipales, que se concentra en las técnicas y condiciones propias de los países en desarrollo, y una bibliografía comentada, con extractos de más de 200 publicaciones sobre reciclaje. Fue preparado como parte de un trabajo global de investigación, desarrollo y demostración del Programa de las Naciones Unidas para el Desarrollo y el Banco Mundial.

El término reciclaje se emplea en su sentido más amplio, que comprende toda la gama de las técnicas de recuperación y reuso de recursos, incluso la reparación, remanufactura, recuperación de materiales y conversión de energía de materiales de desecho, piezas de máquina rotas y productos de consumo desechados. La idea que hay detrás de este informe es que parte del valor agregado en actividades como la agricultura, minería y manufactura se retiene cuando se recicla un "desecho". Por lo tanto, mediante el reciclaje los países y ciudades pueden lograr economías más sostenibles.

La reseña contiene numerosos ejemplos de reciclaje en todo el mundo. Permite discernir la red informal de relaciones e incentivos que afectan al reciclaje. Las técnicas de reciclaje se presentan en cierto orden, poniendo de relieve las de mecanización limitada que mejor se adaptan a las necesidades de los países en desarrollo en lo que respecta a la generación de empleos y las limitaciones de las divisas. Se destacan las estrategias que varios países ya han usado para fomentar el reciclaje y se demuestra que para vincular los beneficios macroeconómicos con los costos microeconómicos se necesitan la educación pública y el apoyo del gobierno.

La bibliografía comentada --que contiene selecciones efectuadas después de haber reunido y examinado varios miles de documentos que se buscaron en el munto entero-- comprende una amplia gama de referencias publicadas que ofrecen información técnica, económica, institucional, ambiental y cultural sobre el reciclaje.

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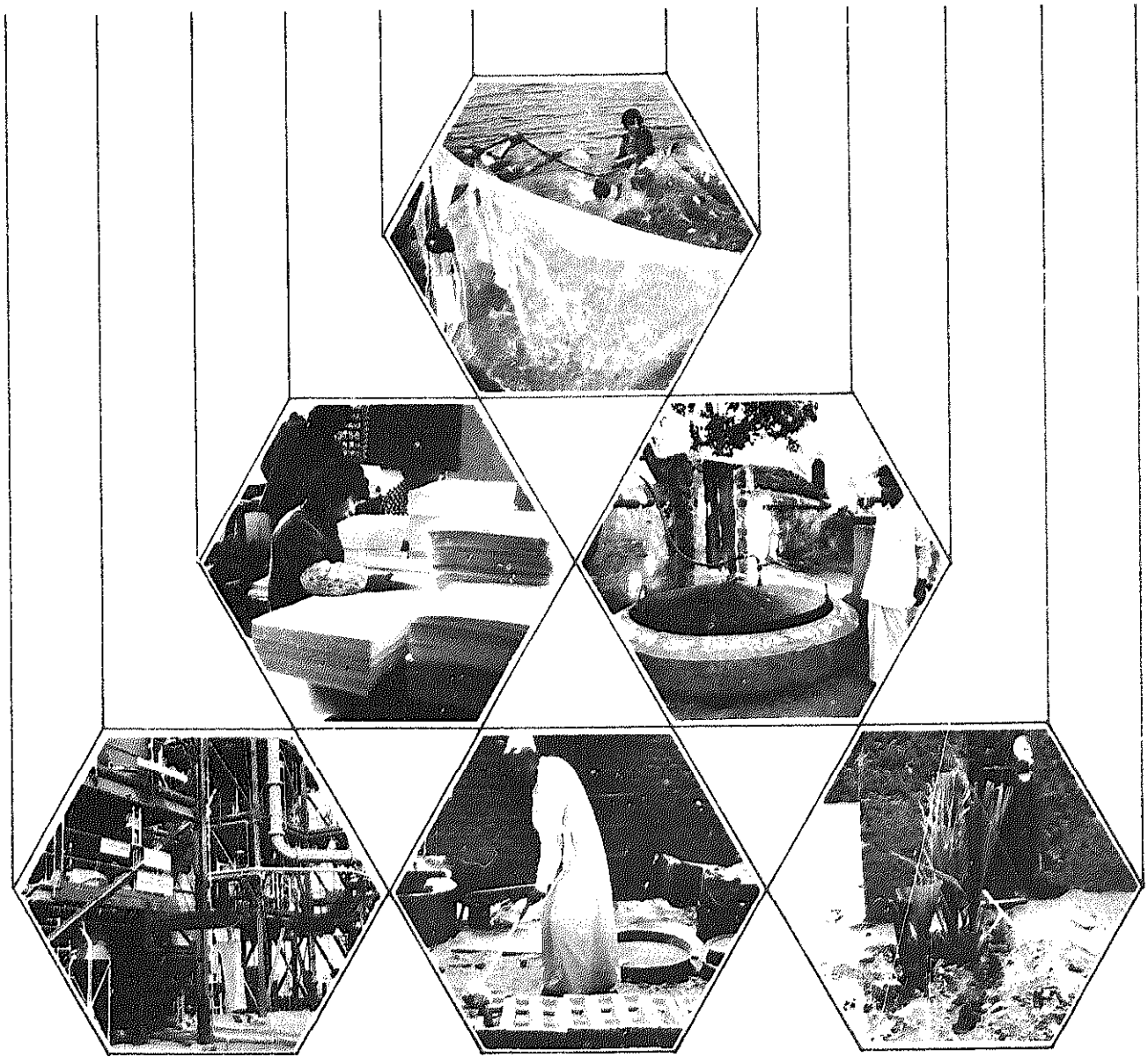

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FOREWORD

There is increasing recognition in both developing and industrial countries of the need for technical and economic efficiency in allocation and utilization of resources. A World Bank Report has been directed to this end, within a study on Appropriate Technology for Water Supply and Waste Disposal. As part of the United Nations International Drinking Water Supply and Sanitation Decade, it was concluded that research and development in integrated systems for recovery and utilization of household and community wastes should be conducted.

In 1981, a three year global research and development project on integrated resource recovery (GLO/80/004) was undertaken by the World Bank as executing agency for the UNDP-United Nations Development Programme (DGIP). Project goals are to achieve economic and environmental benefits through sustainable resource recovery and utilization projects and programs in developing countries. Liquid and solid wastes from municipal, commercial and agricultural sources and their recycling are within the scope of the project.

Sustainability in waste management systems depends upon a number of important policy, technical and economic interrelationships. These interrelationships are particularly important in integrated resource recovery. The project was conceived and initiated by John M. Kalbermatten, Senior Adviser, Water and Wastes. The objective of the series is to provide governments, development agencies, consultants and others with information necessary for waste management policy development and implementation. This document summarizes the state-of-the-art of resource recovery applicable to cities in developing countries as reported in the literature, mostly in English, up to the early 1980's.

We would like to express our sincere thanks to Charles G. Gunnerson whose efforts led to this report and the others that will be published. Your comments on this report would be especially welcomed.

PREFACE

This is the first in a series of reports being prepared by the Resource Recovery Project. It is part of a global effort to realize the goal of the United Nations International Drinking Water and Sanitation Supply Decade, which is to extend domestic and community water supply and sanitation services throughout the developing world during 1981 to 1990.

The Resource Recovery Project was conceived and initiated by John M. Kalbermatten, Senior Advisor, Water and Wastes, and received executive and administrative support from Christopher R. Willoughby, Director, Transportation and Water Department, World Bank; and financial support from the United Nations Development Programme, Global and Interregional Projects Division, William R. Mashler, Senior Director.

The project objective is to encourage resource recovery as a means of offsetting some of the costs of community sanitation. This report and the annotated bibliography which follows focus on municipal refuse and its recycling potential. The bibliography includes documentation published mostly in English through 1981. Readers are referred to the publications and regularly scheduled specialty conferences listed in Annex I for more recent bibliographic documentation.

CONTRIBUTORS

The text of the state-of-the-art report on recycling was written by Sandra Johnson Cointreau, Solid Waste Management Consulting Services, Ltd. John M. Huls, Harding, Lawson & Associates, and Neil N. Seldman, Institute for Local Self-Reliance, reviewed and compiled the literature and contributed to both the report and the annotated bibliography.

Charles G. Gunnerson, Senior Project Officer, World Bank, contributed to, and was responsible for, scientific and technological editing of the state-of-the-art report and annotated bibliography. Lee Jackson Long and Elissa Courtney Bellassai, consultants, edited both the report and the bibliography.

Phillip Mitchell, World Bank, performed the computerized literature search. Grace Whittome, World Bank, retrieved documents through interlibrary loan; and David Bardaglio and Belinda Watts, Institute for Local Self-Reliance, also retrieved documents and provided report production support.

PART I. STATE-OF-THE-ART REVIEW

RECYCLING FROM MUNICIPAL REFUSE

Introduction

Municipal refuse contains inherent values. Recycling provides an opportunity to recover some of these values in municipal refuse, particularly in the form of long-term energy and resource savings. For the purposes of this report, the term recycling is used in its broadest sense, encompassing the full range of resource recovery and reuse techniques, which include repair, remanufacture, and conversion of materials, parts and products.

The essential reason for recycling is that some of the value added through production activities such as agriculture, mining and manufacture is retained. And thus, through recycling, more sustainable economies, for countries and cities, are achievable.

A key to increasing the extent of recycling is to acknowledge and assess long-term savings. Costs ordinarily accrue to different sectors than those receiving benefits, and over different time spans. Therefore, economic strategies are needed to translate the more macroeconomic benefits into short-term direct profits for communities, entrepeneurs, residents and workers who actually perform the work of recovering and reusing wastes.

In this report, potential benefits from recycling wastes are summarized. Furthermore, prominent reasons why recycling is not practiced to its fullest potential are discussed. The report outlines methods of recycling which are being used, concentrating on those which are readily applicable in developing countries.

Further details on recycling techniques are provided in the references and the accompanying bibliography. Perhaps more importantly, strategies which have been implemented in several developing countries to overcome cultural, economic and institutional barriers to recycling are discussed.

The focus of this report is municipal refuse, and the formal and informal institutions involved in recycling. Included in municipal refuse are solid wastes from households, commercial establishments, markets, industries, institutions, and streets. Refuse composition is a function of levels of consumption, which are related to overall economic levels. Table 1 indicates how paper, metal, organic matter, etc.,

Table 1

PATTERNS OF MUNICIPAL REFUSE QUANTITIES AND CHARACTERISTICS FOR LOW, MIDDLE AND UPPER INCOME COUNTRIES

	Low-Income Countries[a]	Middle-Income Countries[b]	Industrialized Countries
Waste Generation (kg/cap/day)	0.4 to 0.6	0.5 to 0.9	0.7 to 1.8
Waste Densities (wet weight basis-kg/cubic meter)	250 to 500	170 to 330	100 to 200
Moisture Content (% wet weight at point of generation)	40 to 80	40 to 60	20 to 40
Composition (% by wet weight)			
Paper	1 to 10	15 to 40	15 to 50
Glass, Ceramics	1 to 10	1 to 10	4 to 12
Metals	1 to 5	1 to 5	3 to 13
Plastics	1 to 5	2 to 6	2 to 10
Leather, Rubber	1 to 5	-	-
Wood, Bones, Straw	1 to 5	-	-
Textiles	1 to 5	2 to 10	2 to 10
Vegetable/Putrescible	40 to 85	20 to 65	20 to 50c
Miscellaneous inerts	1 to 40	1 to 30	1 to 20
Particle Size, % greater than 50 mm	5 to 35	-	10 to 85

a Includes countries having an annual per capita income of less than US$360 in 1978.

b Includes countries having an annual per capita income of more than US$360 and less than US$3,500 in 1978.

c This may be reduced in areas with household or commercial garbage grinders which discharge to sewers.

contents vary in cities of low-income, middle-income, and industrial countries.

A material becomes a waste when the owner or generator of a material discards it without expecting to be compensated for its inherent value. Most municipalities consider wastes to be their responsibility (and within their domain of "ownership") only after they have been placed on the curb or street for municipal collection and disposal.

Municipal solid waste recycling activities contend with mixtures of materials. The more a waste is mixed with others from various sources of generation, the more difficult it is to recover for reuse. There are a number of points in the waste management system, between initial waste discharge and ultimate waste disposal, where recycling can occur. Generally, the nearer to the origin of the waste that recovery occurs, the less sorting and processing will be needed before the material can be recycled.

Incentives for Recycling

Recycling both conserves and uses energy, materials and products. If it conserves more than it uses, it may save material, money, and enviromental degradation. In the process, it may also reduce dependence on foreign imports, create employment and small scale enterprises, and build up skills of industrialization through repair and remanufacturing.

Energy savings occur from the recycling of metals. For example, producing copper from already segregated scrap metal requires only about one-tenth the energy required for production from virgin cooper ore.(70) Recycling magnesium results in a 97 percent energy savings, and recycling aluminum results in a 96 percent energy savings.(32) Using scrap instead of iron ore to make new steel means a 74 percent energy savings.(33) This is equivalent to estimated energy savings of about 350 x 10^{6} BTU per ton (95 x 10^{6} kcal/tonne) of recycled magnesium, 250 x 10^{6} BTU per ton (60 x 10^{6} kcal/tonne) of recycled aluminum, and 200 x 10^{6} BTU per ton (55 x 10^{6} kcal/tonne) of recycled steel.

Similarly, energy is saved when paper, glass and rubber are recycled. Recycling of office-grade paper, for example, has been shown to result in an energy savings of 26 x 10^{6} BTU per ton (7 x 10^{6} kcal/-tonne), over production from virgin wood materials.(32) The U.S. Glass Packaging Institute notes that roughly a 1/2 percent savings in energy

accrues from every 1 percent of cullet (broken glass) above 15 percent.(5) To produce a pound of virgin rubber, 31.4 x 10^6 BTU per ton (8 x 10^6 kcal/tonne) are required; while that expended to produce recycled rubber is only 9.2 x 10^6 BTU per ton (2.5 x 10^6 kcal/tonne), an energy savings potential of over 70%. Furthermore, much less energy is required to manufacture a product from recycled versus virgin rubber, sometimes as little as 60% of the energy required for virgin rubber.(33)

Grandjean estimated energy savings from the existing recycling of municipal refuse of two main Colombian cities--Medellin and Bogota.(36) Extrapolating from his estimates, and assuming comparable waste generation and waste recovery rates for all of Colombia's urban population, an estimated 2.4 x 10^9 kilowatt hours of energy probably was saved in 1980. This total was equivalent to about 1.4 x 10^6 barrels of oil, or 19 percent of Colombia's petroleum imports.(30, 31)

These examples indicate that the energy equivalent of recyclable materials could be far greater than potential energy generated from the conversion of solid wastes by incineration, refuse derived fuel, pyrolysis or anaerobic digestion technologies. It has been estimated that converting refuse to energy in Germany, France, Great Britain and Italy could offset only 1 to 2 percent of their national electricity demands.

Product recycling yields the highest potential energy savings. Overby (56) reports from a number of sources on the potential for saving energy through reconditioning and remanufacturing goods (which involves centralized disassembly, inspection, restoration or replacement of worn components, reassembly, testing and distribution of durable products). For example, original manufacture of a new automobile engine requires about 13 x 10^6 BTU (4 x 10^6 kcal), of which 35% can be retained by remanufacturing. Similarly, he estimates that 65 x 10^{12} BTU (16 x 10^{12} kcal) could have been saved in the United States in 1973 if all tires had been recapped once, which is roughly equivalent to 160 x 10^6 barrels of petroleum.

Recycling also conserves water resources. For example, nationwide implementation of reuseable beverage containers in the United States could reduce use of process-water for glass manufacture by 44 percent. (14) Use of steel scrap instead of virgin iron ore can reduce water use in steel-making by 40%, as well as reduce resulting water pollutants discharged by 76%.(33)

Some recycling is stimulated by environmental concerns, as well as market demand for recoverable resources. For example, a plant converting solid waste to energy in Nancy, France, is removing polyvinylchloride from plastic bottles prior to combustion, in order to limit chlorine emission from the stack as well as recover plastics.

Dependence on chemical fertilizers, which are petroleum-derived and commonly imported by developing countries, could be reduced through recycling and reuse of organic wastes as organic fertilizers. Solid wastes containing appreciable portions of organic matter are converted to organic fertilizers through techniques such as composting and anaerobic digestion. The latter technique also produces a useable, medium BTU gas (biogas).

Compost does not approach the nutrient value of chemical fertilizer by weight. However, unlike chemical fertilizers, which ordinarily dissolve readily and are easily leached away from plant root zones, organic fertilizers hold their nutrients in colloidal forms which slowly release as the organics decompose in the soil.(65, 24, 39) Furthermore, there are traces of minerals in compost which provide micro-nutrients to crops. Researchers in China report that as compost is increasingly applied, enzymes such as urease and proteinase become more active. This results in a higher rate of mineralization of nitrogenous compounds and an increase in the overall supply of nitrogen to the crop.(13)

Studies on refuse-derived compost indicate other potential resource conservation benefits: erosion control, soil moisture retention, soil density improvements, increased ion-exchange capacity, and trace mineral availability.(79,81) These are in addition to the primary fertilizer effect of nitrogen and phosphorus in compost. Field experiments throughout China demonstrate that application of 500 kg/ha of refuse-derived compost increases rice grain production by 25 to 50 kg/ha. The Chinese typically apply 60 to 70 tons of compost per hectare of rice paddy during land preparation before planting, and usually there are two crops and related planting periods per year.(13)

Shredded paper wastes have been used successfully as soil mulch.(65) Soil mulching, whereby organic matter is spread on top of the soil around plants, limits soil erosion, suppresses weed growth, buffers against temperature fluctuations, and limits evaporation of soil moisture.

In Rome, since 1964, recycling has been a daily city-wide endeavor. Depending upon market demands, various amounts of paper, ferrous metal, plastic, organic matter as animal feed, organic matter as compost, and energy through incineration are recovered from refuse. The estimated annual benefits include: saving over 400,000 trees, amending 60,000 acres of agricultural land, and saving over 30,000 tons of fuel.(12)

Recycling results in fewer solid wastes requiring ultimate disposal. In China, the Shanghai Donghai Oil and Chemical Recycling Works has diverted over 2 million tons of liquid and solid industrial (and sometimes hazardous) wastes from landfill since 1958. Much of this has been accomplished through an active waste exchange program; i.e., spent acids from one industry are recoverd and used as feedstock in another industry.(51) Furthermore, the Shanghai Materials Recovery and Utilization Company has, since 1957, retrieved more than 20 million tons of waste metal, paper, cloth, plastics, rubber, etc.(50)

Constraints to Recycling

With such worthy benefits as those noted above, it is appropriate to ask why recycling is not more widely practiced.

As discussed below, whether recycling is practiced at the source depends on whether the original owner feels it is convenient and/or economically worthwhile. Thereafter, people performing the various steps of retrieval, sorting, recovery and reuse must receive enough tangible benefit to compensate them for their time and effort.

When the owner of a material discards it as a waste, he ordinarily has little incentive to prepare it so that others can recycle its contents. Unless the owner derives comensation or is otherwise induced for the time and effort involved in keeping recyclable materials segregated, some or all of these materials may be contaminated or damaged beyond recovery.

Another point is that the value of waste tends to increase as the income level of the population does. In Cairo in 1982, for example, the total resource value of household waste ranged from a high of LE 5.23/ton ($7.47/ton) for upper income residents and a low of LE 1.86/ton ($2.66/ton) for low income residents.(54) At the same time, as income level increases a higher value usually is placed on leisure time. Thus, more compensation is required to help convince people that it is worth their time and effort to continue to recycle as their incomes rise.

Julius (44) postulates that one way to increase recycling by higher-income populations is through public education programs that stress the benefits of recycling and by enhancing the access to scavengers of materials discarded by these populations.

Money is not the only means of motivating people to recycle. Sometimes, good will towards one's neighbor is enough of an incentive. In Sri Lanka, for example, wealthier residents actively separate coconut shells from their other wastes in order to donate these shells to their launderers who use them as char in the irons.(15) In the United States, the recycling activities of Goodwill Industries, St. Vincent de Paul, the Salvation Army and others rely on good will to motivate people to donate their used goods for others to reuse.

In much the same manner that recycling is encouraged when people are compensated for cooperating with the process, recycling is discouraged by perceived costs of inconvenience to the waste generator or owner. If, for example, collection of recyclables occurs at irregular and infrequent intervals, the owner may choose disposal over storage. Furthermore, owners may not wish to be bothered with visits by various buyers or their agents.

Traditional attitudes toward scavengers influence whether there is an antagonistic environment for recycling. In large part, these stem from the social stigma typically applied towards those who handle wastes.(61) This can be exacerbated when the scavenging population is composed largely of religious or ethnic minorities, low castes, or rural immigrants.

When citizens perceive wastes as recyclable materials, attitudes toward scavengers could change. In Manila, Philippines, a pilot recycling program was established and supported by a wide-spread public information campaign. The program trained workers (called ECO-AIDES) and provided them with clean attractive uniforms emblazoned with the message: "pera sa basura" (money from refuse). To some extent, the social stigma toward house-to-house scavengers appears to have lessened.(17)

Another factor contributing to lack of recycling is poor documentation of the full costs of safe, environmentally acceptable solid waste disposal -- particularly in developing countries where unregulated open dumping prevails as the means of disposal at what appears to be little or no cost, because there is no accounting for the adverse social,

environmental and health effects that occur. Furthermore, in industrialized countries, there is seldom a full cost accounting of landfill disposal costs, particularly life-cycle economics that take into account landfill closure and monitoring expenses.

Retrieval Systems

There are several points within a solid waste management system where wastes can be retrieved for purposes of recycling. The first of these is at the source, the place of waste generation and initial ownership. A second is at the designated place of waste pickup, such as along the curb. A third is within the refuse collection and transport vehicle. A fourth is at an interim transfer station or waste processing facility. And the fifth is at the ultimate disposal site.

At the source, the owner of the waste has three options: (a) to deliver it to a redemption or purchasing center or sell it directly to a buyer, (b) to allow others to retrieve the waste and be responsible for recycling it, or (c) to have it be collected for disposal.

In Colombo, Sri Lanka, the National Paper Corporation publishes a price list for waste paper.(15) The list tells residents how much compensation they will receive if they bring their waste paper directly to the Corporation's redemption centers, and indicates fair buying prices they can expect to receive from neighborhood agents collecting door-to-door.

To encourage retrieval at the source, a number of industrialized countries rely on mini-redemption centers strategically placed for convenience. Commonly, this involves a portable metal container placed in a shopping area. The site is generally not manned, and the residents are not compensated for bringing materials to be recycled. Cooperation relies on public awareness of the resource conservation derived from recycling and the savings based on diminishing landfill requirements. In Germany, there is approximately one container provided to every 5,000 residents for glass recycling. Highest returns of used glass are obtained where the containers are located at central supermarkets.(67)

When the owner of a waste allows others to collect and recycle it, the service may be informal or formal. The informal system operates when individual scavengers walk through neighborhoods and pick through discarded wastes awaiting formal collection. In most cities within developing countries, this occurs to some extent; and is usually

evident in the early morning in high-income residential neighborhoods. While not encouraged, it generally is tolerated if the scavengers leave the piles and containers of discarded wastes in the same general condition as when they found them.

Commonly, the informal system is based on a network of buyers and their appointed neighborhood agents. Typically, the buyers and agents specialize in only one or just a few categories of materials (e.g., paper, bottles, cans) and have an established rapport with residents to service their neighborhoods on a fairly regular basis, using carts and bicycles for transportation.

In some cases, the informal system has even more tiers than this. In Istanbul, Turkey, there are scavengers who collect from door-to-door using handcarts; they sell to collectors who then transport it to merchants who operate sorting yards; if the merchants have transport, they sell direct to the user factories; otherwise, other merchants with transport buy it and sell it to the user factories.(57)

Cairo, Egypt, has a private sector system for collecting refuse for purposes of recovery and reuse. There, through indirect negotiation and contracts with original owners of individual buildings, organized communities of Zabbaleen, most of which are Coptic Christians, have the sole rights to collect and reuse wastes from these establishments.(53) A major portion of the city's refuse is collected by the Zabbaleen, with service provided primarily to high-income and middle-income establishments.(35) Each day, Zabbaleen heads-of-household, usually with their eldest sons, go to their service areas to collect wastes. The full carts are brought home, emptied into their small court-yard, and the wastes sorted by the women and younger children of the family. Edible wastes are fed to pigs raised by the family, and materials are sold to dealers. Zabbaleen families are strongly tied to their dealers, as the dealers often provide advance cash when needed.(45)

Sweepers in Kathmandu, Nepal, are privately engaged by residents to clean courtyards, etc., within and between homes. The edible portion of the wastes collected is fed to pigs, and the pig manure is sold to farmers. Scavengers work door-to-door in the wealthier neighborhoods of Kathmandu, returning home with a full cart for the women and children to sort into piles of materials and edibles. There is a close relationship between scavengers and ealers (kabaris), since scavengers are usually provided free housing by the dealers.(59) The recycling systems of most cities in developing countries are characterized by strong informal

networks.(17) Lomnitz (48) has written a comprehensive and engaging book on the informal networks of the Mexico City recycling system, which has its roots in certain shanty-town communities.

Driven by the increasing amount of refuse and the decreasing availability of land for waste disposal, some communities in industrialized countries are returning to separate collection systems for wastes which can be recycled, as part of their refuse collection system. In Islip, New York, USA, one day a week is set aside for the collection of recyclables such as paper, cans and bottles. Residents are required to sort and clean these materials and place them outside for collection.(55) Prison labor (non-violent offenders) is used to perform the final sorting and grading at the Islip redemption center.(20) The use of prison labor in recycling is not new. In 1915, the Chicago Salvage System used prisoners to sort and repair goods collected from public buildings.(64)

Simultaneous collection of refuse and presorted recyclable materials is being implemented using a number of techniques, including compartmentalized vehicles, racks built onto vehicles, trailers, and bags.(70) Open trailers hitched to refuse collection trucks incur little additional cost, but do reduce truck maneuverability.(5) Bags and baskets are most often used in developing countries, as noted in Colombo, Sri Lanka; Manila, Philippines; and Bangkok, Thailand.(15, 16, 72) Bags can even be used in conjunction with compaction-type refuse collection vehicles. Tests in Modesto, California, USA, showed that 70% of the color-coded bags containing dense recyclable material, when placed on one side of the hopper of a rear-loading compaction truck during refuse collection, were later retrieved unbroken.(19) Note, however, that compaction vehicles are generally inappropriate in developing countries; because the uncompacted density of the refuse in developing countries is usually as much or greater than the compacted density of refuse in industrialized countries where the vehicles are designed and manufactured.(16)

Specially designed vehicles are being built and tested for simultaneous collection of refuse and presorted recyclables.(21, 37) A USA version, known as the Separate Discards Carrier, has compartmentalized containers for glass, cans, newspapers, and refuse The glass and cans are contained in bins, the newspapers on shelves, and the refuse in a compaction chamber.

Wastes may be retrieved for recycling by collection crews.(15, 16, 17, 72) Collection crews of municipalities in developing countries often supplement their income by recovering materials from refuse and selling it to agents buying for various end-users.(17) For example, in Bangkok, Thailand, collection crews spend up to 40% of the time while on their service routes recovering and sorting paper, bottles, cans, and plastics. Reportedly, they earn an income from recycling which is comparable to their official salary.(7)

On the other hand, in Manila, Philippines, collection crews spend no more than 6% of their time enroute recovering materials for reuse.(72) This is attributed to the fact that many crews in Manila allow an extra man to ride the truck (one that is not an employee of the city) solely for the purpose of sorting.(17)

Collection crews can become involved in the recycling process in other ways, as well. For example, they may sell their load to the highest bidder at the dump. At one unofficial dump site in Lima, crews receive a fee for dumping within pig corrals on-site rather than on the open disposal area accessible to scavengers.(17) At the main dump site for Mexico City, agents for various groups of scavengers bid against each other to have collection crews dump in their picking area.(29)

Local government officials often complain that these recycling activities by refuse collection crews tend to take away some of their available working time.(17) However, there have been no measurements on the relative speed and efficiency of such crews who, provided with the added incentive of increasing income through increasing the quantities of materials recovered for recycling, may be correspondingly increasing the quantity of wastes collected.

At the very end of the retrieval system are the scavengers who work at the dump sites and typically live on its perimeter in shanty-towns. There are scavengers at dump sites in most major cities of developing countries. Estimated numbers of scavengers at dump sites are as high as 5,000 in Metro Manila, a metropolis of about 8 million; 10,000 for Mexico City's 10 million people; 1,000 for Lima Metropolitana's 4 million people; and 400 for Cali, Colombia, with its 1-1/2 million population. (10, 28, 29, 72)

The impacts described above of collection equipment and practices upon scavenging are amply demonstrated. They are highlighted by responses to proposals for replacing entrepreneurial small-scale waste

collection in carts by municipal-scale collection in compaction trucks. In addition to increased municipal costs, such replacement would largely eliminate employment of the scavengers and the small-scale enterprises dependent upon them for materials.(37)

The reverse is also true. Scavenging practices can determine the success of innovation in collection and disposal. In Jakarta, hand-operated baling equipment was introduced to increase the capacities of the open-top collection vehicles and of the dump. The scheme was sabotaged when scavengers went for the bales with cutters to remove and salvage the baling wire. This response to technical intervention was not predicted, and indicates the need for carefully designed demonstration projects as precursors to full-scale implementation.(17)

Strong informal networks of agents and buyers typically control these sites. For example, only certain scavengers are allowed access to the main dump site in Manila. All materials retreived at this site reportedly must be sold to one of the approved agents. Any scavenger discovered removing found materials from the site, is likely to have his access privileges revoked.(17)

Birbeck (10) provides an in-depth view of the working conditions and informal networks which exist at dumping grounds in Cali, Colombia. He describes the factory-like atmosphere of the dumps, where a large force of workers is controlled by a few bosses. There is limited chance for upward mobility of the scavengers, since becoming an agent or buyer requires capital and the payments scavengers receive for materials they have retrieved do not provide very much for private savings.

Generally scavengers at dumps work independently and are paid by the piece. The direct link between work efforts and daily wages is a key motivator to scavengers. However, this system can also lead to fierce competition among them. Birbeck (10) notes that conflicts in Cali dumps over certain choice materials have resulted in arguments and have led to killings. In Manila, several years ago, such conflicts reportedly led to a large fight at the dump, which resulted in 28 scavengers killed.(17)

In a few instances in developing countries, scavengers are noticeably absent from dump sites. Recent efforts to implement sanitary landfill operations in, for example, Buenos Aires and Cordoba, Argentina, have been enforced by guards being posted to keep out scavengers.(6, 80) One area of research of the UNDP Resource Recovery Project is to study

the effects of eliminating dump-site scavenging on the overall recovery and reuse of waste materials, and the relative costs and benefits to different sectors of the population.

Intermediate Handling

Once wastes are retrieved for reuse, they either may be sent directly to the recovery or reuse site, or to a station for intermediate handling. At a station for intermediate handling, wastes are sorted and accumulated. Small lots obtained from various sources are aggregated and graded to meet the needs of individual buyers. To the extent that there is available space and cash flow, materials are stored. This allows the intermediate handler to have supply better match demand, and thereby obtain a better price.

Intermediate handling is done by community redemption centers, salvage dealers, secondary materials processors, and special interest groups. Each of these is briefly discussed below.

There are municipal redemption/purchasing centers in Shanghai, China. Individual scavengers and residents bring their recyclables to these centers and are paid according to posted prices. Materials are sorted and graded to meet the users' needs. These post-consumer wastes are sent, along with industrial scrap, to central factories for payment and processing. These factories are under municipal management, which is also responsible for street cleaning, sewerage, and refuse and night soil collection.(50)

Salvage dealers do essentially the same things as municipal redemption centers. Both are likely to handle a variety of recyclables, including metal, paper, textile, and plastic. The key difference is that these dealers' centers are run by private entrepreneurs. Their position in the system depends on their network with scavengers and agents retrieving recyclables and with buyers. Cities such as Bangkok, Thailand, and Colombo, Sri Lanka, appear to have a well-run system of salvage dealers who interact largely with municipal collection crews as their source of recyclables.(17)

Secondary materials processors are apt to specialize in one type of recyclable material, such as paper or ferrous metal. Generally, they have strong connections with end-users, such as paper or steel mills. They are likely to process the incoming waste to meet their buyers' specifications. Mechanized equipment to reduce the volume of waste is

often used. In Lima, Peru, a government-owned paper corporation includes about 10 percent waste paper in its feedstock. The corporation has a fixed number of secondary materials processors who buy waste paper from sorters and transport it to the corporation's storage area where it is baled.(26)

In industrial countries, special interest groups providing intermediate handling tend to rely on voluntary support. Charitable groups, including church groups, commonly receive and distribute used clothing, furniture, and household appliances. Service organizations such as the Salvation Army, Goodwill Industries, and Volunteers of America do the same.(40) Generally, goods are cleaned and repaired before they are distributed.

In communities throughout the United States, various organizations provide drop-off stations for paper, cans, and bottles. These efforts stem from concern over resource conservation and desire to limit the amount of land required for ultimate disposal. Some sorting usually is done by such organizations; but for the most part they rely on residents to sort their materials before leaving them at the drop-off station.

Recovery and Reuse

Solid wastes can be recycled in many ways. For purposes of this report, we categorize these into three levels of recovery and reuse:

Level 1--after sorting and cleaning, discarded items are reused, repaired or remanufactured;
Level 2--the waste is sorted, cleaned, processed, and recycled as a new material or product; and
Level 3--the waste is converted into a different material or into energy.

To illustrate, tires can be reused at all three levels. Tire retreading, whereby the worn treads are removed and replaced with new uncured rubber, is an example of Level 1 recycling.(78) A Level 2 example is when tires are split into strips and woven into doormates.(18) And at Level 3, used tires may be pyrolized into fuel oil.

Recovery and reuse activities grouped in the lower levels tend to use less mechanical energy for sorting, processing, transporting, etc., than those grouped in the higher level. Also, Level 1 and 2 activities often involve wastes before they are mixed with other wastes, and

potentially degraded; and Level 3 activities often involve mixed wastes. Each level is discussed below, and examples of recycling within each level are noted from the literature.

Level 1. This level involves direct reuse of a product or material without changing its basic form and/or function. A common example is reusing (after sorting and cleaning) a packaging container, such as a can, bottle or box.(58) Standardization of bottles in the Federal Republic of Germany has facilitated this level of reuse.(11) Another common example is when discarded clothing, donated to charitable groups and service organizations, is cleaned and mended for reuse.

Through physical labor, and with simple tools, products often can be repaired and returned to a functioning state. For example, textiles can be sewn, patched, rewoven, and dyed to restore them to usefulness. Furniture can be rebuilt and re-upholstered. Garden tools are commonly restored by replacement of their wooden handles.

Remanufacturing involves disassembling similar products at a central facility, with the parts subsequently cleaned, inspected, replaced or refurbished, reassembled, tested and distributed.(56) Examples of remanufactured products are: automotive engines, transmissions, water pumps, clutches, and brakes; refrigeration and air conditioning compressors; white goods such as stoves and dishwashers; and telephone sets. Generally, products contain most of their original parts. In the United States, the Xerox Corporation operates remanufacturing plants for its equipment.

According to the Association of Petroleum Re-refiners in the U.S.A., "Oil never wears out -- it just gets dirty." Re-refined lubricating oil has been proven to be equal in quality and performance to that made from virgin oils. And yet, in 1982, less than 10% of recovered used lubricating oil was recycled in the U.S.A.(33)

Discarded products can be reused in the same basic shape as the original, but for a different function, for example as building components. A WOBO (World Bottle) was conceived by Habraken for reuse as a building block.(58) Old tires are used to form breakwaters and artificial reefs in the United States. Building materials are retreived from cardboard cartons, wooden crates, and demolition debris to build shelters and workplaces all over the world.

Level 2. Recycling of glass cullet is a common example of Level 2 recovery and reuse, whereby the waste is reprocessed into a new product of comparable composition. In the United States, a number of states have passed legislation requiring citizens to return beverage containers to stores selling beverages.(49) For example, in the U.S.A. in 1981, 24.8 billion aluminum cans and 3 billion glass bottles and jars were processed into new containers.(33)

Materials for conventional glass-making include sand, soda ash, limestone, and broken glass (cullet).(25) The cullet replaces soda ash.(5) Glass manufacturing using 100 percent cullet is found in plants from Bangkok, Thailand, to Dayville, Connecticut, USA, where carbonated beverage bottles are produced.(34, 77) More commonly, glass cullet makes up 20 to 30 percent of the total mix.(25)

In Manila, a pilot project implemented by the Technology Resource Center involved forming a cooperative of low-income women to collect high-grade paper from office buildings and (using a simple labor-intensive process) wash, bleach, and pulp it into a high-quality stationery.(17) In Colombia, an estimated 46 percent of the total material requirements of the paper mills is waste paper.(10) Waste papers should, where possible, be separated at the source, before it is contaminated and degraded. There is no equally cost-effective mechanical substitute for manual separation and sorting. The mechanized fiber-sorting techniques that do exist (9, 83) tend to produce a low-grade fiber.

The extent to which steel mills can utilize scrap as an input depends on type of furnace.(41, 43, 75) The Basic Oxygen Furnace is the most limiting, using no more than 40 percent ferrous scrap in the charge. On the other hand, the Electric Arc Furnace can use up to 100 percent scrap. Because of this, and the fact that the Electric Arc Furnace can be economically implemented in a smaller unit size than other furnace types, it may be particularly appropriate for developing countries.

Steel foundries can melt steel scrap to produce steel castings; and iron foundries can combine pig iron with iron scrap to produce iron castings.(25, 43) Other foundries use nonferrous metal scrap, such as aluminum and copper scrap.(69)

Recycling may involve changing both the shape and function of a product. Tires are cut into soles for shoes, as in India and Peru.(17,

68, 78) Bottles are cut into glasses, ashtrays and funnels in Cuzco, Peru.(77) Textiles are reused in rag dusters, as stuffing for pillows and dolls, sewn into patchwork cloth, or woven into rag rugs.(78) Waste paper is shredded into animal bedding.(78) Steel drums from oil are cut up and made into charcoal-burning jika cooking stoves.(68)

Vogler (78) focuses on labor-intensive technologies appropriate to developing countries. He explains how to start-up a number of Level 2 recycling operations, including: asphalted roofing sheets made from waste paper; tools, horseshoes, and machine parts forged from ferrous scrap; iron manhole covers cast from ferrous metal scrap with some tinplate cans in the mix; saucepans and kitchen utensils cast from scrap aluminum; and roofing felt made from textile wastes.

Level 3. Waste is processed into a different material or a form of energy at this level of recovery and reuse. For example, the new material may be recovered element, or some relatively homogeneous substance. The new energy may be heat, char, a combustible gas, or incineration steam. A number of Level 3 processes (e.g., composting, anaerobic digestion [biogas], fermentation [ethanol production] and incineration) are described from an engineering standpoint by Diaz, Savage and Golueke.(28) There is increasing interest in extraction of methane generated within refuse dumps and landfills.

Tin can be recovered from tin-plate scrap through several detinning processes readily applicable for implementation in developing countries.(78) Because the resulting tin is more pure than primary tin, it is commonly used in pharmaceuticals (particularly stannous fluoride toothpaste). Furthermore, detinning renders the original tin-plate scrap more saleable. According to Vogler (78), detinned scrap with less than 0.05 percent tin normally fetches a price double that of scrap tinplate.

Glass can be reprocessed into a number of new materials. For example, it can be substituted for quartz or feldspar in the manufacturing of high-strength porcelain.(60) Up to 50 percent waste glass can be used in the manufacture of mineral wool insulation.(82) Composites of waste glass and polymers can be used to make durable construction products, such as sewer pipe.(82)

Composting and anaerobic digestion are biochemical processes that decompose organic wastes. In composting, aerobic bacteria decompose organics in the waste to carbon dioxide, nitrogen compounds and water

vapor, leaving behind a relatively dry humus-like material composed of cellulosic (humic) organics, nitrogen compounds and inert substances. In anaerobic digestion, successions of anaerobic bacteria decompose organics in the waste to methane and to carbon dioxide with traces of hydrogen sulfide and nitrogen, leaving behind an organic slurry carrying humus and fertilizer constituents.

High temperatures of over 50°C and as much as 80°C are achieved in aerobic composting and may be provided in thermophilic digestion by using say 30 percent of the methane for heating. These temperatues are sufficient to destroy human pathogens and fly larvae within one day. Both compost and the slurry from digestion are used for soil amendment, because of their organic and trace mineral contents, as well as their nitrogen-phosphorus-potassium contents. The slurry product of anaerobic digestion would tend to be richer in nitrogen than compost, because nitrogen would not be converted to a gas and released as it is during composting.

It is common in cities of China for domestic garbage to be composted. Garbage from Shanghai, for example, is trucked and barged to farms surrounding the city. Typically, the garbage is mixed with night soil, piled into a heap about 4 meters wide, 4 meters long and 1.5 meters high, set with subsequently withdrawn bamboo poles to provide aeration, then sealed with a thin layer of mud. Temperatures within the pile rise to over 50°C and are maintained at this level for more than 10 days, effectively destroying disease-causing micro-organisms and parasite eggs. It takes 3 to 4 months before the compost is ready for application to crop land.(13)

Vermicomposting uses common earthworms to decompose organic wastes, and has been demonstrated in small-scale projects. For example, in Manila, vermicomposting is being promoted as a means of recycling-at-the-source and thereby reducing the overall costs of Municipal garbage collection.(17, 27) Garbage segregation is done at the household in separate containers provided at cost by the Metro Manila Municipal Government to project participants. The earthworms, Eisenia foetida, reduce the waste volume by up to 50 percent, and their castings consolidate the nutrients originally found in the waste.(22) The earthworms are harvested every 40 to 45 days and recycled to new pots of garbage. The castings can be either marketed as soil enhancers or used in the soil pots to raise selected vegetables and herbs.(1, 2, 3)

Anaerobic biochemical processes that result in methane gas generation become dominant in most refuse landfill cells, usually after about 2 years wherein all the entrapped oxygen is consumed. Methane is produced and collected from refuse in landfills in West Germany, the United Kingdom, the United States, and Brazil. To maintain oxygen-free conditions, the refuse should be well compacted under a soil cover. To maintain moisture content at levels optimum for bacterial growth and gas production (about 60 to 75 percent moisture), it may be necessary to recirculate leachate or add water. Recirculating leachate can have the added benefit of also providing nutrients, buffer and assimulated bacteria; but must be approached with great care to insure that groundwater quality is protected. Active gas removal systems are recommended, and consist of a site perimeter trench or series of wells fitted with mechanical pumping systems. After processing for removal of condensate and particulates, the gas has an energy value ranging from 450 to 600 BTU/ft^3 (4,000 to 5,300 kcal/m^3), which is suitable for use in boilers. For pipeline quality transport, the carbon dioxide is removed to provide about 1,000 BTU/ft^3 (8,900 kcal/m^3).(8)

Energy recovery from refuse incinerators is not ordinarily applicable to developing countries, where kitchen wastes make up a much higher portion of refuse. Therefore, moisture contents are markedly higher. The moisture content of refuse in developing countries tends to range between 40 and 70 percent, compared to the 20 to 40 percent moisture content of refuse in industrialized countries.(16) As a result, incineration would require supplementary fuel and result in a net energy deficit. Even Japan, which has more incineration plants than any other country, is reported as recovering little useful energy for sale because of the high moisture content of its refuse.(62) Nevertheless, recent developments in separation technology, if proven in practice, may eventually offer an economic way to separate the dryer combustible portions from the rest of the waste.

Strategies for the Future

Sustainable resource recovery and utilization are essential elements of living within finite resources. Economically justified recycling practices are objectives of a number of individuals, groups, and governments. Examples of both efficient and inefficient recycling systems abound. Improvements always involve building on existing activities. This requires that three strategic objectives be addressed:

1) Identify and acknowledge existing strengths in both the formal and informal systems.

2) Improve productivity of existing systems by removing technical, financial and institutional constraints to recycling.

3) Link macro-economic and micro-economic factors.

Examples of how various cities and countries have addressed some or all of these objectives are discussed briefly below. Common threads which wind through most of these examples are improved public education and cooperation, as well as government encouragement of, if not participation in, the recycling endeavor.

Recognizing the contributions that informal sector scavengers make to recover materials for recycling, reduce dependence on foreign imports, and lessen the volume of wastes requiring land disposal, the Ministry of Environment in Indonesia is developing strategies aimed at supporting scavenging.(17, 76) For example, some communities are being encouraged to provide scavengers with water supply and sanitation facilities at the main refuse handling and disposal sites, and to provide them with access to health care services.(17)

In Indonesia, scavengers belong to the low income group. Many families earn from scavenging only enough money for one meal a day. For their day-to-day survival, income is also needed from other informal business activities. Profits accrue mostly to the higher circuits of the recycling system: dealers and middlemen.(76) The Ministry of Environment, together with the Informal Sector Project, is planning a pilot effort to form a local cooperative of scavengers at one municipal landfill.(17) The cooperative is viewed as one means of strengthening the individual scavenger's bargaining position in obtaining fair market value for recovered materials, easing access to credit, and providing

education on basic rights and resources available for greater self-reliance.(17, 76)

Recycling is a community employment activity of the Zabbaleen in Cairo, Egypt. Few of their inhabitants work in other trades.(45) In an effort to extend the activities of the Zabbaleen to low income neighborhoods which have a lower fraction of recyclables in their refuse, the city is pilot testing contracting with the Zabbaleen for collection from these neighborhoods. Because the Zabbaleen are limited in number, studies are underway to improve their efficiencies through better cart designs and sorting/handling facilities.(54) Credit has been built into a World Bank urban project loan to support this effort.(4)

During a recent solid waste master planning effort for Manila, Philippines, integrated materials recovery and sanitary landfill facilities were recommended.(72) To take advantage of the pool of talent available at the present open dumps, and to minimize loss of income to the many hundreds of scavengers working at these dumps, scavengers are proposed to be hired as sorters along the conveyor lines of the materials recovery facilities.

In Shanghai, China, there are separate collection systems for residential and commercial/industrial wastes. This minimizes the content of potentially hazardous substances within wastes targeted for composting and application to cropland. And the purity of commercial/industrial wastes entering the materials processing and exchange network is maintained.

A waste materials exchange program was established in the United Kingdom in 1974, with funding provided by the government as a free service to industry. A small secretariat was established with staff seconded from the Warren Spring Laboratory, which already had significant involvement and expertise in waste utilization. Quarterly bulletins announced the wastes available from various manufacturers, as well as those wanted. Information was coded and stored by computer to facilitate matching industries with specific wastes to discard and industries needing those same wastes as feedstock. Eventually, more than 5,000 organizations participated in the program.(74) After 5 years, participants were invited to subscribe to the costs of operating the Exchange, but response was insufficient to maintain a self-funding operation and the Exchange was closed down.

One difficulty in materials recycling is balancing of supply, storage and demand. Since 1957, the Shanghai Materials Recovery and Utilization Company has set up 502 centers to purchase, store and balance the flow of materials. Over 1,000 agencies in the surrounding rural areas work on a commission basis with the Company. Twenty-six agencies (each with about 300 workers) are set up to separately retrieve materials from industrial wastes. To complete the system, there are an additional 15 processing factories, 59 specialized business centers and 121 waste materials sales departments.(50)

Not all efforts to address perceived obstacles are successful; however, they may provide valuable lessons for others. Despite a series of projects begun in 1978 in Manila, Philippines, to develop a municipal recycling system based on neighborhood redemption/purchasing centers, recycling continues to be characterized by informal private sector individuals.(17) Thirty community redemption centers employing over 300 workers were eventually equipped and put into operation. The redemption centers were temporarily closed in 1979, so that their efforts could be fully assessed. Among the problems perceived were: insufficient participation by residents, inadequate communication with local neighborhood leaders to gain their support, too few collectors (called ECO-AIDES) to cover the redemption routes, competition from private "junk dealers," and faulty arithmetic and poor record-keeping. Lack of adequate financing was manifested by the inability of the responsible private organization to procure vehicles to transport the recyclable materials. This in turn led to an unsightly accumulation of recyclables at the centers, and complaints by neighbors. It further led to an inability to market the materials, and an aggravated shortage of cash.(27)

Within a year, six centers were temporarily reopened under public management. Once again financial problems were encountered, and the municipality recognized that specialized knowledge and experience was needed to operate the centers and business of recycling. Arrangements were then made with private entrepreneurs interested in and knowledgeable of recycling, who would use their own capital and personnel. Eventually 31 municipal redemption centers were operating under the new system.(27)

However, there then was a proliferation of competing privately owned "junk shops," and the market became saturated. The redemption centers accumulated more materials than they could sell, became unsightly, and were forced closed by residents. Presently, there are no redemption centers operating under the municipal program.(27)

The number of biogas digesters in China has increased from only 1,300 in 1972 to approximately 7 million in 1982. This impressive development is attributed to strong government support and advocacy. The government focused its efforts on areas of firewood shortages and severe schistosomiasis--emphasizing the gas use for family cooking and lighting and the slurry use for organic fertilizer. Government programs included financial support to install new biogas units, training, extension offices to provide technical and administrative assistance, publicity, and research and development to improve biogas techniques.(71)

Over the past 8 years, India has made a major commitment to its All-India Co-ordinated Biogas Program. About 62,000 biogas units have been installed since the program started in 1975. Eight research institutes and a number of universities have been actively involved in research and development of biogas technology. However, it appears that implementation has not been as wide-spread as in China. Research and development have not been as closely linked to implementation, resulting in less feedback from users to enable technology to be improved. Also, there has apparently been less effective dissemination of information to the target population. Some of these program deficiencies are presently being amended.(71)

From the case examples described above it is clear that government strategies to promote recycling should be dynamic processes. Research coupled with applied engineering to develop appropriate technology for local users is a necessary component. Continued training and technical assistance need to be coupled with a network of extension offices which also obtain feedback to ways of improving technology. Quite often, financial support for capital investments is essential, as well as start-up operational monies.

Seemingly unrelated government actions can influence the incentives people have to recover and reuse wastes. In Lahore, Pakistan, 40 percent of the refuse generated by residents is collected by farmers. However, with increasingly available, government-subsidized chemical fertilizers, farmers are losing interest in the refuse as soil amendment and collecting it only when it suits their convenience.(84) Similarly. government action to open Colombo, Sri Lanka, as a duty-free port resulted in paper products from other countries being dumped on the domestic market at prices with which local paper products could not compete, leading to a marked decrease in paper recycling.(15)

In many contries, taxes often favor virgin materials. A study in 1971 by the Joint Economic Committee of the USA government found that federal tax subsidies (depletion allowances) for natural resources amounted to 1.45 billion dollars. The study noted, "The subsidies to timber, oil, and other minerals appear to provide incentives to use these (virgin) resources in greater amounts and instead of other alternatives."(42) Shipping rates set by national governments often favor natural resources over scrap materials.

Government procurement specifications commonly discriminate against refurbished and remanufactured products. On the other hand, in the U.S.A. there are some procurement regulations for securing paper supplies with a minimum content of secondary fiber. Clearly, a national commitment to recycling requires examination of existing and proposed actions in light of the government itself.

Recycling can be an opportunity to reduce dependence on foreign imports, create domestic employment, and conserve limited resources, including space that would be required for burial of waste. In the annotated bibliography which follows, references covering the wide spectrum of recycling techniques are reviewed. The bibliography, and the references abstracted, provide information useful to assess the opportunity of recycling. The references also describe a variety of worldwide examples of recycling endeavors. These examples may be adapted to meet the needs of other cities, as part of the continued dynamic process of implementing a recycling program.

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PART II. ANNOTATED BIBLIOGRAPHY

INTRODUCTION TO THE ANNOTATED BIBLIOGRAPHY

This annotated bibliography is based on a one year literature search and review. The objectives of this search were to identify, assemble and review for annotation relevant literature useful to developing countries in selecting appropriate technologies in resource recovery, especially those considered to be alternatives to conventional means of solid waste management.

Many urban and regional governments, national and international agencies, and private industries are aware of the need for approaches to solid waste management that will maintain or enhance established recycling programs. However, information on many of the current recycling practices is not readily available.

As a result, many countries have experienced numerous failures in attempting to set up recovery systems. It is not because there are inherent problems in recycling but that often the intricacies of developing recovery programs are ignored, thereby building failure into the project from the start. Equally important, much of the available literature is written in an isolated context or in limited theoretical terms, and focuses on traditional or energy recycling rather than remanufacturing or reuse technologies. Therefore, the aim of this bibliography is to identify many of the data gaps and promote research by enterprising individuals and agencies. We hope the abstracts are useful in describing the techniques, issues, and other factors present in the expanding field of resource recovery.

Literature Search

A two-fold search was initiated. A computer search of several internationally available data bases was conducted early on in the project and a manual search of selected private and public information centers continued throughout the project. Constraints on travel required the project team to rely on information centers, verbal, written or telephoned requests for information.

The computer search was carried out under the auspices and direction of the World Bank's Information Center Section, Records Management Division located in Washington, D.C., U.S.A. Sixteen data bases were searched using the key word list shown in Table 2. Over 90,000 potential documents were identified.

Table 2. KEY WORDS

Agriculture

Alchemy

Animal feed supplement

Appropriate technology, low technology

Asia, Africa, Oceania, North America, South America, Central America, Europe, Middle East, India

Collection, separate truck, integrated collection

Composting, vermicomposting

Construction materials, urban debris

Enterprise(s)

Equipment files

Fiber, paper, newspaper, cellulose, insulation, high grade paper

Financing, economic developing, economy of scale, job and employment creation

Glass, bottles, bottle washing, color sorting, intermediate processing, bottle and glass crushers, screens, container deposits

Health and safety, environmental protection

Humus, fertilizer, soil amendment

Landfill, landfill high grading

Less Developed nations, developing nations

Metals, tin cans, steel cans, aluminum, ferrous, non-ferrous, bimetal

Oil, energy recovery

Organic, putrescibles, food wastes, aerobic and anaerobic fermentation, methane

Policies

Polymers, plastics, rubber, cryogenics, crumb rubber, tires

Processing, mechanical separation, hand picking, labor intensive separation

Protein

Recycling, salvage, scavenging, resource recovery, materials recovery

Regulations

Research

Resource conservation, materials conservation

Reuse, reduction, remanufacturing

Secondary materials, industries

Segregation, separation, source separation, collection centers, buy back

Shredding and grinding

Solid waste, refuse, garbage, waste, residuals, municipal solid waste

Thermal processes

Transfer stations

Transportation, horse-drawn wagons, rail

Urban, urban fringe, rural

Waste composition and quantity, waste surveys

Waste utilization, close loop systems

The use of computerized bibliographic data bases was complicated by three factors.

(1) No one data base specializes in waste recycling;

(2) Different data bases do not define subjects in the same way, and there is no standardization of indexing among data bases;

(3) Data bases do not emphesize developing countries, and there is no consistency in indexing geographic locations; e.g., a document dealing with Brazil may or may not be cross referenced to Latin America.

Many data bases do, however, cover waste recycling to the extent that it overlaps with their subject specialty. For example, CAB, which is an agricultural data base, includes waste recycling in agriculture. Thus, by searching a wide variety of data bases, we achieved a comprehensive perspective.

The problem of inconsistent subject indexing was more difficult to overcome. We developed two approaches. The first involved very general key words in all relevant data bases; e.g., solid waste, and waste recycling. This allowed us to cast a broad net and capture most records on our subject. However, it also resulted in many irrelevant items and necessitated searching through long lists to obtain the relevant records. The second involved developing individual key words for specific data bases; e.g., in searching CAB we used key words such as "composting," and when searching Compendex--an engineering data base--we used key words such as "glass crushers." This resulted in many additional items.

To overcome the problem of inconsistent country indexing, a geographic region list and a country list were developed. Also, by using key words such as "appropriate technology," records from the perspective of the developing countries were included.

The best 658 documents from the computer data bases were ranked based on a five-point system for selection using the actual documents or abstracts. The criteria were: (1) the document had to be technical in nature and contain data that would be useful either for evaluating or implementing a technology; (2) the document should deal with resource recovery primarily of low technology origin; (3) the document should contain information on the study wastes (glass, plastics, organics, paper, metals, demolition debris, oil, etc.); (4) the document should cover historical data of developed countries; (5) the document should cover developing countries. Where abstracts showed potential of three or above, the document was retrieved. One hundred and fifty of the computer references received a three or better and eventually, 50 were used in the bibliography. The results of the computer search are presented in Table 3, below.

The manual search was carried on throughout the project. Initially, the World Bank sent a letter under the Project Officer's signature, which solicited data from information centers around the world. This was done very early in the project, as it was expected to provide little information, especially from distant information centers. In fact, it became a most significant source and picked up momentum as the project progressed. Also, fifteen information centers within convenient travel distance were visited. (See Table 4 for information centers visited and contacted.)

Table 3. DATA BASES

Data Base	PreSelection	Selected for Final Review
Agricola	4,562	0
Biosis	109	5
CAB	7,355	50
CAS	4,647	0
CIS	5,587	101
Comp Dissert	4,138	35
Compendex	4,982	8
Control Data	150	0
CPI	4,486	77
Economic Abstracts International	515	90
Enviroline	17,484	40
GPO Monthly	5,396	66
NTIS	24,829	46
Pollution Abstracts	12,638	41
Scisearch	4,486	34
SSIE	1,754	65
TOTAL	93,236	658

Table 4. LISTING OF ORGANIZATIONS AND AGENCIES CONTACTED

American Electroplating Society, Winter Park, FL, USA

American Iron and Steel Institute, Washington, DC, USA

American Paper Institute, New York, NY, USA

American Public Works Association Library, Chicago, IL, USA

American Society for Testing and Materials Committee E-38 on Resource Recovery, Philadelphia, PA, USA

Applications de Recherches sur l'Energie et la Societe, Toulouse, France

Appropriate Health Resources and Technologies Action Group, Ltd., London, UK

Archives of the United States of America, Washington, DC, USA

Asian Institute of Technology, Bangkok, Thailand

Asian Recycling Association, Makati, Philippines

British Plastics Federation, London, UK

Bureau of Industrial Economics, United States Department of Commerce, Washington, DC, USA

Can Manufacturers Institute, Washington, DC, USA

Center for Policy Alternatives, Massachusetts Institute of Technology, Cambridge, MA, USA

Center for the Study of Materials, University of Toronto, Toronto, Canada

Centro Panamericano de Ingenierio Sanitania Ciencias del Ambiente, Lima, Peru

Council for International Urban Liaison, Washington, DC, USA

Department of Industrial Urban Liaison, Washington, DC, USA

Department of Industry, Warren Springs Laboratory, Stevenhaege, Heats, England

Earth Resources, Ltd., London, UK

Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland

Economic Commission on Europe, Geneva, Switzerland

Elmia, Jonkoping, Sweden

Environmental Protection Service, Environment Canada, Ottawa, Canada

Fachzeitschrift des Bundes Deutscher Champignon Züchter e.V., Bonn, Germany (FR)

Glass Packaging Institute, Washington, DC, USA

Governmental Refuse Collection and Disposal Association, Washington, DC, USA

Indian Ministry of Works and Housing, New Delhi, India

Institut für Bodenbiologie der Bundesforschungsanstalt für Landwirtschaft, Braunschweig, Germany (FR)

Institute for Local Self-Reliance, Washington, DC, USA

Institute for Scientific and Technical Information for Agriculture, Prague, Czechoslovakia

Institute for Soil Science, Swedish University for Agricultural Sciences, Uppsala, Sweden

Instituto Centro-Americana de Investigacion y Tecnologia Industrial, Guatemala City, Guatemala

Instituto de Investigaciones Agropecurias, Santiago, Chile

Instituto de Investigaciones en Matematicas Aplicadas y en Sistemas, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico

Instituto Nacional para Programas Especiales de Salud, Bogota, Colombia

Instituto National De Edafologia y Agrobiologia "Jose M. Albareda" del Consejo Superior de Investigaciones Cientificas, Madrid, Spain

Intermediate Technology Development Group, Ltd., London, UK

International Atomic Energy Authority, Vienna, Austria

International City Management Association, Washington, DC, USA

International Development Research Center, Ottawa, Canada

International Institute of Biological Husbandry, Suffolk, UK

International Solid Wastes and Public Cleansing Association, Zürich, Switzerland

Internationale Fachzeitschrift für Verarbeitung, Gestaltung und Anwendug von Kunststaffen, Speyer am Rhein, Germany (FR)

Israel Institute for Technology, Samuel Neaman Institute for Advanced Studies in Science and Technology, Haifa, Israel

Keep America Beautiful, Inc., New York, NY, USA

Merlewood Research Station, Grange-over-Sands, Cumbria, UK

Minimum Cost Housing Group, School of Architecture, McGill University, Montreal, Canada

Ministerio de Industria y Energia, Madrid, Spain

National Academy of Sciences, Washington, DC, USA

National Association of Recycling Industries, New York, NY, USA

National Center for Resource Recovery, Washington, DC, USA

National Conference of State Legislature, Washington, DC, USA

National Environmental Engineering Research Institute, Inside Chandrauel Water Works No. 2, New Delhi, India

National Science Council of Sri Lanka, Colombo, Sri Lanka

National Solid Waste Management Association, Waste Equipment Manufacturers Institute, Washington, DC, USA

National Technical Information Service, United States Department of Commerce, Washington, DC, USA

Office of Energy Conservation, Department of Energy, Mines and Resources, Ottawa, Canada

Pan American Health Organization, Washington, DC, USA

Ross Institute , London School of Hygiene and Tropical Medicine, London, UK

Royal Netherlands Society of Agricultural Science, The Hague, Netherlands

Royal Swedish Academy of Agriculture and Forestry, Stockholm, Sweden

Secondary Resources Development, Inc., Alexandria, VA, USA

Secretariat des Missions d'Urbanisme et d'Habitat, Paris, France

Society for Plastic Engineers, Brookfield Center, CT, USA

Soil and Crop Science Society of Florida, University of Florida, Gainesville, FL, USA

Soil Conservation Society of America, Ankeny, Iowa, USA

Technical Association of Pulp and Paper Industries, Chamblee, Georgia, USA

United Kingdom Overseas Development Agency, London, UK

United Nations Environmental Program—Environmental Management Service, Nairobi, Kenya

United Nations Food and Agriculture Organization, Rome, Italy

United Nations Industrial Development Organization, Vienna, Austria

United States Agency for International Development Library, Washington, DC, USA

United States Conference of Mayors, Washington, DC, USA

United States Coordination for NATO Committee on Challenges to Modern Society, Washington, DC, USA

United States Environmental Protection Agency, International Activities Office, Washington, DC, USA

United States Library of Congress, Washington, DC, USA

United States National Archives, Washington, DC, USA

University of Nebraska Agriculture and Engineering Libraries, Lincoln, NE, USA

Urban Development Institute, Bombay, India

Waste Management Advisory Group, Toronto, Canada

Waste Management Group, Organization for Economic Cooperation and Development Paris, France

World Health Organization, Environmental Health Division, Copenhagen, Denmark

Several thousand documents were reviewed using the same criteria as the computer search. In Table 5, sources of all documents selected are presented.

Table 5. SOURCE OF DOCUMENT RETRIEVAL, BOTH PUBLISHED AND UNPUBLISHED

Source	Unpublished	Published	Total
Computer Search	-	50*	50
Consultants' Holdings	8	49	57
World Bank Reports	5	-	5
United Nations Reports	-	15	15
Additional Literature**	3	107	87
	16	221	214

*23 documents already identified were also found in computer search.
**Derived from library search and correspondence with information centers.

Scope of the Bibliography

The final bibliography is not considered complete by any means. It consists of annotated documents useful in evaluating or implementing waste recovery and utilization technologies. Documents provide technical, economic, institutional, environment, and cultural information. They are categorized into areas of waste characterization, collection, processing, waste utilization, environment, cultural aspects, and economics. Twenty two percent of the references originated in developing countries, 70 percent in industrial nations (36 percent are U.S. documents), and 8 percent with international agencies.

The differences in site specific conditions, which include social and economic factors, and the magnitude of the solid waste problem make it difficult to apply technical and institutional data from one country to another. This holds true for applications from an industrial country to a developing country and from one developing country to another. The literature confirms that all too often developing countries are attracted by industrial research and technology, even though local traditions and practices may be better alternatives. The failure to document local accomplishments and development needs of small scale approaches is one reason for the lack of emphasis on indigenous solutions. Furthermore, verification of information is required. Too often, incorrect information within the small literature base is replicated and becomes "fact." This is obviously an inadequate foundation upon which to conduct planning and implementation.

We have focused on low cost, labor intensive technologies which are appropriate to the economic, environmental and social needs and resources of developing countries.

Key words are provided to guide the reader to other relevant documents. The documents are numbered for ease of reference. The numbers are used in the index section. Annexes I and II, providing an Additional Bibliography and a Glossary, the Key Word Index, Geographic Index and Authors' Index follow the Annotated Bibliography.

ANNOTATED BIBLIOGRAPHY

Resource Recovery Technology

101 Bevis, M. J.
Brawley, J. W.

Plastic Waste Resources from Textile and Related Industries. British Plastics Federation. London, U.K. #277/1. October, 1980. 35 pages. References.

This document reports on an investigation of quantities and types of wastes arising from the manufacture of textiles and acrylic fabrics. Detailed information provides a useful data base in identifying business opportunities in the recovery and reuse of plastic wastes in the textile industry. A summary of proven and commercially available techniques is included and the techniques are comparatively evaluated.

The report provides a model for business and municipalities interested in the development of plastics recycling.

plastics, textiles, resource recovery, economics, surveys, United Kingdom

102 Bevis, M. J.
Ham, A. J.

Plastic Waste Resources on the Agricultural, Horticultural and Produce Distribution Industries. British Plastics Federation. London, U.K. #276/1. October, 1980. 37 pages. References.

This report discusses processes suitable for converting waste plastics into products which can be used in horticultural and agricultural industries. It reviews the sources and amounts of plastics available for conversion. Specific uses of plastics are individually addressed.

Although collecting used plastics from farms and nurseries is financially unfeasible because of the widespread area over which the low-density polyethylene sheet plastics are used, farmers supported the idea of reclaiming plastic in the United Kingdom.

plastics, agriculture, recycling, United Kingdom

103 Bhide, A. D.
Arcfivala, S. J.

Solid Waste Management in Indian Cities. U.S. Environmental Protection Agency. Foreign Research Agreement No. 01-504-1. National Environmental Engineering Research Institute. Nehru Marg, Nagrur, India. 1974. 70 pages. References.

This is a study of the refuse practices in 33 Indian cities, which contain nearly 20 percent of the urban population of India. Questionnaires and solid waste samples collected on a seasonal basis

(including chemical analysis of samples) were used to determine existing solid waste practices and characteristics. Conclusions drawn from the study were that: 1) collection of refuse in India is labor intensive, employing 1,000-3,000 workers per million inhabitants; 2) solid wastes are collected daily; 3) glass and paper represented less than 1 and 2 percent of the refuse, respectively; 4) from 32 to 43 percent of the refuse could be composted; 5) chemical analysis showed poor refuse combustibility; 6) solid waste density was 330-560 kg/m^3 (505-943 pounds per cubic yard); and 7) per capita waste generation ranged from 0.15-0.25 kg/capita/day.

In the majority of cities the administrator of the solid waste program was a health officer. Community waste is manually collected and transported in open-body trucks. The average age of the vehicles was seven years.

Twenty two of the 33 cities composted part of their refuse with nightsoil using the Bangalore method. All but a few cities were able to sell the compost they produced. Over 62 percent of these composting facilities were small scale, using less than 4 hectares (10 acres). NPK values ranged from 0.4 to 0.8 percent.

In most of the refuse samples fine earth, ash and compostable matter were the major components. Calorific values were quite low and were always less than 6283.17 BTU/kg (2,850 BTU/lb).

Workers at composting yards did not wear gloves or use protective devices.

Two intestinal parasites were found: A. lumbricoides and T. trichiura. The former predominated in the samples examined.

composting, solid waste, organics, energy, paper, waste composition, collection, recycling, glass, India

104

Grandjean, O.
Rehi, R.
Gomes, I.C.

Composition and Treatment of Domestic Refuse of the City of Blida, Algeria. International Solid Wastes Association Journal. Number 30. pages 7-9. International Solid Waste and Public Cleansing Association. January, 1980. Zurich, Switzerland. References.

A study of the composition and physiochemical analyses of municipal wastes in Algeria was done to determine the most appropriate disposal practices. The major share of the refuse was organic and included vegetable waste (66.9 percent) and paper (15.7 percent). The refuse had a high moisture content, significant salt content and a high potassium content. Composting was the recommended disposal method. The possibility of secondary markets for metals recovered from the refuse was suggested. Further investigation is needed to determine the feasibility of

mixing the refuse with sewage sludge for composting. Extensive local and national benefits in agricultural production and land reclamation could be realized by composting.

Algeria, waste disposal/treatment, composting, sorting, sludge, waste composition, agriculture

105 Grandjean, O.
Gestion des Dechets Solides de la Region de Medellin. Ecole Polytechnique Federal de Lausanne, Lausanne, Switzerland. December, 1980. 75 pages. References.

This document provides an in-depth view of solid waste management in Medellin, Colombia and the surrounding area. It details a proposal to: 1) enhance informal sector activities in reclamation; 2) implement a workable compost system; 3) reduce the use of the landfill and long distance transportation for solid waste disposal. The review of waste management practices finds the current system expensive and a drain on municipal revenues. The environmental impact is negative for the current landfill which suggests either expensive cleanup or moving new landfills to distant locations.

A sampling methodology for wastes is described which deals not only with mixed wastes, but with individual components (glass, wood, paper, etc.) in order to determine their value. Seasonal samples of wastes were collected from several areas of the city. There was little variation noted. Sixty percent of the materials are organics.

Physiochemical analysis of the refuse showed that the energy value was very low--about 30 percent volatiles with energy contents of 1,060 kcal/kg (unprocessed raw), 2,610 kcal/kg (wet, processed) and 3280 kcal/kg (dry, processed).

Analyses for heavy metals revealed 3,000 ppm of chromium, 2,300 ppm of zinc, 1,200 ppm of manganese, 825 ppm of lead, and 1.3 percent iron.

An economic/energy analysis for source separation and composting versus incineration is presented which shows that incineration would be more expensive, less energy efficient and would add a high incremental cost to the current solid waste system. The separation-composting system would show a net energy gain.

Waste Component	Estimated Value		Verified Value
	Pesos/Ton	Pesos/Kg	Pesos/Kg
Average value	250	-	1.91-2.89
Commercial	210	2.39	-
Residential	350	2.54	-
Downtown	450	2.62	-

Further recommendations include: integrating sorting and recycling with end users, and further investigation of markets, transportation and institutional change.

Colombia, sorting, informal sector, economics, composting, organics, paper, waste composition, economic analysis

106 Lohani, B. N.
Thanh, N. C.

Problems and Practices of Solid Waste Management in Asia. Prepared for the Asian Institute of Technology. Bangkok, Thailand. Adapted for publication in Journal of Environmental Sciences. May/June, 1980. pages 29-33. References.

This paper discusses variables which affect solid waste generation and management activities in urban areas of Asia. The nature of waste is changing with rising standards of living. Homes and businesses are increasingly highrise buildings. Population densities have greatly increased. Religious practices and social attitudes towards cleanliness must be taken into consideration and can compound problems. Comparative data on solid waste generation are presented. In developing countries the density is greater due to the amount of moisture and organic materials which are present.

Wastes are collected at varying frequencies. A large quantity of waste is not collected and accumulates, which causes problems of diseases and rodent infestation. Urban congestion tends to limit collection services.

Use of landfills is not high as land availability is poor and there are not enough vehicles. Ninety percent of landfill is crude dumping. Composting is extensively practiced in India, but is rare elsewhere. Mechanized plants in Southeast Asia are unable to sell the compost which they produce.

Information is presented on pollution and health problems. Constraints to using European and U.S. methods of waste management are detailed.

waste composition, solid waste, Asia, India

107 Munoz, M.
Analysis y Necesidades del Servicio de Aseo Urbano de Lima Metropolitana. Municipality of Lima. Lima, Peru, December 1981. 21 pages.

This document analyzes data on waste composition and institutional arrangements and makes recommendations for new approaches to solid waste management in Lima, Peru.

Per capita generation of solid waste is 0.84 kg/day or 4,000 metric tons per day for the city. Household and commercial wastes are collected daily. The city has 233 compactor trucks, 19 non-compactor trucks and 78 other vehicles. About 50 percent of these are operative. The labor force numbers 3,300. Three transfer stations and one landfill are used. Unofficial landfills are operated by syndicates which cause social and environmental problems. Although feeding organic waste to pigs is illegal, the practice is ongoing and contributes to the risks of infectious disease.

Materials recovered from a landfill in one day's time include 50 tons of corrugated paper, 20 tons of plain waste paper, 10 tons of glass, 40 tons of metal, 10 tons of plastic, 10 tons of textiles, 20 tons of bone, and 10 tons of aluminum.

The report details financial and environmental problems associated with solid waste management in Lima, which has grown in population from 1.8 million in 1961 to 5 million in 1981. Comprehensive planning efforts for 1982-1985 and 1985-1990 are recommended.

waste composition, scavengers, landfills, Peru, solid waste management

108 Rathje, W. L.
The Milwaukee Garbage Project. Solid Waste Council of the Paper Industry. Milwaukee, Wisconsin, U.S.A. 1981. 115 pages. References.

This study compared household income with waste generation. Five neighborhoods, differentiated largely by income, in Milwaukee, Wisconsin were analyzed in detail. The methods used were developed based on seven years of experience analyzing household solid wastes in Tucson, Arizona. The purpose of the project was to investigate how households disposed of their wastes and if waste disposal could be correlated to family income and/or size.

Refuse from five selected and stratified sample areas was recorded during fall 1978, spring 1979 and fall 1979, using standard "Garbage Project" methodology. This work produced three data bases: Total Pickup Weights, consisting of the total weights of individual household refuse pickups (598 samples); Weight Sorts, consisting of refuse samples whose contents were sorted into fifteen material composition categories and weighed (224 samples); and Regular Sorts, composed of refuse samples whose contents, including food debris and packaging, were recorded item by item (179 samples).

It was found that: (1) The solid waste discarded by Milwaukee sample households in 1978 and 1979 were well below projections based on national per capita discard weights calculated by the U.S. EPA for 1971. This is a good indication of what the U.S. EPA has emphasized, that the realities of local solid waste streams are better measured in the field than estimated from product-flow models. (2) The average weight of solid waste discarded weekly by sample households was a little over 25 pounds. Sample households in the two low income, and one middle income area discarded more refuse overall than households in the other two areas. (3) As percentages of total weight, the material composition of refuse from sample Milwaukee households seems within the normal range for other American cities. (4) The material composition breakdown of household solid wastes indicates that sample households in the two low income areas discarded more packaging by weight than sample households in other areas. (5) Differences in discarded packaging are due to home consumption of some prepared foods and beverages and to large numbers of products packaged in small containers. (6) Judging from their higher discard of food and beverage packaging, sample households in the low income areas would probably pay more than households in the other areas--in both real dollars and in percentage of income--if product disposal charges were levied.

municipal wastes, testing methods, United States, waste composition

109 Woodyard, J.
Municipal Solid Waste Survey Protocol. U.S. Environmental Protection Agency. Municipal Environmental Research Laboratory. Cincinnati, Ohio. U.S.A. 1978. Prepared by SCS Engineers. Contract #68-03-2486. 400 pages. References.

This study was conducted for the U.S. EPA and is a comprehensive report on different methods to estimate, characterize and sample wastes. Survey costs, objectives and methods are discussed in detail. Statistical analyses of waste samples were developed and used in computer models to assess economic sensitivity of resource recovery operations.

solid wastes, municipal solid wastes, waste sampling, United States

COLLECTION AND TRANSPORTATION

201
Analysis of Source Separate Collection of Recyclable Solid Waste: Collection Centers. Prepared for Resource Recovery Division, U.S. Environmental Protection Agency, Washington, D.C., U.S.A. Prepared by SCS Engineers. August, 1974. 49 pages. References.

This report presents the results of 13 case studies of collection centers. Information was obtained on performance and operating costs, as well as the time needed for households to separate, prepare and deliver recyclable waste materials to the centers. There are an estimated several thousand recycling centers in the U.S. Recycling/collection centers are of three types: citizen, commercial or municipal. All types require labor, land and equipment. Citizen centers rely on voluntary labor, while commercial and public municipal centers have paid labor.

Expensive and extensive equipment was used at municipal centers, while citizen and commercial centers used donated or salvaged equipment.

United States, solid wastes, recycling center, costs

202
Analysis of Source Separate Collection of Recyclable Solid Waste: Separate Collection. Prepared for Resource Recovery Division, U.S. Environmental Protection Agency. Washington, D.C., U.S.A. Prepared by SCS Engineers. 1974. 103 pages. References.

This report presents results of 22 case studies on separate collection programs throughout the United States. Sample households conducted a two-month study which required separating items suitable for recycling. The amount of time the households needed to prepare the items is detailed, as are complete cost data. An analysis was done to determine optimal approaches to home recycling. Separate versus integrated collection is considered. The data indicate a negative attitude is usually displayed toward the scavenger sector. Recommendations are made to forcibly exclude scavengers from participating in community efforts, rather than integrating their efforts.

resource recovery, scavengers, solid wastes, source separation, costs

203
Case Study: Separate Collection in Hoje Tastrup, Denmark. Organization for Economic Cooperation and Development. Environment Directorate. ENV/WMP/79.5. Paris, France. July 1979. 38 pages. References.

A separate collection program for recyclables was developed in Hoje Tastrup, Denmark. Paper, glass and metals are separated for pick-up at 4 week intervals from homes, using trucks with compartments and adjustable partitions. Apartment buildings use a central container, also

with compartments. Collection is done as necessary. Free collection of recyclables is offered to businesses who separate material.

Collected materials are sorted at the municipal recycling station. Reusable bottles are salvaged. White goods are dismantled for metals recovery using simple hand tools. Goods are sold directly from the station to end users or secondary materials dealers.

Collection from single-family households had contaminants of 15 percent, while apartments had 70 percent. By weight, the recyclables were 58 percent paper, 19 percent metal and 23 percent glass. Energy savings of recyclables versus virgin materials were computed as 162 kg of oil equivalent per ton recycled. The incremental cost of recycling was estimated at 38-57 kroner per household per year. Social benefits include increased employment, and reduction in disposal requirements.

source separation, paper, glass, tin cans, intermediate processing, Denmark

204
Households Contributing to Resource Recovery. Swedish Institute for Resource Recovery. Malmo, Sweden, 1975. 42 pages. References.

This document was prepared by the Swedish Institute for Resource Recovery. It provides municipalities and companies with information on resource recovery. Tests were done to determine how much household waste could be recycled through source separation, on a nationwide basis.

Source separation recycling can be introduced with a net decrease in costs. For example, three to seven percent of the costs of waste disposal can be eliminated in a town of 50,000 people. Further reductions might be possible if treatment facilities and transportation costs were reduced, based on reduced amounts of waste collected. Municipalities should view source separation as an activity at least as important as waste disposal. In addition, professional attention must be given to selling the recycled goods. Recommendations included making long term arrangements with Swedish paper mills to utilize waste paper and establishing other secondary materials markets. Tests were done in 176,000 households and indicated that residents have a favorable attitude and will initiate source separation. Participation averaged 70 percent.

source separation, Sweden, resource recovery, marketing, costs

205
Source Separation Collection and Processing Equipment: A User's Guide. Report (SW-842). Prepared for the Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C., U.S.A. Prepared by Resource Planning Associates. 1980. 55 pages. References.

This document provides an overview of source separate collection processing procedures and equipment. It is well illustrated and helps instruct municipalities in the selection of equipment and systems. In

designing source separate collection systems, the following points need to be considered: 1) estimating citizen support; 2) surveying and negotiating with markets; 3) informing the public; 4) selecting equipment; 5) assessing labor needs; and 6) consideration of local ordinances.

Collection systems are varied. Specific equipment for collection and processing is described, with advantages and disadvantages listed for each.

Manufacturers and suppliers are listed. A number of systems in the United States are identified and described in terms of size, operation and equipment.

recycling, equipment, source separation, appropriate technology, United States

206

Archer, T.
Huls, J.

Resource Recovery from Plastic and Glass Wastes. U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, Office of Solid and Hazardous Waste Research. Cincinnati, Ohio, U.S.A. Prepared by Pacific Environmental Services. July, 1981. 139 pages. References.

This document reports on state of the art for recovering glass and plastics from municipal solid wastes. It is based on a review of the literature.

Questionnaires were distributed to firms involved with plastic and glass recovery. The data were evaluated for technical, economic and environmental content.

Both industries were characterized by processes, material flows, economic dynamics, and waste generated. Methods for recovery and recycling are identified. Economic and environmental parameters are provided. Currently, labor intensive source separation of glass and plastic predominant, although mechanical recovery will achieve greater importance in the future.

Also covered are world wide state of the art reports on materials recovery including estimates of the composition and per capita generation of waste in several countries.

glass, plastic, recycling, equipment, state of the art, markets, economics, processing, environmental management

207

Brown, M. D.
Vence, T. D.
Reilly, T. C.

Solid Waste Transfer Fundamentals. Ann Arbor Science, Ann Arbor, MI, U.S.A. 1981. 69 pages. References.

This manual covers the consolidation of refuse collected by small vehicles and then transferred to large volume trailers for efficient

transportation to a disposal site or a resource recovery facility. Truck transport of refuse is a well established technology which has initiated the development of equipment designed specifically for this purpose.

The manual presents a simple technique to evaluate whether refuse transfer will benefit a specific solid waste disposal situation. It also discusses the basic data required to analyze, design and implement a transfer system. Data include waste quantity and composition, traffic patterns, site characteristics, and opportunities for materials recovery.

There are two basic types of transfer systems: 1) direct dump and 2) hydraulic compaction. Direct dump systems can be subdivided into container, open top trailer, and storage pit systems. Hydraulic compaction systems use a stationary compactor and either enclosed trailers or enclosed containers. A variety of methods are used to feed the compactor: direct dumping, a front-end loader on the tipping floor, a conveyor, or a hydraulic push-pit.

Factors contributing to a successful operation, regardless of size, include a daily operating procedure, proper equipment and facility maintenance, adequate safety provisions, and an effective record keeping system. Transfer stations also offer opportunities for recovery of recyclable materials and energy from the solid waste being handled. Often a drop-off recycling center is provided at the site. Station users are encouraged (sometimes with financial incentives) to separate reusable items and recyclable materials. Additionally, certain materials can be recovered directly from the station floor. It is quite common to see cardboard picked from commercial loads and baled for resale. The transfer station may also serve as the first step in the development of a mechanized resource and energy recovery facility. As the cost of energy rises, systems utilizing the energy value of refuse become more and more attractive. Transfer stations should be designed to allow for a possible future resource recovery project.

The manual presents a case study based on the authors' experience in transfer station design. A city of 110,000 responded to the impending closure of its municipal landfill by developing a plan for a three part solid waste management center. It will include a recycling center with storage capacity for curbside collection of source separated materials, a transfer station, and a materials and energy recovery facility.

salvaging, solid wastes, intermediate processing, economics, collection

208 Bukreyev, Y.
Waste Systems in the U.S.S.R. Waste Age. National Solid Wastes Management Association. Washington, D.C., U.S.A. Volume 13, Number 2. February, 1982. Pages 68-70.

Collection practices in the U.S.S.R. share characteristics with operations in the U.S., but there are notable differences. For example, most housing in large Soviet cities consists of apartment buildings which require centralized collection. Containers are loaded from garbage chutes in the buildings and then hauled to a central depot.

Another example is a vacuum system for removing household wastes through special sewers that have been established in Moscow.

Currently, collected wastes in Moscow are incinerated. Metal is extracted from the residues with an electro-magnetic separator. Emissions have been acceptable. Other cities use landfill disposal, with increasing costs due to longer hauling requirements.

Composting of mixed waste is practiced with contaminants mechanically removed after processing. Compost is applied primarily on agricultural lands, but can also be used in greenhouses to raise temperature levels, and as a fertilizer supplement.

A waste to energy (steam) plant will soon be operating in the city of Vladimir. Its three chambers will burn 180 tons per day of solid waste, generating 53,000 hectocalories annually to be used by the city's utilities. Up to 30 percent of the residues (slag and ashes) will be used for making tiles. Metal will be recovered from the slag. The Vladimir plant will test equipment produced in the U.S.S.R. There is a high demand for installation of similar plants elsewhere.

solid waste management, Union of Soviet Socialist Republics, incineration, energy recovery, composting

209 Bunk, B.

Refuse Separation and Utilization on the North Sea Island of Juist, Federal Republic of Germany. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 204-210. References.

This paper discusses source separation on the island of Juist. Two experiments were conducted in 1977 and 1978 which resulted in an ongoing program of separation and recycling, using horsedrawn carts. Recycling begins with on-site separation at commercial and residential locations. Three categories of waste are collected: paper, glass and metal/plastics. Organic wastes are composted and used in agriculture. Metals and plastics are currently disposed of, due to no end use markets.

recycling, source separation, Juist (Island of), Germany (Fed. Rep. of)

210 Flintoff, F.

Management of Solid Wastes in Developing Countries. World Health Organization. WHO Regional Publications, South-east Asia Series #1. 1976. Green Park, New Delhi, India. 276 pages. References.

This manual was initially developed to guide Indian officials who are responsible for solid waste collection and disposal. It is an important work useful for solid waste management in all developing countries. Topics covered are: sampling methods to characterize wastes, refuse storage and collection, collection vehicles, sources of waste, transfer facilities, and treatment and disposal.

The data is based on experiences in over 20 countries in Southeast Asia, the Western Pacific, and the Eastern Mediterranean. Well illustrated, the document present technical, economic and sociological data.

The author suggests that Western technical literature is not directly applicable to developing countries. Cultural differences, the lack of capital and the type of wastes all must be considered when planning a solid waste management system. It is important to create a system that is labor intensive, using indigenous tools and equipment. Costs should be in keeping with local budgets.

Composting is discussed in substantial detail. Wide variations are noted between countries in what is composted and how best to utilize the product.

waste composition, testing methods, composting, economics, solid waste management, India, recycling, developing country

211

Gotah, S.
Tamara, E.
Yukhi, Y.

Source Separation for Resource Recovery--State of the Art. National Institute for Environmental Studies. Tsukuba, Japan. November, 1978. 58 pages. References.

This report describes resource recovery in two medium sized Japanese cities. Resource recovery is extensively practiced in cities where the population is less than 300,000. Incineration is a major form of waste disposal and the resulting environmental problems helped influence a move towards resource recovery and source separation. It is recognized that resource recovery at the source reduces waste and, at the same time, collection costs and requirements. Citizens separate three to five categories of recyclables and non-recyclables.

The document details a community conflict of recycling versus incineration which was resolved to allow for both recycling and incineration--an example of an integrated approach to resource recovery where high and low technology co-exist. The costs and design of the system are presented.

resource recovery, state of the art, processing, collection, costs, economics, incineration, source separation, Japan

212

Hoy, S. M.
Robinson, M. C.

Recovering the Past: A Handbook of Community Recycling Programs, 1890-1945. Public Works Historical Society. Chicago, U.S.A. 1979. 24 pages. References.

This document traces the roots of conservation and recycling in the United States. Basic strategies for implementing recycling programs include marketing, labor, materials handling and promotion.

In the early 20th century industrialization and the resulting waste and pollution created new citizen awareness of the need to clean up the cities. New York City, under the direction of George Waring, created a comprehensive program of resource recovery and promoted cleaner streets and better public health, which reduced costs of solid waste management. This program, begun in the early 1890s, was successful and widely copied.

World War I gave further impetus to resource recovery and materials reclamation. Some cities used prisoners as a labor source for these programs and set aside some of the revenues for the prisoners' families. For example, in 1916, the city of Chicago gave US$40,000 to the families. Additional revenues were used for landfill reclamation projects.

During World War II, the War Production Board coordinated renewed recycling efforts. However, after the war, with the coming of prosperity, Americans abandoned most recycling, until the early 1970s.

United States, recycling, prison employment, historical

213 Stearns, R. P.
Anthony, R. V.
Howard, S. E.

Office Paper Recovery: An Implementation Manual. Prepared for U.S. Environmental Protection Agency. Washington, D.C., U.S.A. Prepared by SCS Engineers. 1977. 53 pages. References.

This document was prepared by the U.S. Environmental Protection Agency in accordance with the Resource Conservation and Recovery Act of 1976. The recovery and utilization of paper from office buildings can save valuable fiber resources, lower environmental emissions and reduce waste management expenses. This implementation manual was prepared for distribution to the public and private sectors.

Information is provided on the quantity of paper which could be recovered, its market value, the various kinds and grades of paper, separation methods, collection and storage equipment, and model contracts.

Recovery of high grades of paper from office buildings is one of the fastest growing forms of resource recovery in the U.S. Costs of waste disposal from office buildings can be significantly reduced through revenue from sales.

office building recycling, waste paper recovery, waste management, costs

214 Von Heidenstam, O.

Swedish Experience in Separation at Source Solid Wastes. Institute of Solid Waste Management. London, U.K. Volume LXVII, Number 7. July, 1977. pages 284-95. References.

This document reports on the increasing need for source separation of waste in Sweden. The government view is that refuse is raw

material to be recovered. In May 1975, a national bill was approved on the collecting and recycling of wastes. It required the collection of waste paper exclusively by the municipal refuse disposal authority. In homes, compulsory sorting applies only to newspaper and magazines. The legislation was preceded by pilot studies indicating household cooperation was essential.

State grants are available for 50 percent financing for recovery plants and 25 percent grants for material benefication. Regional solutions are preferred.

Municipal wastes are characterized. Also the amounts of recovered material are noted in the report.

Collection is done by separate vehicles or by bagging recyclables separately which are picked up with the regular refuse collection. In apartments, the landlord pays for extra sacks or dustbins and benefits from lower refuse removal costs. For private homes, a 2 1/2 to 3 ton truck with a two person crew is used while a 3 1/2 to 4 ton truck with a one person crew is used for apartment house pickups.

Contracts between municipal authorities and paper companies vary in regard to price and responsibility for collection. Problems in paper recovery by municipalities are price and storage.

paper, source separation, separate collection, municipal waste, vehicles, waste composition, solid wastes, Sweden

215 Werth, P.
Vehicles and Containers for Separate Collection--Technical and Economic Criteria. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 853-858. E. Freitag--Verlag für Umwelttechnik. 1979. References.

This paper examines several types of vehicles and containers which collect and separate recyclables.

Recycling is enhanced by cleaning and keeping the various materials separate. Once mixed, they are usually reduced to their lowest economic value unless additional sorting takes place. Separate collection of recyclables requires large scale citizen information and motivation, a highly developed organization, and special attention to proper integration of collection systems and equipment with end use markets.

Separate collection in trade industries for recycling is feasible due to high and concentrated volumes of scrap. Drop-off boxes and roll-off containers are convenient to use. For selected light materials it seems advantageous to use a compaction mechanism. The author compares compaction vehicles and roll-off containers for plastics and paper. The results suggest greater payload opportunity for compaction vehicles but larger volumes are needed to justify the vehicles. Problems can also be created if more than one material is collected and separation is required at a

later date. Separate collection was found to be more efficient than collection centers for household wastes.

separate collection, economics, source separation, vehicles

216 Willerup, O. H.
Recycling of Glass. Conservation and Recycling. Pergamon Press. U.K. Volume 1, Number 1, 1976. Pages 149-159. References.

Recovery of glass from European households is discussed in this article. The arguments for and against nonreturnable beverage containers are discussed. The results of a Swedish study are reported where the energy consumption is compared for a returnable bottle, a nonreturnable PVC bottle, a nonreturnable steel can and a nonreturnable glass bottle. Results are reported of British, Danish and Swedish test collection of paper, glass and metal. Reuse procedures are described for collected glass.

Household refuse in Europe generally contains five to ten percent glass. Per capita production of refuse in Denmark is about 300 kg per annum. An unusually low percentage is comprised of beer and soft drink bottles because government legislation permits brewers to sell only four percent of their total consumption in non-renewable bottles.

Glass scrap is not simply competitive with virgin materials; it complements the manufacturing process. This both aids and complicates the possibilities of recycling glass. Glass usually contains a specified addition of cullet which, because of its lower viscosity, speeds up the mixing and reaction of raw materials and also reduces the energy consumption. For this reason, glass manufacturers usually produce a supply of their own cullet, whose quality is known and preferred to purchased glass scrap of unknown quality and composition.

glass recycling, Denmark. Sweden, United Kingdom, returnable containers

217 Diaz, L. F.
Savage, G. M.
Golueke, C. G.
Resource Recovery from Municipal Solid Wastes, Volume 1 Primary Processing and Volume 2 Final Processing. CRC Press. Boca Raton, Florida. 1982.

The authors summarize and evaluate municipal solid waste management and recycling practices in the United States as of 1980. Cost data presented for a few of the unit processes reflect the greater emphasis in the United States on technological and operational aspects of capital intensive resource recovery from mixed refuse. Engineering observations or principles are given for selecting equipment for conveyance, size reduction (horizontal and vertical hammermills), separation (air classificators, trommel screens, magnets), incineration with heat recovery from mixed refuse or from refuse derived fuel (pelletized or loose), anaerobic digestion, single cell protein and ethanol production, composting, and

residual disposal (landfill) systems. Glass, paper, and other recyclable components are identified.

anaerobic digestion, appropriate technology, composting, costs, equipment, fuel, glass, incineration, landfill, municipal solid wastes, paper, processing, recycling, solid waste management, United States

218 Vogler, J.
Work from Wastes. Intermediate Technology Publications, Ltd., and Oxfam. London, United Kingdom. 1981.

The author provides comprehensive technological information and marketing strategies for recycling paper, ferrous and nonferrous metals, glass, plastics, rubber, nonferrous and precious minerals, chemicals, oil, and human and animal wastes. Details of designs or names of manufacturers are provided for such products as egg cartons, roofing paper, sorted and processed metal scrap or billets, metal fabrication, shoe soles, simple and advanced glassmaking, molded and extruded rubber and plastics, and construction materials. Initial costs are provided for selected systems.

Case studies of small scale enterprises based on waste plastics or vegetable matter are presented. Emphasis is on collection, sorting, quality control, health aspects, and pricing.

agricultural wastes, appropriate technology, building materials, chemicals, collection, costs, equipment, ferrous/nonferrous recovery, glass manufacturing, glass recycling, health and safety, marketing, molded products, oil, paper, plastics, plastics recycling, processing, recycling, rubber, small scale industry

219 Abert, J. G.
Resource Recovery Guide. Van Nostrand Reinhold Company, Inc. New York, New York, U.S.A. 1983. 593 pages.

This publication is a selection of articles, some condensed, mostly published in the United States from 1976 to 1979. One section considers planning, procurement, marketing, economic and financial aspects of industrial systems for resource recovery, and for some systems aggregated costs. Information is provided on glass, paper, steel, plastics, rubber and aluminum recycling, energy recovery through direct combustion of unprocessed and processed waste, pyrolysis, and other recycling techniques.

Some of the changes in attitute and technology regarding municipal waste recycling during the 1970s are documented. Also included are details on U.S. Department of Energy planning approches and risk analysis.

costs, economic analysis, energy recovery, ferrous/nonferrous recovery, glass, marketing, paper, plastic, pyrolysis, recycling, rubber scrap, technology

PROCESSING

301 Ambrose, J. A.
Composting. In Proceedings of International Symposium, "The Practical Implications of the Reuse of Solid Waste." 11-12 November, 1981. London, U.K. Pages 63-111. Institution of Civil Engineers. 1981. References.

This paper reviews several large composting plants. The mechanical methods by which batch production has been modernized into continuous plant operations are discussed.

Italy: The large Dano plant feeds refuse to stabilizers without pretreatment. Compost is produced and stored in covered shipment from the site. A large percentage of plastics is removed. This includes the bags used for collection, which are then burned in incinerators. Metals are left in the refuse and extracted from the product after discharge from the stabilizers. The presence of metals in the stabilizer was reported to help in the breakdown of the refuse.

Hong Kong: The plant was commissioned in 1979 and has a through-put of 240 tons per eight hour shift. It is a combination of several methods of producing compost. Refuse is fed through a primary and secondary crusher before it is fed into a horizontal slow speed drum. From this drum it is lifted to vertical composting towers. Each tower has three floors. After a 72-hour retention period, it is passed to a covered windrow for final maturing. The main purpose of this plant is to produce suitable material for covering landfills, which is not readily available in Hong Kong.

Libya: Three plants have been built in Benghazi, Tripoli and Beida. Benghazi produces 400 tons per day; Tripoli 500 tons per day and Beida 60 tons per day of compost. The refuse at all plants is pulverized in both primary and secondary mills before being screened. The fine product is then passed to the digester. Metals are extracted before screening. The system includes a compost grading plant, an incinerator for materials not composted, a metals "roaster" and a baling system for recovered ferrous metal.

India: The Bangalore system of composting has been used in India for many years. Originally this was an anaerobic system used on a small scale which provided a low-cost solution for the combined disposal of solid wastes and nightsoil. These materials are placed in alternate layers in small trenches which are sealed and left undisturbed for many months. The contents are then dug out and used as compost.

This system is now being abandoned in favor of aerobic methods, which are faster and need less land than anaerobic methods. The character of solid waste components has to be analyzed to determine how suitable it is for composting. Although similarities exist in solid waste throughout the world, there are extremely wide variations in the proportions of the components. This can vary not only between countries but even between regions within the same country. Middle Eastern wastes are compared with those of India and Europe in the table below. It illustrates the importance of adopting composting systems to match available wastes.

CONSTITUENTS

	% By Weight		
	India	Middle East	British
Essential to compost			
Vegetable, putrescible	75	50	28
Acceptable for compost			
Mixed paper	2	20	37
Inert below 10 mm	12	14	9
Compostable total	89	84	74
Salvageable Constituents			
Paper (also included above)	2	20	37
Metals	0	9	9
Glass	0	4	9
Textiles	3	4	3
Plastics	1	3	3
TOTAL of potential salvage	6	40	61

composting, technology, solid waste, India, Italy, Hong Kong, Libya, organics

302
Advances in Small Scale Refuse Incinerators. Seminar Proceedings. Newfoundland, Canada. Solid Waste Management Branch. Environmental Conservation Directorate. EPS-3-76-10. 103 pages. 1978. References.

This document is based on two seminars held in Newfoundland to consider the use of small-scale refuse incinerators as a solution for provincial solid waste problems. Topics included design, costs and benefits, air quality standards and a detailed description of state of the art. Detailed illustrations explain how the design of the incinerator relates to the combustion process. The costs for all basic types of units are presented and compared to typical landfill costs. Case studies of three sites in Canada are reviewed. The data focus on how the incinerators were selected, how their sites were selected, and how to meet environmental standards economically. Federal regulations pertaining to incinerators are evaluated.

Based on practical experience, the authors recommend specific actions to take to meet various standards, e.g., where hydrogen chloride is a problem they recommend limiting PVC in waste to 0.25 percent of feed.

small scale industry, incineration, Canada

303
The Bangkok Solid Waste Management Study in Thailand. Prepared by Japan International Cooperation Agency. Tokyo, Japan. 1981. 523 pages.

This study provides a comprehensive analysis and implementation plan for developing a solid waste management policy in Bangkok, Thailand. The goals of this policy are to help clean up the city and promote effective use of compost.

A history of solid waste management is presented and includes present volume and properties of solid waste. Estimates are based on statistical data and results of field investigations. Forecasts of future volumes of waste for the year 2000 are made based on socio-economic data.

Short-term improvement of solid waste practices was considered from the point of view of management, collection, transport, compost plants, final disposal and management during floods.

Compost operations began in 1961 with four plants currently operating. An incinerator is attached to each plant to combust organic wastes classified as unsuitable for composting. The four plants' treatment capacity is 1,120 tons per 8 hour shift. The process begins with impact pulverization of delivered solid waste, classification, 5-day indoor primary fermentation, and 2-month outdoor secondary fermentation using an open-air storage method. Upgrading of compost for sale is conducted by a system of 12 rotating trommel screens. Quality and fertilizer aspects are described. Retail price for compost grades range from 370 Bhat/ton to 740 Bhat/ton. In 1980, total sales value was 7.7 million Bhat.

Ferrous metal is also recovered and sold. The amount of recovered ferrous metal by the magnetic separator from the raw waste entering the compost plants is approximately 0.8 tons for each 100 tons of raw waste. The recovered ferrous metal is compressed into blocks weighing 30 kg on average. There were 2,400,616 blocks (about 72,000 tons) recovered by the 4 compost plants in fiscal 1980. Retrieval of materials by workers is done during regular collection of solid waste. The recovered materials are purchased by junk dealers.

The monthly earnings by scavenging materials is about 1,500 Bhat. Coupled with other fees, a worker can almost triple his income.

Specific recommendations to improve composting operations include: a manual or mechanical system to remove glass, metal, and plastics; building a roof over the secondary fermentation yard; preparing an operating and quality control manual; changing the pricing policy to realize large scale sales at a low price; increase sales by selling composted material as landfill cover and for use on parks and road shrubbery; and encouraging trial applications on farm land.

Total estimated demand for city compost is 90,000 tpd, or 1,900 tpd of compost plant capacity. Since the existing compost plants have a total capacity of 1,120 tpd, additional plants with a capacity of 800 tpd could be constructed. New plants should use aerated composting which is low in production cost and easy to operate and maintain. Fertilizers derived from various types of wastes are detailed.

Methanation and feeding (conversion to cattle feed) were excluded from resource recovery evaluation since these technologies are not yet fully established.

Recommendations for improved environmental protection and public health include door-to-door collection, intermediate treatment (physical, chemical and/or biological processes) to make solid waste non-toxic, reduced in volume, and reusable.

solid waste management, composting, ferrous scrap, Thailand, scavengers

304
Bibliography on Disposal of Organic Refuse by Composting. Institute of Engineering Research, University of California. Berkeley, California, U.S.A. 1950. 80 pages. References.

This document is an annotated bibliography compiled by the Sanitary Engineering Research Project of the University of California, Berkeley, after a critical review of the literature. It includes selected articles pertaining to composting. The main source of references from which the bibliography was compiled were Chemical Abstracts, Industrial Arts Index, Engineering Index and the World Bibliography of Bibliographies.

The bibliography is divided into sections of general references, references to journals, and a subject index.

composting, developing country, organics, waste disposal/treatment

305
Compendium on Solid Waste Management by Vermicomposting. Prepared for U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory. By Camp Dresser and McKee, Inc. Boston, Massachusetts, U.S.A. March, 1980. 55 pages. References.

This report assesses the technical and economic feasibility of vermicomposting. It is based on a pilot study in Ogden, Utah, U.S.A. The species of earthworms used, the physical parameters of the worm culture and the physical and chemical changes that occur during vermicomposting are described. Facilities and costs for cities of 50,000 and 500,000 are detailed, using the Ogden model and compared with sanitary landfill, windrow composting, and modular combustion. The cost of US$24-32 per ton of processed waste was high compared to the other methods. The reason for this may have been the use of shredding and magnetic separation to homogenize materials. The Ogden test used shredded mixed waste subjected to one pass through a magnetic separator for ferrous metal. This material was windrowed for composting. Worms were added after three weeks. Additional mixed waste was added. After the prior separation of paper, glass, and metals, the study showed that for every 100 tons of waste, 36 tons of recyclables and 33 tons of worm castings are produced with 13 tons

lost as moisture and volatilized solids and 18 tons left as residue for land fill. Markets for the product and its environmental impact are discussed.

vermicomposting, solid waste management, economic analysis, markets, United States

306
Improving Soil Fertility Through Organic Recycling: Compost Technology Collected Lectures. Delivered during project training course held at New Delhi, India. October-November, 1980. Food and Agriculture Organization of the United Nations. 214 pages. 1980. References.

This course covered theoretical and practical aspects of composting. Both urban and rural composting techniques are discussed. Participants in the training course were from ten Asian countries. Lecture topics included fundamentals of composting, different methods, present state of composting, low cost technology, compost enrichment, agricultural aspects and more. Practical laboratory work and visits to compost factories were part of the course.

This training course is intended for use as the basis for a field manual.

technology, Asia, organics, soil amendment, recycling, composting

307
Improving Soil Fertility Through Organic Recycling: Management of Organic Recycling. Proceedings of Project Seminar held in Kathmandu, 9-14 March, 1981. Food and Agriculture Organization of the United Nations. New Delhi, India. 1981. 221 pages.

The proceedings of this seminar concluded that recycling of urban wastes has made substantial progress, although much research remains to be done. Reports came from Burma, Hong Kong, India, Indonesia, Korea, Malaysia, Nepal, Pakistan, Philippines and Thailand. Recommendations were: 1) it is important to consider the value of NPK in compost. Other benefits such as an improved environment, better health and long-term improvement of a country's soil need to be assessed when appraising proposals for compost plants. 2) Local and national agencies need to closely coordinate their efforts. This will aid marketing and promotion activities. 3) When compost is produced from municipal wastes, it is essential that monitoring programs be established to ensure that the product is safe. 4) It is advisable to start marketing compost in advance of the commissioning of plants. This could be accomplished by setting up a small (5 ton per day) plant during construction of the main plant. 5) More research should be done on the enrichment of compost in coordination with agricultural research institutions.

composting, organics, soil amendment, recycling, waste management, municipal wastes, Burma, Hong Kong, India, Indonesia, Korea, Malaysia, Nepal, Pakistan, Philippines, Thailand

308
Materials Reclamation Weekly 1981 Directory and Handbook. A. Cohen and Company, Limited. London, U.K. 1981. 432 pages. References.

This catalogue is an up-to-date source for equipment for handling secondary materials and market information. Primarily United Kingdom manufacturers are represented. Materials specifications for European, American and Indian industry are discussed for paper, nonferrous metals, ferrous metals, textiles, plastics, rubber, chemicals and oils. Technical test programs are reviewed. A glossary of terms is also presented for each material. Legislative developments are reviewed. There is an index to advertisers and directory of United Kingdom reclamation companies.

equipment, manufacturers, paper, textiles, rubber, plastics, chemicals, oils, United Kingdom, ferrous scrap, nonferrous scrap

309
Mechanical Sorting of Household Waste in Rome, Italy. Environment Committee, Waste Management Policy Group, Environment Directorate, Organization for Economic Cooperation and Development. Paris, France. 1979. 16 pages.

Italy has established a national policy which examines all types of resource recovery and reuse. This document is a case study of householdwaste collection and mechanical sorting in Rome.

There are two plants, 600 tpd and 1,200 tpd in operation. Residues are incinerated. Paper, iron, plastics, animal feed, compost, steam, glass and electric power are recovered. Incinerated wastes produce steam of 8 atm saturation used in internal technical process with part sold to neighboring industrial plants. Local markets for materials are described, including types of contracts, and processing required.

In 1973 a basic charge of 3,850 lire per ton processed was paid to the company by the Rome municipality. This includes a charge of 70 percent share for write-off. The average charge for the period 1973-78 was 6,100 lire per ton. This corresponds with costs per ton for a safe and effective treatment system.

sorting, municipal waste, animal feed, incineration, Italy, secondary materials recovery, recycling, energy recovery, collection

310
Recycling of Waste Paper from Federal and Provincial Buildings in Toronto. Environmental Conservation Directorate of Canada, Ottawa, Canada. 1977. 105 pages. References.

This document reports on the feasibility of collecting waste paper from federal office buildings in Toronto, Canada. A pilot project was initiated that determined volume, composition, potential markets, and costs. The pilot project indicated significant savings. Estimates of

revenues from sales and disposal cost savings are US$57,420 per year. Implementation costs are estimated at US$44,000. Total annual operating costs are estimated at US$21,000. Net revenue and savings of US$8,020 per year could be generated at an assumed % opportunity cost of capital (or market cost).

waste paper recovery, office building recycling, Canada, cost analysis

311
Waste Oil Reclamation. United States National Technical Information Service, United States Department of Commerce. Springfield, Virginia, U.S.A. July, 1981. pages 1964-1981. PB81-87471. References.

This published literature search contains state of the art data on oil recovery, reclaiming and re-refining, from both technical and economic perspectives. Generally, high technology systems are noted, although pilot scale and small scale applications are included.

oil, environmental management, resource recovery, state of the art, economics

312 Baldensparger, H. L.
The Akron Industrial Salvage Company: A Community Incorporated Waste-Saving Experiment. United States Department of Commerce. Waste Reclamation Service. Government Printing Office. Washington, D.C., U.S.A. 1919. 20 pages.

This historic article discusses a community operated salvaging program started in Akron, Ohio in 1918. Eventually a warehouse on a railroad siding was chosen for the sorting of salvaged materials. No heavy equipment was used. Material flow was: (1) offloading outside the facility; (2) movement of materials into a basement; and (3) material moved to a sorting room in an upper story. During a little more than a year, the operation handled 600,000 pounds of wastes and sold 220,000 pounds. Payment was based on weights of unsorted materials minus sorting charges. Several firms pooled their wastes, creating a greater volume of salvageable materials.

The document also discussed municipal source separation; prison labor systems; public building collections; training of salvage managers; and a British national waste saving program similar to the one in Akron.

source separation, community enterprises, recycling, salvaging, processing, marketing, historical, prison employment, United States

313

Bates, C.I.
Neilson, T.D.

Pulling Iron Out of the Fire: Extracting Tinplate from Domestic Refuse Prior to Incineration. Material Recovery, Ltd. and Staffordshire County Council. U.K. February, 1980. 19 pages. References.

This article discusses the removal of tinplate scrap from mixed waste. Detinners require that the scrap be relatively free of contaminants such as food and plastics and not be crushed to permit adequate cleaning. As a result, transportation costs for loose cans are very high.

The incorporating of a ferrous recovery system into an existing waste incineration plant in Stoke-on-Trent Staffordshire is described. The system constraints include: limited space, need to open plastic bags, and minimum nuggeting (crushing). A flail mill shredder was considered. It would open bags and not nuggetize cans and was the least costly of the options. However, it was rejected for its size and the vibrations it produced at high speeds. Eventually, a slow speed shear shredder was chosen. It shredded to minus 6" throughout at up to 30 TPH, opened all bags, did not overnuggetize the cans, handled bulky material and some white goods, and operated quietly.

After the first shredding, ferrous material is conveyed to a secondary magnetic separator for a finer secondary shred. The final product is baled for transport.

tinplate recovery, ferrous scrap, equipment, recycling, United Kingdom

314

Bowerman, F.R.
Compton, C.R.

Composting Operation in Los Angeles County. Compost Science Journal. Rodale Press. Emaus, Pennsylvania, U.S.A. Volume 1, Number 4, 1961. Pages 5-8. References.

This historical paper documents a unique pilot program in Los Angeles County, California, U.S.A. which involved low cost composting of combined refuse and sludge. A concrete drum dryer unit, alfalfa grinder, and miscellaneous conveyors were combined into a functioning pilot plant. Mechanical rotation and forced air feed prepared sorted raw refuse during a two day retention. This material was then windrowed for 4-6 weeks and sold. Internal temperatures reached 160°F for 2 days which was sufficient to destroy harmful bacteria. The mechanical unit was 5 feet in diameter, 30 feet long, and was rotated at 0.67 rpm or 10.5 feet per minute. The unit functioned as continuous batch process and was later compartmentalized to offset operating difficulties from the uniform mixing of stabilized and unstabilized materials. Principal advantages include low capital cost, use of readily available materials (dryer drum) and application of diverse technologies to the composting process.

composting, costs, equipment, processing, organics, pilot plant, United States, historical

315 Bowring, E.
Mitchell, G.

Small Scale and Low Technology Resource Recovery Study. United States Environmental Protection Agency. Municipal Environmental Research Laboratory. Cincinnati, Ohio, U.S.A. Prepared by SCS Engineers. January, 1979. 253 pages. References.

This study was conducted to assess the applicability of various approaches to resource recovery. Institutions, businesses, multi-unit residences and small cities were included. The resource recovery systems and technologies were limited to small scale operations, defined as less than 100 tpd input, or low technology approaches, defined as having more than 50 percent of operation and maintenance costs as labor. Out of seven systems evaluated, two were identified as economically and technically feasible for the study: modular incineration with energy recovery and source separation. A detailed analysis showed that modular incineration is best suited for larger organizations and institutions. Source separation was also found to be more suitable for larger situations, but better for smaller institutions than modular incineration.

Recommendations for future research and development include: more thorough waste characterization of the sources studied, investigation of the effects of building design on resource recovery feasibility, and further study of technologies.

waste recovery, technology, small scale industry, source separation, incineration, energy recovery

316 Chesnin, L.

Windrow Composting Municipal Sewage Wastes for Land Application. The Environmental Professional. Pages 85 to 91. Pergamon Press Ltd. London, U.K. 1981 (Author at University of Nebraska). References.

This article is a historical review of sewage composting, including pollution, technical and health problems. Examples of ongoing projects in Nebraska in the public and private sectors are discussed. Composting can reduce waste disposal costs. Windrow composting involves mixing filtered sludge or sludge slurry with a drying and/or bulking agent (organic) such as saw dust, leaves, straw, feedlot manure, ground corn cobs and husks. This mixture is placed in an extended pile or windrow. The moisture content should be less than 60 percent.

The author wrote a computer program which determines the optimum amount of drying and/or bulking agents necessary to compost sludge or slurry. The amounts depend on the temperature and differ seasonally. This approach is less capital intensive and more flexible than forced aeration systems despite the need for more land.

Windrow composting is an aerobic process which depends upon the pile to supply oxygen needed by the mirobial population. Mixing can be achieved by using modified manure spreaders, hydraulic feed mixing wagons or front end loaders.

High application rates of compost to agricultural soils were found to reduce soil density and fuel requirements for tillage operations. Also, the availability of nitrogen present in an organic form was greatly increased.

composting, technology, municipal waste, organics, land application, historical

317 Clasen, G.A.
Present State of Processing of Salvaged Glass. Erkelenyer Maschinenfabrik. Erkeleny, Federal Republic of Germany. (Reprinted from Sprechhsaal Ceramics, Glass, Cement. November, 1977. Pages 425-429 and pages 664-668).

The West German glass manufacturer Erkelenzer Maschinenfabrik pioneered work in the processing of salvaged glass cullet. They were the first to apply the principle of screening cullet after the breaking operation, in addition to traditional separation and removal of foreign contaminants by means of an air classifier.

The development of the combined labor and automatic process is described after tracing the evolution of glass cullet recovery processes from labor intensive manual processing in 1957 to its present state.

Crushing equipment used for in-house, homogeneous cullet, was modified for use on postconsumer glass. A circular vibratory screen with a gradation of size of the perforations and a considerably enlarged total screen area, 3,000 X 1,000 MM was used. After screening, freed paper, aluminum pieces and other contaminants are sucked off by two jets. Foreign contaminants are eliminated by a maintenance free, high performance cyclone with collects materials in container continuously.

Overall process implementation has led to the development of wire cloth reinforced conveyor belts and high quality wearing plates, among other improvements. Experiments in color sorting based on ore sorting equipment is ongoing.

Efficient handling procedures have lowered raw material costs and contributed to reducing glass in the municipal solid waste stream (8 percent by volume, 15 percent by weight).

glass, manufacturing, processing, equipment, municipal waste, glass recycling, cullet

318 Cointreau, S.J.
Environmental Management of Urban Solid Wastes in Developing Countries: Project Guide. World Bank. Washington, D.C., U.S.A. 1982. 165 pages. References.

The project guide provides information and procedures for planning and implementation of solid waste management improvements. It is designed to facilitate project preparation, appraisal and implementation of

World Bank financed solid waste projects in urban areas. Current World Bank objectives, policies, and project requirements are summarized. It should also be of use to a wide audience involved in solid waste collection and disposal in developing countries.

The project guide reflects the lessons and experience gained from World Bank solid waste projects. The text discusses establishment of an acceptable standard of collection and disposal service delivery, selection of appropriate technology, development of suitable phased action plans, arrangement of institutions for planning and management, arrangement of financial resources, development of regulatory and enforcement support services, provision of public education and participation programs, and incorporation of incentives and disincentives to facilitate project success.

Information on solid waste generation rates and compositions for countries of various levels of economic development is provided. Case study information on the formal and informal sector refuse collection and disposal activities prevalent in cities of developing countries is provided. Problems and issues to investigate when planning are highlighted through case study examples.

Annexes to the project guide include sample terms of reference for consultants, a data collection workbook for planning technical and management improvements, and worksheets for calculating municipal budget requirements to maintain, upgrade and expand solid waste management service.

waste composition, waste management, environmental management, developing country, municipal solid waste, waste disposal/treatment

319 Darnay, A.
Franklin, W.E.

Salvage Markets for Materials in Solid Wastes. U.S. Environmental Protection Agency. Washington, D.C., U.S.A. 1972. 182 pages. References.

This document discusses the structure, economics and institutions of the salvage and secondary materials industry. Data on raw and secondary materials usage is described. Technical, economic, institutional, and behavioral data are further detailed in 14 separate case studies. Trends are noted which affect industry concentration and market pricing and have resulted in a decline of the salvaging industry.

The salvage industry is noted as an old industry composed of several levels of activity. These include: scavenging and collection networks, dealers and brokers, and manufacturers. The industry has tried to keep pace with the virgin materials extraction industry by concentrating and mechanizing its operations. In the U.S. this has resulted in a dramatic loss of small scale, family owned enterprises and a decline in scavenging. Even so, paper, textiles and rubber are secondary materials losing markets to virgin materials.

The authors detail factors affecting recycling. Assuming the reasonableness of recycling, they ask why the declining rate? Some factors affecting the declining rate of recycling include: (1) costs of acquiring secondary materials are high; (2) virgin materials tend to be more homogeneous prior to processing; (3) sorting of wastes has become repugnant to many householders; (4) costs and benefits are somewhat equal and quality demands have tipped the scale toward virgin materials; and (5) the advent of synthetic materials and composites have limited the need for and cost of recovery.

Costwise, secondary industries expand (ca. 1972) between US$10 to $20 per ton on physical acquisition and processing of wastes, exclusive of price paid to suppliers and delivery. Such industries, though, can do little, considering the structure of the marketplace, to influence commodity demand. Instead, they encourage or discourage supply networks depending on demand and price.

A key to increased demand for recycled products is that virgin materials should reflect their true socio-economic cost which would make recycled goods competitive with virgin materials, thereby equalizing factors between the feedstocks.

secondary materials recovery, salvaging, economics, United States, solid wastes

320 Duckett, E.J.
Contaminants of Magnetic Metals Recovered from Municipal Solid Waste. National Center for Resource Recovery. Washington, D.C., U.S.A. November, 1977. 51 pages. References.

This publication contains three reports discussing recovery of magnetic fraction from mixed municipal refuse--primarily steel cans. The United States National Science Foundation funded the research to identify technological barriers to increased recycling, where they exist, and to present approaches mitigating their effects on the barriers themselves. While technological barriers were the focus, economic and institutional issues were discussed.

The document also presents data on the degree of mechanical specification achievable.

sorting, ferrous/nonferrous recovery, organics, technology, magnetic separation

321 Fukuda, H.
Research and Development of High Rate Composting Sub-System Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 1034-1039. E. Freitag--Verlag für Umwelttechnik. 1979. References.

This paper describes a high rate composting subsystem, as part of a complete material recovery system. The features of this subsystem

include quick composting within digester, mechanical turnover, aeration and forced draft of air, with the result that aerobic fermentation and decomposition forms compost in a short period. The compost which is produced has few contaminants in balanced particle distribution. The whole system is automated from input of refuse to output of product. This cuts operating and maintenance personnel to a minimum and reduces running cost. The eggs of parasites and other harmful bacteria are killed by the heat generated by aerobic decomposition.

Results of basic research are detailed as well as site layout, materials balance and equipment specifications.

Basic tests on fermentation conditions and the ability to separate contaminants have satisfactorily demonstrated its practicality. It is expected that the technology required for the design and operation of a production plant will be established in further trials.

composting, pilot plant, organics, health and safety

322 Golueke, C.G.
Biological Reclamation of Solid Wastes. Rodale Press. Emaus, Pennsylvania, U.S.A. 1977. 249 pages. References.

This is a comprehensive guide to biological and mechanical processes associated with reclamation of organics found in municipal and industrial refuse, animal manure, crop residues, and sewage sludge.

As opposed to burial or burn systems, organic reclamation systems recover one or more resources present in waste. They require less energy than strictly physical or chemical process systems and this aspect is important to developing countries which are usually resource and energy poor.

Technical and economic data on biological waste treatment are presented. Figures and exhibits illustrate the many techniques and equipment used in the processes.

composting, organics, soil amendment, solid wastes, municipal waste, industrial waste

323 Golueke, G.
Composting--A Study of the Process and Its Principles. Rodale Press. Emaus, Pennsylvania, U.S.A. 1975. 110 pages. References.

This book presents a modern historical perspective of composting, particularly as a solid waste management technique. The early trend to overmechanization is criticised as an attempt for quick profit. The use of inoculums led to the overselling of the process and an expectation that the sale of the end product would return all costs. Early reliable mechanized systems included the Dano, Naturizer, VAM, Fairfield-Hardy digester and the Terex-Cobey 74-51 composter.

Composting is the biological decomposition of the organic constituents of wastes under controlled conditions. Systems are classified on bases of oxygen usage (aerobic or anaerobic), temperature (mesophilic and thermophilic) and technology (open or windrow and mechanical or "enclosed"). Variable factors include the microbial population and the nature of the infeed (substrate).

Compost has a low NPK value relative to commercial fertilizers and potential problems of heavy metals and virus survival. Rate controlling factors are moisture, temperature, pH, nutrients, and oxygen. The major factors in the destruction of pathogens in the compost process are heat and antibiotic reactions. Temperatures in the upper 60s and low 70s C reached in the process are sufficient to kill most pathogens and parasites.

The product may be used as a soil conditioner and mulch, and has high potential for land reclamation.

composting, organics, appropriate technology, historical, health and safety, land reclamation

324 Golueke, C.
Manual de Composteo en Pilas Para La Ciudad de Toluca. Sanitary Engineering Research Laboratory. University of California. Berkeley, California, U.S.A. 1975. References.

This manual promotes the use of compost in Mexican agriculture. It provides useful information on how to make and use compost. Data is provided for farmers for using refuse derived compost to reduce fertilizer use, stabilize soils and increase water retention.

The author suggests that a local farmers plan and coordinate the composting program.

The first phase includes a demonstration project which monitors effects of refuse composts on land, crop yield and cost. The advantages of beginning with a small scale operation are (1) flexibility, (2) psychology (the prospect of 5 tons is not as overwhelming as 100 tons), (3) visual evidence to farmers, (4) transition benefits to larger scale, and (5) a basis for economic and technical evaluation.

The manual presents easy to follow instructions on constructing a pile, turning arrangements, and detailed directions for operating compost processes. Monitoring for heat release can be an excellent indicator of the maturing process. Managing the pile includes controlling basic conditions including nutrient levels, water balance, and oxygen. Turning involves breaking down and rebuilding a compost pile. This can be done with equipment on hand and should, ideally, involve placing interior material from the pile on the outside of the pile in restructuring. Uniform decomposition will result. Other aspects noted included frequency of turning, a monitoring program for oxygen, moisture, and process completion.

Excessively high carbon to nitrogen ratio is important to quantify as soil bacteria will compete successfully with plants for nitrogen, at least until the bacteria die off or the carbon is exhausted. Eventually, the nitrogen in the bacteria will also become available to plants; therefore immature compost can be applied to land but only well in advance of crop planting.

Mexico, composting, processing, marketing, agriculture

325 Gotaas, H.B.
Composting: Sanitary Disposal and Reclamation of Organic Wastes. World Health Organization. Geneva, Switzerland. 1956. 205 pages. (Author at University of California, Berkeley, U.S.A.) References.

This book is a world wide state of the art review of composting. The author presents sanitary methods to treat and dispose of organic waste materials which constitute health hazards. Proper utilization of wastes can also help alleviate nutrition problems and soil deficiencies.

Raw materials, processing fundamentals and methods of composting for cities, villages, small towns and individual farms are detailed.

composting, historical, state of the art, health and safety, organics

326 Hortenstine, C.C.
Rothwell, D.F.
Pelletized Municipal Refuse Compost as a Soil Amendment and Nutrient Source for Sorghum. Journal of Environmental Quality. Volume 2, Number 3. American Society of Agronomy, Crop Science Society of America and Soil Science Society of America. 1973. Madison, Wisconsin, U.S.A. References.

This study evaluated pelletized compost versus nonpelletized compost for ease of handling and soil amendment value. Pelletized compost was used in a green house study as a soil amendment and as a nutrient for plants. The compost was first mixed with arrendondo sand and then spread on the plants. The application of 8 metric tons/hectare of compost increased the yields of two sorghum crops compared to the control. When compost was applied at a higher rate of 64 metric tons/hectare, yields again increased compared to 10-4, 4-8.3 fertilizer applied at 2 tons/hectare.

Compost applications increased all plant nutrients, except manganese. In addition, water retention and caution exchange capacity of the arrendondo sand were generally increased by compost applications.

composting, organics, municipal wastes, nutrients, soil amendment

327 Kaiser, R.
Wasson, R.P.
Daniels, A.C.W.

Automobile Scrappage and Recycling Industry Study, Overview Report. United States Department of Transportation. Washington, D.C., U.S.A. 1977. 398 pages. References.

The principal factors which influence the recovery of materials from junked automobiles are discussed in this report. These include: a list of the kinds of materials which can be reprocessed, how automobiles become part of the commercial recovery cycle, operations of the auto wrecking industry which salvage serviceable parts, operations of the scrap industry which take automobile hulks and make them into commercial grades of scrap metal and problems associated with junked cars. A legal review of key policies and legislation which effect the recovery of materials from junked autos is included. Currently there is a strong demand for auto hulks by ferrous scrap producers and this has helped alleviate the problem of an ever-increasing accumulation of junked autos. In 1974 the fractional recovery of metallic materials from approximately ten million automobiles was higher than from other forms of obsolete scrap. The estimated value of the recovered materials was in excess of one billion dollars. The report also discusses future trends and research, government policy and technical analyses.

secondary materials recovery, ferrous scrap, nonferrous scrap, recycling, plastics, rubber, government policy, automobiles

328 Volk, V.V.

Application of Trash and Garbage to Agricultural Lands. Land Application of Waste Materials Conference Papers. Des Moines, Iowa. 1976. Soil Conservation Socley of America. Ankerry, Iowa. Pages 54-64. References.

This document is a review of technical papers pertaining to the application of shredded raw municipal waste and composted municipal waste on agricultural lands. Shredded or composted municipal refuse can be added to soils provided large objects such as glass, metal and plastics are removed. Most compost and all fresh municipal wastes have a high C/N ratio and require additional nitrogen fertilizer to maximize crop production. Composts generally increase soil pH unless large applications of acid-forming fertilizers are applied, or the soil has an initially high pH. The total amount of most plant nutrients is increased with solid waste application. The plant availability may not increase in proportion to elements added because of the increase in soil pH with compost additions and resulting precipitation of elements, such as copper, zinc, iron and manganese. Plant nutrients immobilized in organic fractions of the waste may become available over a long period of time. Before application of either compost or shredded garbage to soil, a chemical analysis should be completed, with special attention directed to cadmium, zinc, copper, nickel, boron, and electrical conductivity. Boron problems in soils can be alleviated by water management and careful selection of plants to be grown. The application of compost and shredded municipal waste improves the physical properties of the soil. The water holding capacity,

infiltration, and moisture retention in coarser textured soils at given stresses are increased; soil erosion by water and wind is reduced; soil structure is improved and friability of heavy soils is improved.

Composted refuse has greater flexibility than shredded garbage because of its aesthetic appearance, more stable nature, and higher nutrient content. Compost has been successfully used in roadside revegetation programs, city recreation areas, nurseries, and land reclamation areas. Compost application to agricultural soils on the basis of plant nutrient content is currently not economically feasible for most farms.

municipal waste, composting, land application, crop yield, nutrients, agriculture, soil amendment, land reclamation

329

McGinnis, J. L.
Opperman, J.
Stephenson, D.
Boileau, G.

An Evaluation of Handling Stations in Waste Reclamation Systems. Waste Management Advisory Board. Ontario, Canada. November, 1979. 196 pages. References.

This report evaluates handling stations/intermediate processing facilities in Canada. They are important as a link between collectors and users of recyclable materials. Materials flows, markets, feedstock arrangements, economics, energy balance, building design, labor, and general operations are covered. The study indicated a need for the following: 1) the handling station must be located near both sources and markets; 2) the station should act as a positive force aiding local collectors with program design, implementation and operations; 3) in addition to marketing materials, the station should be involved in more extensive marketing efforts; and 4) the program should support existing solid waste management. The study showed that five times as many jobs can be created using recycling collection centers, versus ordinary refuse collection. This is an important implication for developing countries, where job creation is a critical issue.

recycling, intermediate processing, economics, markets, equipment, Canada, waste management, animal feed

330

Ming, C.

The Recycling of Waste Acid, Oil Metal Scrap of the Shanghai Donghai Oil and Chemical Recycling Works. Conservation and Recycling, Pergamon Press. U.K. Volume 3, Number 3/4. 1980. Pages 323-325. Abstract from Profit From Pollution Prevention by Monica E. Campbell and William M. Glenn. Published by Pollution Probe Foundation, Toronto, Canada. 1982. Page 318.

In the last twenty years the Shanghai Donghai oil and chemical recycling works (Shanghai, Peoples' Republic of China), built in 1958 for the comprehensive utilization of waste acid, oil and metal scrap, has recovered more than 2.5 million tons of waste acid; extracted 8,200 tons of chemical products of 30 varieties including copper sulfate, copper

carbonate, nickel oxide, and cobalt chloride; and refined 15 tons of silver and 6,300 tons of oil from industrial residues, waste liquids, and oils.

Prior to the establishment of the materials recovery plant, 300,000 tons of waste acid were discharged annually from the industrial city of Shanghai. The rivers and farmland were seriously polluted, and an indemnity of 10 million yuan was paid annually.

Prior to the construction of the acid reutilization component of the recycling facility, investigations were completed to fully assess acid consumption and discharge of waste acid. After an education phase of informing acid utilizing companies in Shanghai on the benefits of recycling, recovery plant employees began reutilization trials.

To win the confidence of the acid utilizing factories, samples of processed waste acid were sent to individual companies for trial use. Because the factories were previously accustomed to high quality acids, they were not convinced that the recovered acids could ensure high product quality until test trials provided satisfactory results.

Today waste acids discharged by 60 factories are processed for use by 300 factories. For example, the waste liquid discharged by pharmaceutical and titanium-white factories contain 15 percent sulfuric acid and a high percentage of iron with a few impurities. After it is retrieved and used by iron and steel plants in cleaning rolled steel, it is returned to pharmaceutical plants for making iron protosulfide for medical use.

The waste organic sulfuric acid solution containing 70 percent of the acid discharged by dye works and chemical works is sent to chemical fertilizer plants to make phosphate fertilizer. Weak sulfuric acid and hydrochloric acid solutions are transferred to paper, printing and dyeing mills to neutralize waste alkali solutions, and to make ammonium salt of humic acid, a chemical fertilizer.

Waste hydrochloric acid is first used by electroplating plants and metal drawing plants for cleaning their products, and is then re-used in the manufacture of chemical reagents such as magnesium chloride and calcium chloride.

The recovering and reuse of waste acids at Shanghai not only minimizes environmental pollution but it also saves resources and cuts costs. For example, one iron and steel plant which used to clean rolled steel with virgin sulfuric acid saved 54,000 yuan a year by using recycled waste acid.

China, ferrous/nonferrous recovery, acids, oil, environmental management, pollution, chemicals, resource recovery, waste utilization, small scale industry, reuse

331 Prohmmanee, P.

Composting of Refuse with Sewage Sludge. Asian Institute of Technology. Bangkok, Thailand, 1968. 60 pages. References.

This thesis focuses on composting as the optimum approach for solving Bangkok's environmental problems. Both open windrow and mechanical composting were studied. Two mixtures, ground refuse and refuse mixed with sludge, were used. The mechanical methods studied were an enclosed chamber system and a rotary drum system. The composting materials were turned every day for the first week and then once a week for five weeks, for a total composting time of six weeks. Temperatures were recorded before turning and samples were analyzed for moisture content, volatile solids, carbon, total nitrogen, phosphate and potash. In most cases, pasteurizing temperatures were maintained and there were few problems from flies or odors. Results indicated that mechanical composting is better as less land is needed, odor and vector problems can be controlled and decomposition occurs faster. The major plant nutrients varied only slightly in finished compost between refuse, refuse sludge, and the mixture. As it is economically advantageous to dispose of two wastes by the same process, the mixture of refuse and sludge was favored.

composting, sludge, organics, Asia, recycling, Thailand, nutrients, health and safety

332 Riley, M.
Bubnick, J.
Pandya, V.
Peters, R.

Low Technology Solid Waste Management Options. Pollution Probe Ottawa Solid Waste Management Group. Ottawa, Canada. 1977. 55 pages. References.

This article analyzes the potential for recycling in Ottawa, Canada. Waste recovery projects in Canada, U.S. and the U.K. were contacted for information. Document excerpts and reprints are included. During a two month period local merchants, households, and government agencies were contacted to assess their attitudes towards recycling. A successful composting operation was carried out in an urban neighborhood, in order to demonstrate its viability. The authors recommend that further research is needed. The study found that source separation of waste and decentralized collection of separated wastes are technically and economically feasible. A system including local processing of recycled materials will improve the urban economy, help create jobs and encourage small scale industry development. A majority of the people surveyed were prepared to recycle their wastes, provided it is not too complicated and curbside collection service is provided.

source separation, collection, economics, surveys, Canada, solid waste management, recycling

333 Sathianaman, V.

New Shortcut Method of Making Compost (Kasala Menik) by the Dalpadado Process. Ministry of Agriculture, Sri Lanka. 1981. 2 pages.

This circular is distributed by the Ministry of Agriculture, Sri Lanka, as part of a pilot project to encourage small scale composting of municipal wastes in low income urban areas. The availability of finished compost will enhance urban gardening. Compost has numerous advantages. It can be produced by anyone, with a minimum of tools and technical training. A 12-day process for composting municipal wastes is described. Suitable organic wastes such as lawn clippings, cattle dung, human wastes, etc., should be well mixed, and gathered in a heap. The heap should be composed of 15 to 16 layers of material, each about six inches thick. The finished heap should be no more than six feet wide and three feet high. The length will depend on the site and availability of material. It should be kept moist at all times. Small materials decompose faster. Plastics, which do not break down easily, should be sorted out. Turn and add water on the second, sixth, ninth and twelfth days.

composting, small scale industry, Sri Lanka

334 Seldman, N.N.
Ospina, F.

Report to the World Bank Solid Waste Collection and Disposal Project for the Metropolitan Area of Medellin, Colombia. Institute for Local Self-Reliance. Washington, D.C., U.S.A. 1979. 32 pages. References.

This report assesses the potential application of new and developing waste utilization technologies which could maximize the productivity of working people already active in the informal waste recovery sector. The technologies, which are characterized by their labor intensive procedures, are of benefit to the economy and society in general and waste recyclers in particular.

The report documents the production aspects of the solid waste sector in Medellin. Approximately 4,000 people earn their living exclusively from recycling waste in Medellin. From 300 to 800 people hand pick recyclable materials at the landfill, and 3,500 buyers go from door-to-door purchasing or scavenging materials from households and businesses. Several thousand formal jobs in processing and manufacturing enterprises are supported by this flow of secondary materials to industries. Key aspects of the economic, organizational and technological structure of this activity are presented.

The report concludes that there is an immediate opportunity to increase the social welfare. The scale, efficiency and costs of establishing technologies/enterprises are estimated. These enterprises could rationalize existing recycling activity and integrate recyclers into the formal economic structure of the Medellin metropolitan area. A preliminary requirement is a nontraditional approach to solid waste planning which establishes as its goal the need to integrate and balance the requirements and scale of the solid waste collection/recycling system

with economic and social needs of people making a living from the waste. Alternative solid waste management recommendations are made and guidelines for investment in technologies are provided.

scavengers, landfill, recycling, research and development, community enterprises, waste disposal/treatment, Colombia, solid waste management

335

Stone, G.E.
Wiles, C.G.
Clemons, C.A.

Composting at Johnson City. Final report on Joint United States Environmental Protection Agency--Tennessee Valley Authority Project. EPA/530/SW-31r.2.U.S. EPA, Washington, D.C., U.S.A. 1975. 336 pages. References.

The technical feasibility of windrow composting of municipal refuse with or without sewage sludge was established. Windrow temperatures of 122°F to 130°F maintained for at least seven days destroyed pathogens predicted in refuse and known in sludge.

Sewage sludge, cow paunch, poultry manures, animal blood, and pepper canning wastes in varying amounts were successfully co-composted with municipal refuse.

The addition of urea-ammonium nitrate appeared to inhibit microbial activity while adding limestone aided composting. Both additions caused a loss of nitrogen. About 33,503 tons of refuse were processed, averaging 37 tons per day. Screened compost accounted for 44 percent of incoming refuse. Rejects accounted for 41 percent.

Upgraded screened compost samples contained an average carbon to nitrogen (C/N) ratio of 28. Nitrogen content of 1969-70 compost was 1.3 percent (dry weight). An air classifier removed most glass contamination from screened compost.

Total plant construction cost in US$960,452 plus US$61,280 for mobile equipment. Operating costs varied from US$18.45 to US$22.91 per ton of refuse processed and cost at operating capacity was estimated at $13.40 per ton. The most cost effective procedure was handsorting to remove selected materials for resale. Significant elements of cost were attributed to special projects. Costs per ton related to plant size were estimated ranging from about $10 per ton for a 200 ton/day plant to $19.70 for a 50 ton/day plant.

Yield tests for grain sorghum, corn, and bermuda grass were positive with compost application. In addition, physical properties of soil were improved as were soil content of potassium, calcium, magnesium, zinc, organic matter and pH value.

Market values varied, averaging US$5.80 per ton defined more as a user willingness to pay rather than actual worth.

composting, municipal waste, economics, sludge, organics, health and safety, sorting, small scale industry, United States

336 Vesilind, P.
Riinu, A.E.
Unit Operations in Resource Recovery Engineering. Prentice-Hall. Englewood Cliffs, New Jersey, U.S.A. 1981. 452 pages. References.

Accelerated extraction and continuing scarcity of raw materials, coupled with environmental and ethical constraints on the disposal of wastes, has resulted in a steadily increasing interest in the recovery of materials and energy from solid waste--especially mixed municipal wastes. The problems associated with mixed refuse processing and material extraction for sale has spawned a discipline popularly known as resource recovery engineering. The book literally borrows from diverse sources so as to develop a generic information base focusing on mixed waste materials separation and energy recovery operations from a fundamental viewpoint. As a state of the art of research, pilot scale, and benchmark applications, coverage is very analytical.

resource recovery, energy recovery, solid waste, municipal waste, state of the art, pilot plant

337 Vogler, J.
Municipal Refuse Composting. Materials Reclamation Weekly. A. Cohen & Company, Ltd. London, U.K. January 17, 1981. Pages 20-22. January 24, 1981. Pages 16-18.

This paper discusses composting facilities in several developing countries. Composting offers an excellent opportunity to fertilize and rebuild depleted or fallow soils. However, many countries ignore the advantages of long-term considerations in favor of short-term solutions. Transportation costs often preclude active marketing of compost.

Various programs in Mexico, Thailand, and India are described. Problems and solutions are presented. All plants are highly mechanized. Costs of construction and operation are greater than the return on the sale of compost. Mechanical failure and low quality compost resulted from the use of over sophisticated equipment and processes. Final screening of compost through a 10 mm mesh is essential to produce a quality product, but was not used in the majority of plants studied. The compost was usually contaminated with pulverized glass and plastics. Other problems which need to be overcome are high moisture content and a lack of market research.

organics, composting, municipal waste, Mexico, Thailand, India

338 Weiss, D.B.

Intermediate Glass Processing. NCRR Bulletin. National Center for Resource Recovery. Washington, D.C., U.S.A. Volume 9, Number 3, September, 1979. Pages 52-61. References.

This article reviews the development of intermediate glass processing (IGP) which improves the quality of glass for recycling.

Virtually all glass supplied for recycling is derived through source separate recovery. However, most glass is not in a readily usable form. Intermediate processing in this category is defined as glass acquisition, beneficiating and sale to glass manufacturers. IGPs are intermediate in terms of (1) providing marketing and upgrading services needed by glass manufacturers; (2) acting as intermediaries between markets and collection programs/generation sources; and (3) the level of technology used. The level of technology may consist of varying combinations of labor or manual picking and small scale equipment including crushers, magnets, screens, washers, etc. With different combinations of equipment and labor, materials other than glass can be processed.

Three factors influence the success of an IGP: economies of scale, management of transportation, and management of labor. Larger operations (1,000 tons/month) are the most economically viable. Often these operations have successfully promoted backhaul arrangements. The number of employees may vary between three and thirty people, with the average being five to eight people.

processing, glass, equipment, labor

339 Yoda, T.
Mjazaki, T.
Machida, O.

Making Pulp from Municipal Wastes. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages. 1176-1179. E. Freitag--Verlag für Umwelttechnik, 1979. References.

This technical brief describes a pilot scale resource recovery system operated in 1977 in Japan. It contained a subsystem of 10 tons per day capacity which could process pulp from a subflow with an increased percentage of fiber.

Raw material is also contaminated by spoiled garbage and bacteria, so the system consists of: (1) shredding, course screening, washing, sterilizing and (2) bleaching and fine screening. The equipment consists of: a pulper for disintegrating; screen and cyclone for eliminating plastics and other foreign matter; Decker and Screw-thickner machine for washing; down for bleaching; and pulp machine for making pulp sheets.

The pulp endproduct may be used for middle or back layers of white board and corrugated fibreboard together with other pulp. If the amount of contamination of pulp is reduced and the mixing ratio with other pulp is increased, pulp may be used for lower grade of writing paper and toilet tissue paper.

paper, pulp, municipal waste, fiber, Japan, Asia, cardboard

WASTE UTILIZATION

401 Aleshin, E., ed.
Proceedings of the Sixth Mineral Waste Utilization Symposium: Industrial Wastes--Scrap Metal--Mining Wastes--Municipal Refuse. United States Bureau of Mines. Department of Interior. Washington, D.C., U.S.A. 423 pages. 1978. References.

The value of secondary materials is determined by many factors including changing technology, tax policies, transportation costs and new applications. This symposium examined technical and economic factors, highlighted progress over the last 10 years, and reviewed problems and solutions. The proceedings are comprised of 55 papers grouped in categories dealing with material and energy recovery technology; the categories are general, mining and mineral wastes, municipal refuse, industrial wastes, and scrap metal. The papers presented on municipal wastes focus on resource recovery from mixed waste. Plants in Albany (New York), Baltimore County (Maryland), Ames (Iowa) and plants built by AB Svenska Flakfabriken are discussed with regard to their operations and costs. Other papers focus on glass, aluminum and paper recovery. Various fuel preparation technologies are described. Complementary processes for benefication and utilization of paper, plastic magnetics and degradable organics are also described.

resource recovery, energy, secondary materials recovery, technology, United States

402 Alone, B. Z.
Pathe, P. P.
Titus, S. K.
Bhide, A. D.
Anaerobic Digestion of City Refuse and Dung. Indian Journal of Environmental Health. National Environmental Engineering Research Institute. Nagpur, India, Volume 20, Number 2. 1978. Pages 134-140. References.

Anaerobic digestion of animal dung has been extensively investigated, but the use of city refuse in digestion systems is relatively unknown. This report assessed the feasibility of combined feedstocks, using dung and an organic fraction of city refuse (OFR). The one year study at the National Environmental Engineering Research Institute in Nagpur, India characterized ORF and dung. This was used to design the laboratory scale system. To initiate the digestion, a "seed" was obtained from a nearby dung digestion plant. Critical to the design was that the town refuse fraction has only a 1-5% moisture content, indicating extensive drying prior to use. Results showed maximum gas production was obtained from a mixture of 62.5 percent dung and 37.5 percent OFR. Reduction of volatile matter ranged from 45 to 54 percent. Gas production ranged between 97 to 347 litre per 1000 kilograms of volatile matter depending

upon the temperature of digestion and composition of slurry feed. The study showed that OFR could be digested alone, although gas production was lower than that produced from the optimum mixture.

biogas, anaerobic digestion, organics, India, small scale units, energy

403

Anderson, M. W.
Lipshutz, T.
Cooey, J. T.
Savage, G.

Recycling Mixed Waste Paper into Innovative Products. U.S. Department of Energy. Performed by Garbage Reincarnation, Inc. Santa Rosa, California, U.S.A. January, 1982. 77 pages. References.

This report presents preliminary data on uses for mixed grade waste paper. A literature search and site visits produced two potential uses: paper-derived firelogs and agricultural products. Firelogs underwent a feasibility study that included technical, environmental and economic evaluation. Animal bedding was subject to field and laboratory testing. Emphasis in selecting technology was for environmentally sound products which could be locally produced and used with a low to moderate capital investment. Mixed paper is a low value material and normally cannot support extensive transportation, processing and marketing expenses. It was found that successful operations develop horizontally integrated products which can be produced in relatively small amounts, with shared equipment. The report summarizes paper grades (definitions and uses), availability and collection of mixed grades, firelogs and pellets (technical and economic data), agricultural products (bedding, compost process bulking agents, fiber mulches), cellulose insulation, and construction materials (construction board and molded products).

fiber, paper, agriculture, animal bedding, cellulose insulation, wood substitutes, cardboard, molded products, recycling, composting

404

Glass and Glassmaking. United Nations Industrial Development Organization (UNIDO). New York, New York, U.S.A. 1977. 111 pages. References.

This monograph is intended for those entering the industry and for experienced glassmakers who do not have a formal grounding in their subject. The monograph presents a history of the industry, a technical discussion of the theory and practice of glass making, a consideration of the economic problems involved in setting up a glass factory, and a survey of current trends.

Modern automatic glass making is a capital intensive industry depending on a large output to be viable. Profitability may be lost because of an inability to reach the projected output, as well as from insufficient demand. A target of perhaps 60% yield in the first year, working up to 90% in the third year, is reasonable and will probably correspond to the time it takes to penetrate the market, but substantial amounts of working capital will be needed.

Establishment of a glassmaking industry is usually proposed in developing countries as a substitute for imports. In theory, the demand should be known. In practice, the degree of potential market penetration is unknown unless the industry is protected by tariff walls, at least during the early stages of development. However, the possibility of using exports to expand demand is limited because the industry seldom grows out of its early stages; prices remain high and the quality tends to remain low. Market trends over the three years of building are very difficult to foresee; the establishment of the industry itself may have a significant effect on those trends. If the project is truly viable, it is likely to realize potential markets because it makes glass locally available, but if it has only an apparent viability because of tariff walls, it may have the opposite effect, by driving bottle customers to alternative containers such as cans and plastics, for example.

In developing possible glass industrial plants which could theoretically utilize cullet or scrap glass, three steps are considered:

- Pre-feasibility study with the purpose of determining whether a detailed study is warranted;
- Feasibility study to determine the best choice of product and technology, estimate the viability of the proposal, and establish the ground rules for seeking offers;
- Preparation of offers.

Comparison of firm offers and reappraisal of the project should not involve more than minor rethinking. However, it is probable that considerable economies in the capital cost can be made if capabilities already existing in the country are fully exploited.

The size of the market and consequently the scale of the operation to be considered has more aspects than the effect of volume in absorbing fixed cost. If the volume requires several production lines, production can be planned to make the load on the furnace substantially constant and a furnace designed to this capacity will provide economical melting. On the other hand, if one forming machine will meet the whole of the demand, melting efficiency is going to be very low when a light weight article is being made, and any breakdown will stop production altogether. Again, many of the capital items are required whatever the scale of operations is, and the cost of those which are scaled down in output is disproportionately high. In the same way, staff and labor requirements are relatively higher for small scale operations. The size of the individual orders is another important consideration; a production run on automatic machines must last long enough to absorb setting up costs.

Attempts to scale down a conventional factory must reach an absolute limit corresponding to a one furnace, two machine installation. For both glass containers and sheet-glass production, this limit corresponds to an annual output of about 10,000 tons, or 30 tons per day.

Import statistics seldom give any details of the size, shape, and color of containers or of the numbers in individual orders. This information, the market spectrum, is vital for automatic production. It usually happens that a country, without its own factory, imports a wider

variety of sizes and shapes than is necessary because they have had the whole world to choose from. The prospects of some degree of standardization must therefore be established, and the likely trend of future demand must be estimated.

While the monograph considers only factory cullet, the opportunities for use of locally derived waste cullet (post consumer) exists. The monograph concludes that a glass factory in a developing country has few advantages, and that the most must be made of them due to the competition from factories in industrialized countries, with their large markets, developed skills and know-how. The advantages include local materials, fewer import costs, and efficient use of labor. The cost of labor, when efficiently used, is usually lower in developing countries. The scope for optimization depends very much on efficient labor utilization. Certainly, the use of two persons to do one person's work is particularly inefficient in the glass industry, where "too many cooks spoil the broth."

glass, glass manufacturing, labor, small scale industry, developing country, industrial development, cullet

405
International Forum on Appropriate Industrial Technology. Prepared for Agency for International Development. Washington, D.C., U.S.A. 5 October 1978. Working Group Number 10--Appropriate Technology for the Manufacture of Pulp and Paper Products. Held at New Delhi/Arand, India on November 20-30, 1978. 18 pages. References.

This article describes a low temperature and low pressure pulping operation. It is designed for small, independent producers of paper board in areas where wood supplies are limited. Low pressure temperature pulping is operated in conjunction with a waste paper mill or packer. The system is designed for flexibility and low cost. Employee training is easily accomplished. Results of environmental studies showed low quantities of specific pollutants which are normally found and difficult to remove from water used in traditional high temperature/high pressure pulping systems.

small scale industry, developing country, pulp, waste paper recovery

406
Proceedings of Symposium on Utilization of Waste Glass in Secondary Products: A Study of the Technology, Marketing, and Economics of Manufacturing Valuable New Products from Waste Container Glass. Technology Application Center. University of New Mexico, Albuquerque, New Mexico, U.S.A. 358 pages. 1973. References.

This reports documents the first meeting devoted exclusively to the recycling of waste glass bottles and jars. Virtually all of the available technologies for turning used container glass into a variety of new and useful products are discussed by industry and university experts.

Papers are presented on topics including: road surfacing and construction; terrazzo and other glass products in existing buildings; refuse glass aggregate in Portland cement concrete; use of glass as a Pozzolan; vibrocasting glass containing construction panels; glass wool and other ceramic products; glass-polymer composites; foamed glass insulation; tiles; recycling glass in remote areas; and analysis of economics and markets for secondary glass products.

Back hauling in empty trucks is suggested as a remedy for high transportation costs. Material specifications and investment criteria are included for most papers. A contact list of industry officials is provided.

glass manufacturing, glass recycling, road surfaces, vehicles, small scale industry

407
Pulp, Tomlinsons Paper Pulp Molding System Booklet. Tomlinsons, Ltd. Rochdale, U.K. 6 pages.

This booklet describes a comprehensive range of paper pulp processing machines offered by Tomlinsons, Ltd. based on the unit originally conceived by E. F. Schumacher in his famous small scale egg carton production idea for Zambia.

Colorfully illustrated, the booklet covers the process, plant sizing requirements, resource requirements, and various products.

paper, pulp, molded product, small scale industry, fiber, equipment

408
Report of the First Year of Operations for ENCORE!s (Environmental Container Reuse) Wine Bottle Washing Project and a Look at the Potential for Wine Bottle Reuse. Ecology Center, Inc. Berkeley, California, U.S.A. March 1976. 43 pages.

This document is a report on the first year of operation of ENCORE!, a wine bottle washing project. It projects the potential for expanded wine bottle reuse. The operation is described in detail with economic data for the current facility and for a larger scale plant. ENCORE! links wineries, recycling centers, restaurants, stores, community groups and individuals in a program that demonstrates that glass bottles can be washed and reused. The process involves collecting bottles and transporting them to a central facility, where they are hand sorted, washed and sterilized in a hydraulic bottle washer. The bottle washer was custom engineered for ENCORE!. After processing, bottles are packed into new cartons and distributed to wineries.

ENCORE! is a self-supporting project, which employees six people. It processes 8,000 cases of wine bottles monthly, as of 1976.

bottle washing, economics, collection, recycling, equipment, labor, environmental management, glass

409
Technical Factors Governing the Recycling of Plastics. British Plastics Federation. London, U.K. #243/1. July, 1979. 12 pages. References.

All plastics recycling depends on remelting and reprocessing by extension and molding as reported by this document. It documents technical factors governing plastics recycling from technical and nontechnical perspectives. End products can be either feedstocks (resin or blends) or actual marketable items (such as fence posts).

Major constraints to increased polymer recycling include: (1) difficulty in identification of polymers during sorting; (2) inability to melt impurities as a means of quality control; (3) difficulty in transporting low bulk densities; (4) incompatibility among the wide range of polymers for blending.

Ideally, recycling occurs when a single polymer type of known and consistent formulation is used. An effective general rule is that the greater the mixture, then the dirtier, the wetter, and the less consistent the scrap will be; consequently, the cruder and less consistent the end products will become that use the mix as a feedstock. As a result, industrial scrap (known formulation, concentrated, and generally unmixed) is routinely reclaimed while post consumer polymers derived from municipal solid wastes are not.

plastics, plastics recycling, technical factors

410
Urban Waste Wood Utilization. Proceedings of a Conference on Alternatives to Urban Waste Wood Disposal. 26-28 March, 1979. Charleston, South Carolina, U.S.A. 126 pages. U.S. Department of Agriculture, Washington, D.C., U.S.A. 1979. References.

The Southeastern Forest Experimental Station sponsored a conference on the subject of urban waste wood. Seventeen papers were presented with topics focusing on: resources, utilization options, and planning. Urban waste wood is a source of fiber and construction materials. The best way to obtain it is via source separation. A significant benefit is that it does not enter the landfill. Potential products are: paper, stakes, mulch, firewood, and industrial fuel. Legal and environmental issues and consumer demand are the focus of planning efforts.

wood, fiber, source separation, environmental management, product development

411
Use of Agricultural and Industrial Wastes in Low Cost Construction. Department of Economic and Social Affairs. ST/ESA/51. United Nations. New York, New York, U.S.A. 1976. 56 pages. References.

Many countries produce large quantities of agricultural and industrial wastes as well as growing quantities of consumer wastes. None of these are adequately utilized. In order to assist developing countries to find ways to reduce construction costs through replacement of traditional and imported building materials with ones made of wastes, the United Nations Secretariat convened an ad hoc Expert Group Meeting on the use of Agricultural and Industrial wastes in low cost construction. This document presents information compiled at that convention.

Issues were reviewed concerning the development of the building materials industry, with particular reference to practical ways of utilizing agricultural and industrial wastes. They formulated recommendations that would ultimately help the building and construction industries of developing countries. Each country must be responsible for producing critical building materials which are increasingly expensive to buy. This situation is complicated by the fact that raw materials are not evenly distributed. Developing countries cannot continue to depend indefinitely on many of the raw materials that are currently used. Most of the developing countries rely heavily on imports of building materials, especially petro-chemicals. Building materials account for 14 to 40 percent of construction costs.

Ways have not yet been found to substitute wastes for expensive imports. Other topics considered were: survey of past and current research on the development of the production of building materials and components for low cost construction from organic wastes; inorganic industrial refuse and byproducts and consumer wastes; economic and technical aspects of collection and processing various agricultural and industrial wastes; adaptation of current technology to the use of agricultural and industrial wastes for the production of building materials and components; problems of marketing and promoting of building materials and components made from agricultural and industrial wastes; and, the role and importance ofstandards and quality control in the development of new products. Proposals for the development of building materials and components from wastes were presented.

industrial waste, agricultural waste, waste utilization, building materials

412
Using Municipal and Agricultural Waste for the Production of Horticultural Crops. Proceedings of the Symposium of the Industrial and Municipal Waste Utilization in Horticulture Working Group, American Society of Horticultural Science. Alexandria, Virginia, U.S.A. 1979. 20 pages. References.

This document contains six papers presented on processing and utilization technology, regulations and marketing of organic material. These were presented at a symposium for horticulturalists. The purpose was to make them aware of rapidly changing technology for recycling organic wastes and nutrient rich wastewater.

Horticulturalists are in a unique position to help solve pollution problems caused by disposal of certain waste materials. The industry utilizes large quantities of organic and inorganic material to grow a wide variety of food and non-food crops. Fertilizer needs can be reduced.

composting, organics, municipal waste, agricultural waste, agriculture, pollution, fertilizer

413
Utilization of Non-Ferrous Scrap Metal. Report of the Expert Group Meeting on Nonferrous Scrap Metal. Vienna, Austria. 25-28 November, 1969. United Nations Industrial Development Organization 1970. 74 pages. References.

A meeting was convened to examine state of the art in the secondary nonferrous metals industry and to make recommendations for improving this industry in developing countries. The report deals with aluminum, copper, lead and zinc. Resource recovery from home, prompt and obsolete scrap are discussed. The sources and recovery techniques, quality controls, and melting technology for each of the subject metals are presented in detail. The consumption of nonferrous metals in developing countries is increasing (estimated between 5-18 percent per year for the metals listed). The scrap supply is increasing concurrently. Metal recovery lends itself to both large and small scale operations, enabling countries to begin on a modest scale to utilize the best combination of techniques and labor intensive methods.

Recommendations include: promoting the establishment of collection and processing facilities and foundries which would use local scrap, surveying the potential scrap and residue resources, surveying potential uses, and investigating opportunities for technology transfer from well-developed industry sources. Additionally, it is noted that: in nonferrous metal recovery, 60-85 percent is the accepted maximum rate of recovery; the capital cost of secondary metal facilities is lower than the cost of primary metal an order of one to ten; increasing the use of scrap demands a highly efficient service for the acquisition and transportation of scrap to keep cost down; and, complete and accurate resource data are important to assure prudent use of secondary metals.

nonferrous scrap, labor, recycling, developing courtry

414 Barnett, C.J.
Remanufacture of Durable Metal Products: The Concept and Its Potential in the Countries of the Andean Region. Massachusetts Institute of Technology. Cambridge, Massachusetts, U.S.A. 1980. 160 pages. References.

This document examines remanufacturing in six Latin American countries: Venezuela, Colombia, Ecuador, Peru, Bolivia, and Chile. "Remanufacturing" describes a procedure which rebuilds products using discarded units of the product as the principal raw materials. By using techniques similar to those employed in the original manufacture of the product, remanufacturing yields a product which will meet new product performance and durability standards. Remanufacturing of certain types of durable goods is well established in developed countries. For those products, it is substantially less expensive than new product manufacturing. For this reason and because remanufacturing is labor intensive, the concept can be applied to developing countries. Factors which make its consideration in Latin America attractive include: a lack of repair and maintenance services, problems obtaining spare parts, high import duties, and a need for training and industrial skill development opportunities.

The most promising products for remanufacture in the Andean countries are those for which new product distribution networks and repair services are already well established. Light and heavy duty automotive products, mining and construction equipment, and distribution transformers are candidates. Of particular importance is the development of skills and technologies beginning with general repair, specialized repair, rebuilding and finally manufacturing. This evolutionary process by which industrialized nations enter remanufacturing is of direct use for the Andean countries. The role of government policy is critical in the development of remanufacturing, e.g., tariff barriers, government ownership. Some industries in developing countries have started largely on the basis of used machinery. The automotive industry in Argentina, textile manufacturing in India, Pakistan and Hong Kong, municipal and private transport companies in Peru and Chile, are examples where imported used equipment started a local industry.

In the U.S., remanufacturing is a small scale venture and in the Andean countries it is expected that this will also be the case.

remanufacturing, United States, labor, textiles, Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile, processing, economic development, developing country

415 Bebbington, H.
Improving the Properties of Recycled Plastics--Successful Case Histories. Society of Plastics Engineers. Brookfield Center. Connecticut, U.S.A. 1980. 19 pages. References.

Based on programs at Western Electric-Bell system, this document discusses recycling of ABS polymer. There have been continuing improvements in the preparation and properties of flame retardant compositions used for making internal telephone parts. Attempts to upgrade the quality of molding material produced included color matching and a new recycling line for old telephones.

Most important of the areas considered was a processing line that grinds the plastic parts from used telephones and separates metals, paper, lint and dust. A new flotation separator removes contaminating metals, plastics, paper and cotton while preprocessing color separation of phones ensures color separability in end product. This eliminates expensive extrusion and screen packing necessary in contaminated blends.

Improving impact characteristics of recycled ABS involves a 5 percent mixture of various additives or elastomers such as BS or NPR. Such mixtures double the impact resistance of the blend and are relatively inexpensive.

plastics, molded products, plastics recycling, technology, markets

416 Berndt, W.
De-Inking: An Optimum Waste Paper Recovery Method. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 1153-1158. E. Freitag--Verlag für Umwelttechnik. 1979. References.

This paper discusses the process of deinking waste paper. Although recycling is well established in many applications using waste paper, the limiting factor of dyes and inks continues to preclude extensive use by the graphic arts and printing trades, where quality of paper is often associated with color.

Paper is deinked by the following process: (1) soaking and exposure to chemicals (the most common bleach is hydrogen or sodium peroxide); (2) elimination of contaminants; and (3) separation of inks from fibers via flotation or washing. Flotation carries out inks by suspension in surface forms. Washing removes inks by fine dispersion. Wash deinking is prevalent in North America. While investment costs are lower than flotation, the disadvantages are the high rate of fiber loss (the fiber rate is 75-85 percent yield compared to 85-95 percent yield with flotation) and the copious use of water. Flotation uses less water and has a better yield. Factors influencing deinking efficiency and economic considerations are presented.

waste paper recovery, fiber, deinking, recycling, economics

417 Bever, M. B.
The Recycling of Metals: Ferrous Metals and Non-Ferrous Metals. Conservation and Recycling. Pergamon Press. United Kingdom. Volume 1, Number 1. 1976. Pages 55-69 and 147-157. References.

This document discusses the recycling of ferrous and nonferrous metals. It is a highly developed secondary materials industry involving collection, sorting and physical processing.

Ferrous scrap is one of the two major raw materials in the iron and steel industry. Various steel making processes consume scrap in different ratios to other raw materials. Technical difficulties caused by the introduction of impurities into the steel are counterbalanced by advantages such as energy savings, pollution abatement and reductions raw material processing.

Ferrous scrap is supplied primarily via "home" scrap generated by the production process. Collection, transportation and processing problems are negligible. "Prompt" scrap is generated in the conversion of steel into various parts and products. Prompt scrap also has few problems. Nearly all home and prompt scrap are recycled. Obsolete scrap is generated by households, commercial and industrial firms, utilities and transportation firms. It is the most difficult scrap to recycle because of collection and transportation problems and the need to remove contaminants. Obsolete scrap recovered from municipal waste is potentially a large source of iron (6-7 percent of total iron consumption) but it is rarely developed to its full scale, due to the destabilizing impact this would have on the overall scrap market. Also, steelmakers fear contaminants will result in a low quality steel that could damage capital equipment. For these reasons only a small fraction of obsolete scrap is recycled.

Grading schemes for ferrous scrap have been established on a national and international basis. Grading is critical as different steelmaking processes require specific batch material characteristic to avoid technical problems. The growth of electric furnace steel production which can use high amounts of scrap is an encouraging developing for recycling.

Typically the movement of ferrous scrap is from the industrial countries to developing countries. The ferrous scrap industry in older industrialized countries relies heavily on exports during periods of depressed domestic demand. Periods of booming steel production and heavy demand for scrap have usually been accompanied by scrap shortages. When this happens, the domestic steel industry tends to seek an embargo on scrap exports to protect its own supply.

The recycling of nonferrous scrap accounts for a significant amount of nonferrous metals production (50 percent of current consumption for copper and lead, 20 percent for aluminum). Sources of nonferrous metals are primarily automobile body shredding/dismantling, construction debris, and aluminum product packaging. Secondary production of nonferrous

metals is less capital intensive, consumes less energy and tends to be less polluting than primary production. Consequently, entry into the nonferrous secondary metals industry is comparatively easy. This has resulted in a fragmented industry comprised of many small, local units, which together offer a sizable international market. Primary producers can process some secondary nonferrous metals and as a result these integrated firms are active in nonferrous metals recycling.

The contribution of nonferrous scrap as a percentage of consumption is substantial. There is significant opportunity for increasing the contribution of secondary ferrous metals derived from the post consumer waste stream. Production of metals from scrap reduces the the drain on ore deposits. Recycling also saves the indirect materials required by some production processes. For example, the production of aluminum from bauxite by the Hall-Heroult process uses large amounts of petroleum coke which is not needed in the processing of secondary aluminum. Recycling also provides the only indigenous sources of nonferrous metals in some countries. In addition to increasing supplies of materials, recycling can benefit the balance of payments of resource poor countries.

ferrous/nonferrous recovery, secondary materials recovery, energy, automobiles, procesning

418 Bjorkengren, C. A.,
Nilsson, B.

REPAK, A Method for Using Packaging Waste as a Source for Production of Cores. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 1170-1175. E. Freitag--Verlag für Umwelttechnik. 1979. References.

The authors present a unique method to reclaim mixed plastic waste from selected industrial packaging firms. The method, called "REPAK" utilizes packaging industry production waste to produce cores used in connection with reeling of web-materials such as paper, plastic films and various types of laminates. The conventional core for this purpose had earlier been made from paper (low quality) or from steel or plastics (high quality).

Waste from a plant is automatically transported to an intermediate plant, close to the packaging production. All material is ground to flakes to be stored in silos, and then blended. Special additives can also be used for specific needs.

After blending, the flakes are transformed to an extrudable resin agglomerate. The agglomerate is used for extrusion of cores of different sizes in a specially designed and equipped extruder.

The cores meet rigid specifications, concerning dimensional stability, water resistance, ability to withstand high impacts and low measurement tolerances.

A comparison of energy balances showed substantial energy savings compared with virgin polyethylene resins. Slight advantages were accorded REPAK over conventional unbleached paper, which has been known to produce nferior product cores.

plastics, extrusion, plastic recycling, small scale industry

419

Breakspere, R. J.
Heath, P. J.
Morgan, R. J.

Waste Glass--Reuse or Throw Away? Conservation and Recycling. Pergamon Press. U.K. Volume 2, Number 1. 1978. Pages 49-58.

This article presents test results of recycled glass products. Waste glass has been used as a filler in cements and resins for manufacturing floor and wall tiles, industrial castings, and sanitary fittings. Mechanical and physical properties of the products are discussed. Materials are produced by mixing a resin or cement with crushed glass derived from waste bottles (clear and colored). In order to improve the binding properties of the glass particles to the mix, it is generally necessary to pretreat the surface of the glass, which will act as a "key" between the glass and the mix being used. The work to date has been devoted to: (1) determining the physical and chemical properties of resin and cement based materials containing crushed glass of various sizes and pretreatments; and (2) using waste glass for making decorative panels and structural materials.

waste utilization, research and development, glass recycling, glass

420

Brown, A. W.
Needs, R. A.

Land Restoration in the Marston Vale, Bedforshire. Presented at International Symposium at Institution of Civil Engineers, "The Practical Implications of the Reuse of Solid Wastes," 11-12 November, 1981. Institution of Civil Engineers. Westminister, London, U.K. Paper 110.12. Pages 75-82. 1981. References.

This article discusses the reclamation of a worked-out clay excavation site by controlled landfill. Political, commercial and environmental issues are presented. A private company considered ramifications of controlled dumping to reclaim land. County council support was solicited. The company conducted a detailed investigation of site geology to ensure area/waste compatibility. Preparations included land dewatering and leachate control systems installation. Materials are buried in a controlled manner and compacted by heavy equipment. The possibility exists for methane extraction.

land reclamation, landfill, biogas, United Kingdom

421 Bundick, P., Ed.

Selected Appropriate Technology Information for Developing Countries (Abstracts from the National Technical Information Service Data File). National Technical Information Service. U.S. Department of Commerce, Office of International Affairs, 5285 Port Royal Road, Springfield, Virginia, U.S.A.

This bibliography contains 2,500 citations on "appropriate technology" from the National Technical Information Service. Appropriate technology is defined, in the context of this publication, as information which can be adapted and used to improve the quality of life for low income people. The information is broad in scope, covering many fields. Technologies presented are: small scale, labor intensive, low cost, revived, improved traditional, alternative, social and management, and selected modern technologies which can be adapted to local needs and environments.

The references are applicable to solid waste, waste recovery, and recycling, and small scale businesses which use waste materials.

appropriate technology, small scale industry, agriculture, technology, economic development, labor, costs, developing country

422 Callihan, C. D.
Dunlap, C. E.

Single-Cell Protein from Waste Cellulose. Report prepared under Grant No. EP-00328 for the Office of Research and Development. U.S. Environmental Protection Agency. Washington, D.C., U.S.A. October, 1973. 89 pages. References.

This report details a laboratory scale process to convert cellulosic wastes to microbial protein. The procedure involves treating the cellulose with a two to four percent caustic solution subjected to a temperature of 110 to 130° for thirty to sixty minutes which renders the material biodegradable and kills all contaminating organisms.

The intermediate material is then elutriated to remove a large portion of any heavy metals that might be present. This washing also removes soluble carbohydrates which repress cellulose enzyme activity. The intermediate is about 65 percent cellulose.

Fermentation is carried out using a mixed bacterial culture. The protein is harvested by adding cationic flocculating agents. The product can serve as an animal feed supplement and has potential for human feed should related nucleic acid research be successful. Productivity of about one gram per liter per hour yielded an economic estimate of final crude protein cost of 13 cents (U.S.) or less per pound.

cellulose conversion, nutrients, animal feed, health and safety, municipal solid waste

423 Cocqueral, M.A.T.
Burcher, M. G.

Aspects of Recycling Copper Scrap. Conservation and Recycling. Volume 2, Number 2. Pages 111-116. Pergamon Press. U.K. 1978. References.

This article describes problems encountered in designing systems to effectively recycle copper scrap. For example, it is necessary to deal with excessive heat and oxygen liberation and black particle smoke. Detailed discussion is provided on both issues.

Economies of scale are considered, concluding that larger plants are more economical. The average output is 100,000 tons per year. While acknowledging, and that several smaller subunits dealing with different aspects of scrap could have application as integrated units, the optimum solution to produce high quality copper from secondary sources is the larger plant.

The last few years have seen copper scrap change due to an increased use of composites and electronic component miniaturization. This has placed burdens on secondary refiners' ingenuity. Increased requirements for environmental protection, especially in urban fringe areas where much of the industry exists, represent another problem that needs to be dealt with.

nonferrous scrap, recycling, economics, resource recovery

424 Cook, R. F.

The Collection and Recycling of Waste Glass (Cullet) in Glass Container Manufacture. Conservation and Recycling. Pergamon Press. U.K. Volume 2, Number 1. 1978. Pages 59-69. References.

In this document the system for collecting and recycling glass containers is discussed from the point of view of economic and technical constraints and potential energy savings.

The use of cullet is a long-established practice in the glass container industry. Since broken glass is virtually the equivalent to original raw materials, and can be remelted many times, it has always been the practice to recover scrap from defective articles and to put it back into the furnace. The use of "foreign" cullet, from glass containers that have served their purpose, has become desirable for two basic reasons: to reduce the volume of solid waste, and to reduce the consumption of raw materials.

Quality control (temperature, purity, batch mixtures) during processing is crucial in order to meet requirements and protect equipment. Furnaces have operated successfully on 100% cullet, albeit for short periods under special circumstances. Several furnaces in Europe and elsewhere are currently using batches containing over 50 percent cullet. Glass treatment plants needed to eliminate contaminants are economically feasible.

In the United Kingdom, house-to-house collection is deemed uneconomical. Large containers for drop-off are provided in convenient locations. Consumers bring empty bottles with no financial incentive. This "bottle bank" system is similar to schemes in Switzerland, Germany and France. The scheme will break even if ten skips capable of holding 4 tons are placed where they are filled in 3 1/2 weeks; or 600 tons per year.

Potential energy savings can result in two areas: (1) extraction, processing and delivery of batch materials; and (2) melting. An analysis by the U.K. Glass Federation shows that cullet requires less energy than raw materials, given the same delivery distance. This simply means that one can afford to transport cullet further than raw materials, and thus the collection arc can be extended or the quantity of cullet increased. The melting of cullet (at approximately 1500°C) consumes about 70 percent of the energy used in bottle manufacture. It is this part of the process that offers most scope for energy saving. The Swiss glass manufacturer, Vetropak, has reported fuel savings of 2 percent for each 10 percent of raw material that is replaced by cullet.

Recycling old bottles into new ones is the approach to waste reduction favored by glass manufacturers throughout Europe who are convinced that the system can be viable from manufacturer, waste manager and consumer view points.

cullet, collection, glass manufacturing, glass recycling, United Kingdom

425 Deolalikar, A. B.
A Survey of the Indian Economy to Explore the Potential for Remanufacturing. Center for Policy Alternatives, Massachusetts Institute of Technology. Cambridge, Massachusetts, U.S.A. 1979. 80 pages. References.

Discarding products involves an economic loss particularly when goods are not completely consumed during use. The difference between scrap value and the value of the item in its prime is the value added--the labor and overhead costs of making and distributing the product. This can be a significant value. Remanufacturing as a strategy can help to mitigate this loss.

Remanufacturing takes place in both the formal and informal sectors of the Indian economy. Remanufacturing in the informal sector is widespread and includes: automobile engines, transistor radios, bicycles, household appliances, watches, and water heaters. A network of hundreds of thousands of small service agencies is scattered across the country, many concentrated in urban areas. Each employs 1 to 5 people. Surplus labor accounts for low service costs, which are a fraction of new product prices. This small scale sector is appropriate to India, where people are cognizant of scarce resources. It has historically been successful in providing employment and excellent technical training for millions of people, most of whom were previously unskilled.

A large potential exists for independent operators to remanufacture foreign consumer and capital goods for export. However, the government places a low priority on consumer goods and hence, remanufcturing is not encouraged. Also, there has been an overall decline in the small scale sector of the economy. In order for remanufacturing to expand, duty-free export processing zones, technical school graduates, and infrastructure are necessary.

The report concludes that the potential for remanufacturing is good.

remanufacturing, India, small scale industry, informal sector, survey, international trade

426 Dries, W. C.

Heating and Cooling of an Industrial Plant with Unusable Household Discards. Proceedings of the 2nd International Symposium: Materials and Energy from Refuse. Antwerp, Belgium. 20-22 October, 1981. Pages 8.23-8.26. European Federation of Chemical Engineering and International Solid Wastes and Public Cleaning Association. Author at University of Wisconsin-Extension, Madison, Wisconsin, U.S.A. References.

This paper describes the production of heat energy by Goodwill Industries in Milwaukee, Wisconsin. The energy comes from burning discarded household items which are donated to Goodwill and not usable or saleable. Included are shoes, cloth, plastics, paper, cardboard and wood. Large, bulky items such as mattresses and over-stuffed upholstery which do not burn well are not used.

Plastics are fed into the boiler in small quantities because the high heat liberated by burning is harmful to the refractory (which requires additional maintenance). Further, thermal efficiency is reduced due to the fouling of heat recovery tubes by acids created by the combustion process. The annual statement for 1980 showed gross savings of US$136,298 against costs of US$123,911 for a net savings of US$12,387.

incineration, United States, heating and cooling, fuels, household wastes, energy recovery

427 Dutt, B. L.
Levine, H.
McLeod, A.

A Study of the Feasibility of Utilizing Solid Wastes for Building Materials. Phase I Summary Report (154 pages). Phase II, III and IV (177 pages). PB 279 440, and PB 285 437, U.S. Environmental Protection Agency-MERL. Cincinnati, Ohio, U.S.A. 1978. References.

This series of reports presents data on utilization of all types of wastes for building construction. Laboratory evaluation and results are included.

In Phase I, a comprehensive literature search was conducted. The data were reviewed and evaluated for potential matrix, reinforcement, and filler candidates. The more promising candidates were evaluated with limited laboratory studies. From these studies, two types of matrices--furfural-phenolic and inorganic--were selected for further study. Seven reinforcement candidates and five filler candidates were selected for evaluation with the two matrices. A detailed Work Plan for Phase II based on the Phase I study is also presented.

Scrap plastics, paper, glass, sewage sludge and wood waste were post-consumer solid wastes considered among the many agricultural and industrial wastes studied. Waste plastics and paper received high positive use scores when tensil strength, surface volume ratio and other parameters were evaluated.

Phase II, July, 1974 to September, 1975, was an evaluation of the structural and aesthetic properties of the various waste composites. Satisfactory products were made using both inorganic and organic systems; structural and fire-resistant properties of several formulations were found to be superior to those of existing commercial products. Economic analyses were performed on the structurally promising products, and several appear to be commercially viable.

In Phase III, September, 1975 to November, 1976, attempts were made to produce full-scale products and qualify them for structural applications. Particle board panels, 4 by 4 feet, were made of peanut hulls and wood waste on production-type equipment.

In Phase IV of the study, structural tests were performed on wall panels fabricated from rice hulls and an inorganic binder. These tests completed generation of the data required for building code approval.

waste composition, building materials, glass, paper, solid wastes, sludge, agricultural wastes, industrial wastes, plastics, wood, waste utilization

428 Gleason, J.
Efficient Fossil and Solar District Heating Systems. Solar Energy Research Institute. Golden, Colorado, U.S.A. 230 pages. 1981. Author at Self-Reliance District Heating Group, Washington, D.C., U.S.A. References.

This report is a comprehensive review of cogeneration of both electrical and thermal energy for distribution from relatively centralized sources which for space cooling and heating, hot water and process heat needs of commercial, industrial and residential consumers. Building codes, storage systems, pipe materials, maintenance costs, and implementation are discussed with particular reference to urban settings. Solid waste derived fuels may be substituted for less available fuels because low distribution temperature and pressure requirements can be met by this relatively low quality fuel. Small scale systems have more flexibility with regard to energy conversion technology. Small scale low temperature systems can be adapted for use of solar, wind and geothermal energy. Energy conservation among end users is critical for realizing efficiencies. Plant technologies are discussed in detail.

The system was invented in the U.S. in 1877 and proliferated in the 1920s and 1930s. However, its use peaked just prior to World World II. Reasons for the decline include: availability of inexpensive fossil fuels, concurrent scaling up of electrical generation systems and removal of electrical generation facilities away from urban heat loads, decline of cogeneration design, and the limited capacity to transmit steam over long distances. Today, only 1 percent of the population in the U.S. is served by district energy systems.

In Northwestern Europe, primarily in Denmark, Sweden and the Federal Republic of Germany, the experience with cogeneration and district energy has been successful. Post World War II energy scarcity required optimizing less-efficient networks. Cogeneration which is the joint production of thermal and electrical energy, combined with district energy to evolve as a widely employed and efficient energy use system. Prefabricated insulated "pipe in pipe" systems was the European modification which allowed efficient supply and return of water through the system.

energy recovery, United States, Europe, resource recovery, fuels, small scale units, heating and cooling

429 Grabbe, K.
Zadrazil, F.

Organic Residues As Substrate for Mushroom Cultivation. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 1256-1261. E. Freitag--Verlag für Umwelttechnik. 1979. References.

This article discusses technical considerations for using agricultural and industrial wastes for cultivating mushrooms. Special attention is focused on the microbial degradation of cellulosic containing wastes which could produce a suitable growing medium.

Traditionally, compost made from horse manure has been used as a substrate for over 200 years. In order for this to be efficient, the caves had to have the right climate, with few pests or molds. Today, artificial environments can be created which enhance production.

The production of substrates is divided into two stages: (1) composting of horse manure; and (2) compost product or grading. The latter is also called pasteurizing as temperatures reach 60° C for 20 to 30 hours.

Many valuable wastes can be used as mushroom substrate including straw, chicken manure, silage fluid, molasses, whey, sawdust, wood chips, swine manure, horse manure, and even municipal solid and liquid waste (organic fraction).

organics, composting, cellulose conversion

430 Hortenstine, C. C.
Rothwell, D. F.

Composted Municipal Refuse as a Soil Amendment. U.S. Environmental Protection Agency. National Environmental Research Center, Office of Research and Development. Cincinnati, Ohio, U.S.A. NTIS PB-222 422. 1973. 62 pages. References.

Processed residential refuse supplied by four compost plants was evaluated as a source of plant nutrient and as a soil amendment. Three compost products tested had high carbon to nitrogen ratio, resulting in delayed indicator plant growth. Total soluble salts in composts were high and had a damaging impact on seed germination. Positive results were obtained after a time for compost applications above 32 metric tons/hectare. Increased plant yields and improved soil action exchange and water retention capacities were achieved. When mixed with cow manure in equal parts, compost effectively curtailed nitrification by 100 percent. Fungal growth in compost/soil mixtures increased greatly as did bacteria, but bacterial numbers decreased greatly after 4 to 5 days.

Under strict interpretation of requirements that an organic material must meet for both fertilizer supplement and as a compost, only one of the four composts tested would be classified as acceptable. That compost had a C/N ratio of 17 as compared to 26, 43 and 55 for the others. It also was pelletized, free of moisture and agreeable to handle, all characteristics lacking in the other compost products.

composting, organics, testing methods, marketing, soil amendment, nutrients, household wastes, municipal wastes, fertilizer

431 Jackson, F. R.

Recycling and Reclaiming of Municipal Solid Wastes. Noyes Data Corporation. Park Ridge, New Jersey, U.S.A. 1975. 342 pages. References.

This book provides a comprehensive treatment of the collection, processing and recycling of municipal and light industrial solid wastes. It is based on studies conducted by the United States Environmental Protection Agency, other government agencies and system vendors. Case histories are used to explain material recovery via mechanical and labor intensive processes, markets for materials, data on individual materials, and subflows including glass, rubber, plastic and metals. Sources, problems, economics and technology are described.

source separation, processing, markets, glass, paper, plastics, rubber, ferrous/nonferrous recovery, secondary materials recovery, municipal solid waste, sorting, labor

432 Koller, T.

The Utilization of Waste Products: A Treatise on the Rational Utilization, Recovery, and Treatment of Waste Products of All Kinds. Scott, Greenwood and Sons. London, U.K. 1915. 327 pages. Translated from German. 2nd edition. References.

This document portrays municipal and industrial waste utilization between industrializing nations during 1890-1915. The solid waste chapter, "the waste of towns", is a description of materials and energy recovery techniques. High technology, resource recovery techniques implemented with a poor to mediocre performance record include the Arnold and Merz grease extraction processes, the Freyer combustion "destructors" process and the Budapest process. The "Budapest process" is described as involving large scale arrangements for sorting from conveyors by children. Residues are combusted. This process was adapted to a railroad siding at Puchheim, Germany, which had a 450-500 ton per day capacity. Each day two special trains of 30-40 wagons are shipped for processing. This method was eventually rejected for sanitary reasons.

A key concept advanced in the document was that primary separation of materials and waste utilization was considered of secondary importance when public health advocates attempted to overcome problems of waste buildup. Public officials viewed refuse management as removing wastes in the quickest time possible and, subsequently, wastes had to be destroyed. As a result, waste utilizaton decreased as a viable option.

The author also relates the general lack of marketing sophistication exhibited by vendors of high technology systems. For example, slag on incinerator grates was considered a possible marketable item by the vendors. Unfortunately, the glassy slag was earmarked for glass container manufacturers who could not possibly use it in batches, due to high levels of contamination. This illustrates the problem of marketing where data on specifications and user demand are unknown or misunderstood.

waste utilization, municipal waste, industrial waste, Europe, United States, resource recovery

433 LeRoux, N. W.
Wakerley, D. S.
Simpson, M. N.

Microbial Production of Methane from Household Waste: Fixed-Bed Anaerobic Digestion. Conservation and Recycling. Pergamon Press. United Kingom. Volume 3, Number 2. 1979. Pages 165-174. References.

Microbial production of methane from household waste using fixed-bed anaerobic digestion was studied. This article presents technical data. Economic data was inconclusive and varied depending on local conditions.

The fixed-bed anaerobic digestion system consists of a hole or trench lined with admix lining or plastic sheeting to prevent loss of

liquid and gas from putrifying wastes. A dome shaped cover aids in collecting gas. Each unit is large enough to contain a few days refuse on a batch basis.

Putrescible fractions of sorted household wastes were used in operational tests. Digestion was completed in 60 days at 30° C when unshredded waste was mixed with predigested sludge as a feedstock. Gas yield was 0.12 cubic meters per milligram of putrescible waste with an average molecular composition of 58 percent methane and 42 percent carbon dioxide. Tests showed that initial concentration of methane was low, while shredding wastes and adding water increased fermentation time. After digestion, the sludge and slurry are useful as soil conditioners.

biogas, soil amendment, organics, small scale units, household wastes, *anaerobic digestion*

434 Linley, B. D.
Tinplate Recycling. Resource Recovery and Conservation. Elsevier Scientific Publishing Company. Amsterdam, Netherlands. Volume 2, Number 3. May, 1977. Pages 225-240. References.

This article, which reviews recent activities in industrial tinplate waste recycling, covers melting, electrolytic and alkaline detinning practices. It describes extraction of tin cans from refuse and the preparation requirements prior to detinning. Effects of advanced can making technology on the detinning industry are discussed.

There are three mechanisms of tinplate recycling, actually a process of upgrading steel scrap. Melting processes the tin right along with the steel; and the tin is not recovered. Electrolytic detinning is a batch process involving electrolysis and produces a soft tin "sponge." Alkaline detinning is a continuous chemical stripping process producing the highest quality tin and steel. But is a slow reaction, especially when compared to the rapid transfer of stannous ions to negative poles in the aforementioned electrolytic detinning.

A model plant (100,000 tons annually) for the recovery of steel cans from mixed refuse is described. Shredding, magnetic extraction and conveyors comprise the operation which 1975 achieved an efficiency of 90 percent extraction.

ferrous/nonferrous recovery, processing, tinplate recovery

435 Liroff, S. D.
Management of Environmental Risk: A Limited Integrated Assessment of the Waste Oil Rerefining Industry. Prepared for the National Science Foundation. March, 1978. Prepared by Tekneknon, Inc. Berkeley, California, U.S.A. 200 pages. References.

This is a review of a project supported by the National Science Foundation to assess the waste oil rerefining industry. Five different areas critical to the industry were surveyed: (1) an assessment of seeral

rerefining technologies, (2) an analysis of future technologies, (3) a financial analysis, (4) disposal of acid sludge, and (5) state and local governments as a potential market for rerefined waste oil.

The potential for establishing recycled oil programs is evaluated for the 48 states comprising the continental United States. The major fi dings include: (1) although acid/day technology is still the major process, its use is rapidly decreasing (down 30 percent in the last 10 years); (2) total rerefined oil has increased; and (3) oil rerefining generates hazardous wastes and sludges.

oil, hazardous waste

436 Lund, R. T.
Energy Capture Through Remanufacturing: Final Report of Pre-Demonstration Study. Massachusetts Institute of Technology. Cambridge, Massachusetts, U.S.A. 1981. 199 pages. References.

Case studies of remanufacturers were developed in the product areas of automobile parts, heavy duty diesel engines and parts, refrigeration and air conditioning compressors, newly conditioned machine tools, and power plants. These were chosen using selection criteria and methods detailed in the report.

Remanufacturing preserves the functional value of durable products, and is the full scale disassembly of products, pooling of interchangeable parts, and production line reassembly in a fashion similar to the original manufacturing process, with some replacement of worn parts. The term remanufacturing does not refer to the unit-by-unit rebuilding of goods except in the case of large items that are originally assembled on a one-by-one basis. The process restores a product to the point where it meets or exceeds original product performance specifications. Using a variety of research approaches, researchers have obtained a comprehensive overview of the structure of the industry, the operating characteristics of firms in it, and the energy and resource conservation potential inherent in remanufacturing.

It was found that a successfully remanufactured product must be a durable end product or a durable component of an end product. The remanufacturing process is primarily labor intensive. It tends to require lower skill levels of its employees and so pays lower average wages than a comparable new product manufacturing. Because the process does not require complex equipment and because material (core) costs are relatively low, the capital investment requirements are modest.

Remanufacturers rely on cores or discarded products to supply the largest part of the materials requirement, typically recovering about 80% of core weight for reuse in the process.

Remanufacturing was found to be flexible, depending primarily on the nature of the product. Process methods, product ownership during the process and distribution channels all vary from product area to product area. Because the remanufcturing process provides constant dealings with

failed products, remanufacturers tend to become familiar with inherent design weaknesses in the product. As a result, many incorporate appropriate changes in their process to correct the weakness, thus yielding a product with a longer life span. Remanufactured products typically sell for 50-70% of the comparable new product price.

energy recovery, automobiles, labor, product durability, remanufacturing

437 Mandels, M.

Disposal of Cellulosic Waste Materials by Enzymatic Hydrolysis. Army Natick Laboratories. Natick, Massachusetts, U.S.A. 1972. Ad-750-351. References.

Cellulose is first converted to glucose by enzymatic hydrolysis. Glucose is then converted to alcohol by natural fermentation. T. viriede was selected as the enzyme since it grows rapidly on simple media and consumes cellulose. A major problem is that cellulose is insoluble. The reaction rate depends on the available surface, so researchers introduced selected organic solvents to emulsify the cellulose. Many cellulosic materials (newsprint, etc.) contain substantial quantities of lignin, which limit access of the enzyme to the cellulose. Available surface is increased by both the additives and shredding.

hydrolysis, cellulose conversion, fiber, paper

438 Meinhardt, P.
Kolb, J.

Feeding Cattle at the Garbage Dump. Compost Science. Rodale Press. Emaus, Pennsylvania, U.S.A. Volume 12, Number 4. July/August, 1971. Pages 14-16.

The authors have reviewed literature and recommend using refuse derived organics as a feed supplement for cattle. This is especially useful for developing countries where grain is usually consumed by people rather than cattle.

For example, in Cuba surplus supplies of molasses and bagasse (residues from crushed sugar cane) are combined with elephant grass, three percent urea, and fish meal. Average daily weight gains of 2.8 pounds were achieved on diets totalling 12.6 pounds of feed per pound of weight gain. The reported cost was U.S. $0.5/lb. There is an advantage to keeping cattle near food supplies, since over 65 percent of livestock costs come from the transfer of livestock from one foraging area to another. Coupled with stress from shipping, the authors concluded that a steady, quality controlled waste derived feed source with low transportation costs could reduce losses.

Editors note: This article does not deal with any potential health risks that may be associated with feeding cattle mixed municipal refuse.

Cuba, animal feed

439 Minke, G.
Alternative Bauen. OKO-Buchversand. Kassel, Federal Republic of Germany. 140 pages. 1981. References.

This book discusses the potential of alternative construction techniques using a combination of natural surplus building (loam, sand, earth, living plants), waste products (sulphur, bottles and tins), and inexpensive industrialized components (cardboard, textiles, grid shells).

Good results were obtained by the Research Laboratory for Experimental Building, University of Kassel, Federal Republic of Germany on several research and development projects in low cost housing and self help construction were exemplary on several R&D projects on low cost housing construction.

waste utilization, building materials, Germany (Fed. Rep. of)

440 Minsaas, J.
Recycling of Domestic Food Wastes. Conservation and Recycling. Pergamon Press. U.K. Volume 3, Number 3/4, 1979. Pages 427-438.

This articie examines food wastes in Norway. Collection systems and utilization systems are detailed. In a 14 week experiment of source separation, 50 percent of the total food waste was recovered. Processing and end use markets are suggested.

A formula is given to estimate the potential for animal fodder from the substantial amount of waste generated. Feeding experiments have shown a fresh food waste/fodder equivalency of 2.5 to 3 kg/fodder unit 1 kgof feed barley. Using a 50 percent collection efficiency (from the test situation), then the total subflow available as fodder would be equivalent to: total kg/waste food x 0.503 kg/fodder unit = N units.

Collection, segregation and treatment of food is equally important to maintain feed supplement quality. Several plans for moving wastes to end users are detailed. Source separation is also critical and must be easy and convenient for the householder.

The quality of the feed derived from the waste is also considered. Test results based on digestibility and feed nutrients showed excellent prognosis, depending on the type of food waste. If properly separated from potential contaminants, food wastes did not appear to have any heavy metals.

animal feed, organics, markets, source separation

441 Morris, D. J.
A Technical Assistance Handbook for Community Based Cellulose Fabrication Plants. Institute for Local Self-Reliance. Washington, D.C., U.S.A. 1977. 79 pages. References.

This report was prepared for the U.S. Community Services Administration (CSA) and descries a cellulose insulation business.

A business development plan is presented emphasizing current demand levels based on government procurement, the ability to leverage investment capital, and the possibility of forming minority and low income citizen ownership.

Pro forma income statements and balance sheets are calculated for a 2.5 ton per hour, 2 shift operation. Total fixed costs are estimated at US$220,000. The document notes that variable costs relate to supply of chemicals (particularly boric acid needed as a fire retardant for product safety), furnish, and product demand. A list and evaluation of international equipment suppliers is included along with discussion of lease, franchise, and purchase options. Total output equals 11,700 tons. Total revenue would equal US$3,120,000. It is estimated that the breakeven point would be 43 percent of peak capacity.

By establishing a manufacturing plant capable of paying up to US$60 per ton for secondary newsprint and other feedstock materials, community recycling programs and/or municipalities can have a guaranteed market for collected materials.

cellulose insulation, manufacturing, economic development, newsprint, paper, community enterprises, costs

442 Newsome, C. J.
The ITDG (Intermediate Technology Development Group) Paper Pulp Molding Project. Appropriate Technology. Intermediate Technology Publications Ltd. London, United Kingdom. Volume 5, Number 3. Pages 12-14. November 1978. References.

This article reports on a paper pulp molding system for manufacturing egg, fruit and meat trays, etc. from lower grade waste paper. This system was developed in 1971 and has been successfully demonstrated in 17 separate operations as an example of E. Schumacher's "small is beautiful" concept for commercially viable industrial manufacturing in LDCs.

Units are operating in Nigeria, Kenya, Zambia, Trinidad, Ghana, Tanzania, Panama, Haiti, El Salvador and others. Inquiries to the vendor have been received from over 50 countries.

Although it is possible to use the same plant to produce other products, including plant pots, and certain fiber building materials, 80 percent of all production is the standard 30 egg (5" x 6") tray.

The complete unit consists of three principal sub-assemblies: the pulping plant, the moulding assembly and the drying unit. Although the initial design was almost entirely manually operated, a certain amount of electronic equipment was included in the production models in order to control the molding process, particularly in relation to the vacuum and compressed air cycles. Simplicity and safety are major design factors throughout. Each state of the process is detailed in the article.

The major problems have not been of a technical nature, but rather ones of finance and marketing. Established firms are often unwilling to venture capital on R&D for intermediate technology because of lower rates of return versus risks and limited and unfamiliar market prospects.

paper, pulp, small scale industry, economic development.

443 Ouano, E. A. R.
Arellano, F.

Utilization of Waste Tin Cans in the Control of Chromium Plating Wastes. Conservation and Recycling. Pergamon Press. U.K. Volume 3, Number 3. 1980. Pages 130-133. References.

Based on the operation of a bench scale model in the Philippines, it was shown that the control of wastewater pollution in the chromium plating industry could be carried out economically using rusted tin cans as a reducing agent and calcium carbonate as a precipitating agent with effectiveness comparable with that of the conventional process used in the more sophisticated factories in developed countries.

The process has widescale applicability in developing economies such as the Philippines, Thailand, Malaysia and Indonesia where the chromium plating is basically a cottage industry with very low capitalization and technological sophistication. Chromium plating discharges highly acidic wastes with varying concentrations of heavy metals in the form of hexavalent chromium, cupric, nickel and iron salts.

The standard methods for treating such wastes (addition of sulfur dioxide gas or sulfite neutralization to pH 7.5 or 8) are difficult to apply in developing countries because of complex technical requirements and high maintainance costs.

The availability of large numbers of tin cans discarded even by scavengers due to low resale values, however, makes an alternative chromium plating waste treatment attractive. Passing the chromic acid solution through a stock of rusting cans will oxidize the tin and iron to stannous and ferrous oxidation states, and at the same time reduce the hexavalent chromium to the trivalent state during a 12-24 hours retention period. The procedure has the following advantages over the standard method of sulfite or sulfur dioxide reduction: (1) rusted tin cans are in the solid state, and there is no need to measure the stoichiometric requirements; (2) operation is very simple; (3) complete reduction may be observed with the disappearance of the orange color; (4) reactants are available at low cost; and (5) no mixing equipment or complicated instrumentation is required.

Economic evaluation of bench scale operation indicates that the conventional treatment process is twice as expensive as that of the new process. At the same time, a permanent local market for tin cans is created.

The cost of process instrumentation for the conventional process is estimated at US$5,000 for plants with a wastewater flow lower than 2000 m^3/day. This is unfeasible for plants in developing countries where wastewater flow rates range from 10 to 100 m^3/day. Using the new process for a 100 m3/day plant, daily cost is estimated at US$29.31 compared to US$59.71 for the conventional process.

hazardous waste, chromium plating wastes, environmental management, pollution, tinplate recovery

444 Overby, C. M.
A Study of Issues and Policies Related to Recycling of Products. Prepared for U.S. Congress, Office of Technology Assessment. Washington, D.C., U.S.A. 381 pages. References.

This document identifies problems and issues associated with product recycling. Technical and institutional impediments to product recycling are examined as are several advantages and disadvantages-economic, energy (embodied and life cycle energy), materials consumption, waste and pollution, and employment factors. Government policy is seen as a way to encourage product recycling. Implications of policies with national goals are briefly explored.

Product recycling is defined and related to other forms of recycling. It is characterized as "inner loop" recycling, whereas recycling back-to-basics materials is characterized as "outer loop" recycling. The former is a less entropic form.

Product recycling ranges from remanufacturing (which brings products to a central facility and works on a mass production basis)--to do-it-yourself repair and renovation by an individual. Tax, labeling ad other government policies will affect the process.

In remanufacturing, product parts are kept together and the original product is reassembled, usually with some new components. Repairing means simply fixing individual products, usually one at a time. Fixed structure renovation refers to buildings being revitalized.

Product recycling conserves materials, energy, and labor and power. Some see this as implying greater standardization and less variety of product choice and, hence, not desirable.

Products being remanufactured include automobiles, aircraft engines, machine tools, refrigerator and air conditioner compressors, copying machines, white goods, tires, electric power plants, agricultural and construction equipment. Institutions involved are the U.S. Government, General Services Administration, State of Texas Prison Industries System, U.S. Military, and organizations such as Good Will Industries, Inc.

Product recycling is a thriving enterprise for many different kinds of products. Benefits include extension of product life, energy

conservation, cost reduction, and job creation. The private sector has mixed feelings about government policies which encourage this form of recycling.

recycling, remanufacturing, product design, source reduction, government policy

445

Parteous, A.
Franzidis, J. P.

Acid Hydrolysis of Cellulose--A Critical Review of Progress Proceedings of the 2nd International Symposium: Materials and Energy from Refuse. Antwerp, Belgium. 20-22 October, 1981 Pages 2.1-2.14. European Federal of Chemical Engineering and International Solid Wastes and Public Cleaning Association. References.

This article describes a process to convert cellulose to glucose by continuous process hydrolysis, using a dilute acid (1 percent sulfuric acid) on waste paper in a plug flow reactor operated at 230° C. Recent results have consistently yielded up to 56 percent conversion of cellulose.

After the products are flash cooled to 134° C, which stops the reaction (glucose decomposition), the hydrolysate is fermented and distilled to 99.95 percent ethanol.

A model for a 500-ton per day newsprint feedstock plant is presented, based on laboratory scale tests. Daily products will be 91.27 tons per day of ethanol, 10 tons of furfural, 99 tons of CO_2 and lignin cake which is burned to generate steam for process heat.

Capital investment in 1981 sterling was estimated at 21, 562, 500 or £ 43,125 per input ton of paper.

fuel, acids, testing methods, hydrolysis, cellulose conversion

446

Pathe, P. P.
Alone, B. Z.
Titus, S. K.
Bhide, A. D.

Seasonal Variation of Anaerobic Digestion of City Refuse. Indian Journal of Environmental Health. National Environmental Engineering Research Institute. Nagpur, India. 1977. Volume 19. Number 4. Pages 240-245. References.

Laboratory investigations by the National Environmental Research Institute, Nagpur, India on anaerobic digestion of a mixed feedstock of animal dung and an organic fraction of refuse (OFR) indicated technical feasibility of the process. Hence, the performance of the process in a longer time frame in the laboratory as well as under actual field conditions was studied. This document provides the results of the field research.

Simple field units were made from used steel drums. An outer drum of approximately 200 liters served as a digestor tank while an inner drum of 100 liters functioned as a gas entrapment device. Using a startup seed from a working dung digestor, 580 gms of shredded organic refuse and 7.5 liters of water were added to the digestor daily from an inlet pipe for a solid concentration of 7.2 percent. Careful daily monitoring ensured appropriate pH, temperature and measurement of production of gas and volatile organic acids.

A technical problem occurred 5 months after startup. A "scum" buildup interfered with gas collection. A similar digestor was built,but with a number of moveable steel plates affixed to the interior to break up scum formation. This was done 2-3 times per day.

Analysis of the digested slurry showed it easy to drain and dry. NPK of the digested sludge had a slight increase over raw input values, and the value indicated potential use as a soil amendment fertilizer.

Gas production in small field units ranged from a maximum summer value of 0.33 m^3/kg of volatile matter added/day to a minimum winter value of 0.1 m^3/kg. The H_2S content of the produced gas was negligible. The pH of digesting mass remained constant around 6.8 + 0.2. Volatile solids destruction ranged between 40 and 56 percent.

anaerobic digestion, biogas, organics, municipal waste

447 Pawley, M.
Garbage Housing. Presented at International Housing Conference. Santiago, Chile. By Minimum Cost Housing Group. McGill University. Montreal, Canada. 1972. 58 pages.

This document demonstrates ways in which bottles, cans and other containers can be adapted as building materials for developing countries. This could provide low cost housing and prevent significant amounts of waste generation. It has long been a practice in developing countries to use discarded goods as building materials. This report suggests that governments should formalize and promote programs to encourage manufacturers to redesign their products. For example, beer or soda cans could be designed to interlock and be used as building blocks. It is stated that "the ten largest brewery corporations in the world could provide material for no less than 100 million dwellings per year. Even assuming a loss factor of 50 percent, such an output would more than double world housing production at the present time." In order to implement a successful program, more research needs to be done on building with bottles and cans. Tax incentives to encourage manufacturers to redesign their products, and small scale pilot projects to demonstrate feasibility are other needs.

building materials, Wobo (World Bottle), developing country, product design

448

Pettigrew, R. J.
Roninger, F. W.
Markiewica, W. J.
Gransky, M. J.

Rubber Reuse and Solid Waste Management: Part I—Solid Waste Management in the Fabricated Rubber Products Industry; Part II—Waste Rubber and Its Reuse. United States Environmental Protection Agency. Washington, D.C., U.S.A. 1971. 120 pages. References. Glossary.

This two part document presents industry wide solid waste disposal practices and profiles the rubber recycling industry. Part I concerns the solid waste problems which originate with the manufacture of rubber products. Part II outlines the problems associated with rubber products discarded by consumers. The reclamation industry is discussed, detailing its history, wastes used, equipment and processes and industry trends.

Broad solutions to achieve more effective waste management with specific conclusions and recommendations are noted.

rubber, solid waste management

449

Piggott, M. R.
Woodhams, R. T.

Recycling of Rubber Tires in Asphalt Paving Materials. Environmental Protective Service, Environment Canada. Contract Number OISU-RE-109-8-6374. March, 1979. Department of Chemical Engineering and Applied Chemistry. University of Toronto, Canada. 56 pages. References.

This report documents paving trials, laboratory evaluations, stability test results, viscosity considerations, temperature performance, and costs of modification and provides conclusions regarding the use of crumb rubber in road pricing materials.

Although the proportion of asphaltic binder is small (6%) in road surface aggregate construction, its function is critical to road performance. Despite the effort to improve road surfacing materials, the quality of asphalt binders is relatively unchanged. The use of waste rubber as an additive in road aggregate is generally ignored, even though it could add measurably to road performance, as tests have shown. The reasons are additional cost and changes required in conventional paving techniques. Tests and operating resulting in a 1 percent cost increase, could make the use of rubber additives feasible.

rubber, road surfaces, testing methods

450 Rao, J. K. S., Ed.

Status Report on Building Materials from Wastes. Sub-Group on Building Materials from Wastes, Planning Group on Materials Construction. National Committee on Science and Technology. New Delhi, India. 1975. 340 pages.

This document presents a model for using wastes generated by the construction industry in India. National and state governments have generally not dealt with the problem of disposal and/or utilization of wastes. No organizational structure for policy and implementation exists. The planning group assessed India's requirements over the next 5, 10 and 15 years. Potential uses of different wastes for remanufacturing building materials, with status reports of research and development efforts are presented. The possible impact of major research and development programs on identified gaps is discussed. During industrial and agricultural expansion programs in India the problems of waste disposal have become more pressing due to increasing costs, lack of land and environmental pollution. Finding a solution to the problem of disposal of millions of tons of waste has become imperative.

R & D committees have been established to oversee ongoing projects and provide an annual status report on this subindustry. R & D tasks include helping to create commercial pilot scale investigations, fostering multi-discipline research centers, education, and manpower development. Regional state and local implementation strategies are presented.

waste utilization, building materials, India, research and development

451 Ritter, W. F.
Malone, G. W.
Eastburn, R. P.

Potential of Using Recycled Paper Products for Broiler Litter. American Society of Agricultural Engineers/Canadian Society of Agricultural Engineering. Brock University, St. Catherines, Ontario, Canada. 1981. 13 pages. Authors at University of Delaware. References.

This paper evaluates a study done by the University of Delaware during 1978-79 to examine paper products as a potential source of broiler litter (chicken litter). The most common materials used for broiler litter, sawdust and woodshavings, have become expensive and difficult to obtain.

Waste paper products could be an abundant source of cheaper litter material. Several companies are selling waste paper products for animal bedding. In this test, hardwood sawdust was used as a control.Materials for testing were coarse shredded newspaper, processed newspaper, and processed cardboard. The shredded newspaper was made by passing it through a hammermill which made particles approximately 1.27 cm in width. The processed newspaper and processed cardboard were made with a patented process. They were also coarsely shredded and then placed in a

hydropulper where the paper was separated into individual cellulose fibers. The fibers were than compressed to partially remove water. A fiber board product emerged which was then separated into particles ranging from .64 to 2.54 cm in diameter. These materials were dried to approximately 30 percent moisture.

Body weight, feed conversion and the percent of mortality were determined for each trial of 200 straight run Ross & Arbor Acre chicks at both 28 and 49 days of age. Breast blisters and skin pigmentation were also scored. Litter and fat samples for selected chicks were obtained. A heavy metals analysis was done. Processed cardboard was found not suitable for several reasons. Shredded newspaper was found to cause increased litter caking. Processed newspaper was the most suitable of the paper products tested.

Litter material was also tested for effect on corn seed germination. Poor germination was obtained with shredded newspaper, apparently due to compounds in printing ink. Seed germination was also low for processed newsprint. Applying excessive rates of shredded newspaper to cropland may affect seed germination.

waste paper recovery, newsprint, cardboard, animal bedding, pulp, cellulose conversion, soil amendment

452

Rossi, B. A.
Manila, P. I.
Lundgren, E.

Annelidic Recycling of Organic Wastes. International Solid Waste Association Journal. Number 31/32. Pages 10-12. References.

The authors propose using earthworms to recycle organic wastes. Under proper conditions, the worms can consume up to three times their body weight daily, consuming all forms of organic waste. A single worm produces 1,000-1,500 offspring per annum and the average life span is six years. They breed in a temperature range of 5-35°C. Worm castings which are abundant in soluble minerals and richly balanced in nitrogen, phosphate, and potash, can markedly improve soil humus.

Dried red earthworms are 62-64 percent crude protein and are considered equal to fish metal in amino acids for use as a high protein supplement.

Tests conducted at the Tokyo Agricultural Chemistry Testing Station in Japan using castings as an alternative to a supplementary fertilizing medium are described. Increased yields of 14-40 percent were noted on soybeans, chinese cabbage, and green soybeans.

Currently, a mixture of 30 percent castings and 70 percent conventional chemical fertilizer is used in a granular form which releases its nutrients over time. The 30 percent castings contain:

Moisture	44.34 percent	Molybdenum	0.8 ppm
Nitrogen	0.70 percent	Boron	57.0 ppm
Phosphoric Acid	0.91 percent	Manganese	0.01 percent
Potassium	0.57 percent	Organisms	34.88 percent
Silicic Acid	12.22 percent	Ash Content	20.78 percent
Lime	1.28 percent	Fuminsan Acid	7.58 percent
Magnesia	0.55 percent	Base	60.06 ME/100g
Oxide of Iron	0.56 percent	pH	7.65

Worm castings are favored as a way to produce fertilizers without depending on natural gas or crude oil.

Estimates indicate that facilities required for 1,000 tons of wet mixed waste per month require less than 3 acres as follows:

	Land		Labor
Mixing Plant	700 m2		1
Worm Beds	10,000 m2		6
Packing Plant	700 m2		4
	11,400 m2	—	11

Equipment cost is estimated at US$52,000

Profits vary with cost of land, construction, and labor, costs and/or revenues of waste. Profits in developing countries will be higher as land, labor, and construction costs are low. Cold weather housing is generally unnecessary and imported fertilizers are expensive.

The size of the installation can be scaled down to 1/2 ton a day and still be profitable.

vermicomposting, fertilizers, nutrients, organics, crop yield, composting, soil amendment, costs, economics

453 Rossi, B. A., Ed.

International Recycling Group: Seminar/Workshop Proceedings, 1977. Rossi-Nayve Consultancy Services, Inc. 1978. Makati, Metro Manila, Philippines.

This document is a compilation of several papers on recycling in Asia. Both high technology and labor intensive small scale technologies for resource recovery are presented. Topics include: uses of agricultural wastes, oil, plastics, compost animal waste and metals. The economics of small scale technology are presented. It is noted that small scale technologies are economically feasible in a group, whereas singly they

would fail. Thus, horizontal integration provides a mechanism of sustainability.

Asia, small scale industry, economics, labor, resource recovery, technology

454 Shin, K. C.

The Optimalization of Methane Gas Recovery from Waste Material and Possibilities for Its Utilization. Conservation and Recycling. Pergamon Press. U.K. Volume 4, Number 3, 1981. Pages 129-136. Author at University of Stuttgart, Federal Republic of Germany. References.

This document discusses the amount of gas available from sewage sludge, household refuse and agricultural wastes. Sewer gas (biogas) can be generated from anaerobic decomposition of different waste substances, e.g., sewage sludge, household refuse, and agricultural wastes. In the Federal Republic of Germany, one-quarter of available digestor capacity is unused. This is expected to increase, in spite of current limitations, due to the price of energy and increased awareness of potential renewable sources. Laboratory digestion tests were carried out to examine making gas from household refuse. A maximum specific gas yield of 320 ml gas/gram organic dried matter per day was achieved at optimal space loading with organic substances, amounting to 3.1 grams of organic dried matter per litre of gas production yield per day. Based on a 34 percent dried organic matter content of one kg of household refuse, or 349 grams/kg refuse and a decomposition rate of 50 percent, litres of gas are obtainable per kg of domestic refuse. Thus, the quantity of gas yielded in laboratory tests approached the theoretical value. If the gas from only 50 percent of the refuse could be collected from landfills, some 492 x 106m3 of gas per year would be available. New trends in use of landfill gas include heating greenhouses, fuel for motor vehicles, and anaerobic digestion of pulverized refuse. Research programs are testing these applications. To obtain results that were achieved in laboratory tests, optimum working conditions need to be maintained. These are sufficient agitation, removal of scum, continuous charging of the digestor, and the exact digestor or temperature.

biogas, energy recovery, testing methods, sludge, household wastes, agricultural wastes, heating and cooling, fuels

455 Sklar, S.
McBride, J.

Transportation Technologies for Low Income People: A Few Promising Programs. Alternative Sources of Energy. Pages 12 to 15. Milaca, Minnesota, U.S.A. March/April, 1981. Authors at National Center for Appropriate Technology. Butte, Montana, U.S.A. References.

Automobile repair and retrofitting are discussed in this article as a way to promote energy conservation and prolong the life of automobiles, particularly for low income people who cannot afford to purchase new fuel efficient cars. For less than US$2,000 a car can be totally reconditioned, which will add about 50,000 miles to the life of the vehicle. Reconditioning possibilities include changing an 8-cylinder

engine to a 4-cylinder one, new peripheral engine parts, new brakes, new tires, etc. Direct fuel savings could be as much as 40 percent. This type of automobile repair can potentially save 28,000 barrels of crude oil per day in the United States. In addition, a sizeable economic potential exists for job creation through this labor intensive method.

Retrofitting automobiles is a second way to promote fuel economy. For a vehicle which gets 15 miles per gallon and a remaining life expectancy of 50,000 miles, and assuming a 12 percent annual fuel price increase, a US$400 investment would be cost effective if it produced a 10 percent increase in fuel economy. For US$750 a 20 percent saving should be realized. Options include: radial tires, tire inflation, advanced lubricants, routine maintenance, driver skill training, idle-off and coasting systems, water emulsified fuel, thermostatically controlled fans, preheating fuel, and microprocessor controlled fuel intake. Retrofits could save 170,000 barrels of crude or equivalent per day in the U.S. A third approach is local production of alcohol fuels for use in modified automobiles.

automobiles, reuse, remanufacturing, fuel, labor

456 Smith, H. V.
Klobbie--The Wood Maker/Waste User. Rehsifsa. London, U.K. Bulletin #400. 25 February 1982. 10 pages.

In this technical bulletin, plastics reclamation using a klobbie unit is described. This is an automatic extrusion molding machine designed to handle certain mixed polymers. Currently, klobbies operate by Rheem Australia, Limited, Australia, Superwood Limited in Dublin (Ireland), Lankhorst Touwfabricken BV, Sneek (Netherlands), and HVS Mouldings Limited, Fareham (England).

Rehsifsa, the manufacturer, presents specifiations for a 1,100 tons per year klobbie unit. The feeding system is described as being able to handle a wide variety of polymers including both fibrillated film waste and granulated HDPE. Homogenization and plasticization is effected by a high speed adiabatic extender with a normal running speed of 350 revolutions per minute. Extruded materials are forced into a rotating cylinder comprised of 10 molds. The automatic molding operation is conducted by the filling of molds triggering the cylinder to move to the next unfilled mold. A unique feature is that different molds may be used provided they are all of the same length.

The klobbie is rated as very rugged. The equipment is simple with principal wear occurring at (1) the extruder screw (normal use: 1 year before re-stelliting); (2) cutting blades in the mill; and (3) extruder barrel heaters (lasting from 1 to 2 years). Selling price based on U.K. costs (energy, materials, labor, etc.) must be 18.7 pence/kg in order to break even.

plastics, plastics recycling, extrusion, molded products, equipment, wood substitutes

457 Smith, H. V.

Some Criteria for the Successful Commercial Recycling of Heterogenous Plastic Wastes. Conservation and Recycling. Pergamon Press. U.K. Volume 2, Number 2, 1978. Pages 197-201. Geneva, Switzerland.

Six criteria for successful recycling of mixed plastic waste are presented in this article. They are: efficient homogenization; conservation of energy by adiabatic operation; one step conversion of waste to finished product; consistency of feedstock; maximization of plant utilization; and selection of finished product from the standpoint of marketability.

Recycling of heterogenous polymers requires efficient homogenization to produce a molding compound with consistent properties.

The Mitsubishi Reverzer is one machine which can achieve this. Contamination in mixed plastics waste is averted by forming end products in thick sections (2-3 cm). These products do not compete with the plastics industry, but with the concrete and woodworking industries.

Since pyrolysing waste plastics for fuel is not energy efficient, recycling is the best way to conserve energy. This is true because the Reverzer operates at close to adiabatic conditions. Also, the Reverzer obtains a simultaneous transformation of the melt to the end product, conserving the energy otherwise necessary for the intermediate granular stage.

The Reverzer can homogenize almost any mixture of thermoplastics. It is critical that the feedstock for a given product be combined in generally equal proportions.

Choice of the final product determines how profitable the enterprise will be. The profit margin increases accordingly with the cost of wood.

plastics recycling, Europe, small scale industry, product substitution, equipment, pyrolysis

458 Steinberg, M.
Beller, M.

Glass-Polymer Composites for Sewer Pipe Construction. In Proceedings of the Fourth Mineral Waste Utilization Symposium. Chicago, Illinois, U.S.A. May, 1974. 12 pages. U.S. Bureau of Mines. Rockville, Maryland, U.S.A. References.

This article describes the development of a concrete substitute made by the Brookhaven National Laboratory, Concrete Polymer Materials Development program. For example, a glass-polymer composite (GPC) is produced by mixing crushed waste glass with monomer (either methyl methacrylate or polyster-styrene) and polymerizing by chemical initiation techniques. Monomer concentrations are 13 to 16 percent by weight in

ungraded crushed bottle glass. Graded sieved glass results in monomer loading of 9 to 10 percent. GPC is two to four times stronger than ordinary concrete. It is also more durable. Using GPC for sewer pipes is one way to use the large amount of waste glass in urban communities. Various casting techniques including centrifugal casting are being explored.

A field test was done in Long Island, New York. Ten lengths of 8-inch diameter 3.4 inch-wall, 42 inch long GPC were installed in a municipal sewer line. For the same wall thickness, the three edge bearing strength of a polyestyrene GPC pipe is greater than twice the requirements for concrete pipe of the American Society for Testing Materials. Cost estimates indicate that GPC is potentially competitive with asbestos cement, vitreous clay, concrete and plastic pipe in the 8 to 24 inch diameter pipe size range. The construction of large capacity solid waste separation plants within the next few years will create an assured supply of waste glass for producing GPC products such as sewer pipe and building brick.

glass, glass recycling, plastic, product substitution, building materials

459 Sunavala, P. D.
Recycling of Municipal, Agricultural and Industrial Wastes to Generate Renewable Sources of Energy, Journal of Scientific and Industrial Research. Volume 40, Number 9. Pages 543-614. Council of Scientific and Industrial Research. New Delhi, India. September, 1981. Author at Department of Chemical Engineering, Indian Institute of Technology, Bombay. References.

This article covers the state of the art of resource recovery in India. Using the energy crisis as the focal point for development efforts, the article presents thermochemical means of recovering the energy value inherent in wastes, especially from the municipal sector. Pyrolysis is seen as the best answer to refuse disposal problems.

Advantages to the pyrolysis process include available technology, ease of storage, gas volumes considerably less than those generated by incineration (consequently pollution control is lower in cost) and a product which can be used in conjunction with sewage sludge to produce a fertilizer. Charcoal could possibly be used as an activated carbon substitute.

India, pyrolysis, technology, environmental management, pollution, municipal wastes, agricultural wastes, industrial wastes, resource recovery, energy recovery

460 Sweetman, J.

Making Paper by Hand. Appropriate Technology. Intermediate Technology Publications, Ltd. U.K. Volume 6, Number 3, 1979. Pages 9-11.

This document gives the history of paper making and basic requirements for making paper by hand. Drawing on 30 years of experience, the author describes the technical process of paper making beginning with four requirements: vegetable cellulose fiber, water, power and a screen. The raw material must be cellulose because only suspended cellulose has the special property of forming fiber-to-fiber bonds by hydrogen in exchange as water is expelled. Processing is accomplished to break up raw material, soften the fiber and increase water absorption capacity and contact area. In making paper by hand, judicious skill and control in heating the fibers produces a quality paper. Pulping coloration, decolorization, molding, and screening follow. Pressing and sizing forms the final product.

The article discusses why paper making is a capital intensive industry. The author encourages the establishment of small scale, hand made paper factories, especially in rural and urban fringe communities.

historical, paper making, fiber, small scale industry

461 Upaa, R.
Lund, T. L.
Rao, K. N.

Is Re-Manufacturing Adaptable to Nigeria? Center for Policy Alternatives. Massachusetts Institute of Technology. Cambridge, Massachusetts, U.S.A. 1980. 22 pages. References.

This document is one of a series of working papers on opportunities for remanufacturing in developing countries. The potential development, constraints and possible disadvantages of remanufacturing are described.

There are three basic stages of remanufacturing: disassembly to make a pool of interchangeable parts, cleaning and refinishing, and reassembly to produce new or equivalent goods.

Remanufacturing could be of particular importance to Nigeria where 45 percent to 53 percent of the total value of imports are durable goods. Increasing the availability of products through local remanufacturing would have a positive impact on Nigeria's trade balance, and might lower costs by 40-80 percent.

Nigeria places high priority on developing industry, yet remanufacturing is not on the government's priority list. A review reveals that there are few sales and service facilities for imported equipment, and an unreliable power system causes malfunction and damage to industrial plants and domestic durable products. Favorable development characteristics include the sufficient availability of older units to support an industry,

and the high price of new equipment. Unfavorable characteristics include concentration of units for remanufacturing in large towns. insufficient skills training, and resistance to buying used products.

A list of candidate products for remanufacturing in Nigeria is suggested. Full feasibility studies are required. A strategy for implementing an industry includes: technical schools and vocational training centers; incentives for small independent firms; incentives for original equipment manufacturers to locate in Nigeria; and, product acceptance and marketing programs.

Skills transfer, low capital requirements and simpler technology design are factors which lead the authors to conclude that remanufacturing is appropriate for rural and urban development to benefit people in LDCs.

Background notes on manufacturing in Nigeria.

remanufacturing, economic development, small scale industry, Nigeria

462 Veal, F. J.
Whalley, L.
Renewable Resources as Chemical Feedstocks. Conservation and Recycling. Pergamon Press. U.K. Volume 4, Number 1. Pages 47-57. 1978. References.

The prospects for converting cellulosic materials into a wide range of chemical products and the economic implications for product substitution industries are reviewed in this article. At this time hydrolysis is not economically feasible. However, the actual methods, technology and research results are presented in the event that the economic situation may change.

fiber, cellulose conversion, hydrolysis, chemicals, product substitution

463 Vogler, J.
Glassmaking as in the Time of Yore. Materials Reclamation Weekly. A. Cohen & Company, Ltd. London, U.K. October 18, 1980. Pages 24-26.

This article discusses case studies of small scale glassmaking enterprises now operating in Thailand, India, Egypt, Mexico, and Peru. For example, in Bangkok, Thailand, a 100 percent foreign cullet fed (broken glass) glass factory employs 50 people and products 4 metric tons per day. Material is collected by an informal recycling structure at bottling plants, and from merchants and residences. It is washed, stored in bunkers, and fed by elevators directly to a furnace. Most of the product is flint (clear) glass. The furnace is poorly constructed of thin brick and fire clay with corrugated iron to deflect 400°F heat from workers.

Three hour retention is followed by 5 hour cooling. Products are "seedy" but entirely acceptable. Small handmade operations elsewhere use potatoes or an arsenic oxide/sodium nitrate mixture to reduce impurities.

small scale industry, glass, cullet, glass manufacturing, job creation, product development, Thailand, India, Egypt, Mexico, Peru

464

Webber, H.
Meyer, M.

Utilization of Compost in Agriculture--Experiences in Europe and Especially in the Middle East. Proceedings of International Symposium "The Practical Implication of the Re-use of Solid Waste." 11-12 November, 1981. London, U.K. Pages 47-56. Institution of Civil Engineers, London, U.K. 1981. References.

This paper examines the significance of compost quality as a grading indicator. As a direct result of growing uneasiness about modern farming methods and use of chemical fertilizers in agriculture, compost marketing is encouraged. While compost products derived from agricultural and animal wastes can be routinely marketed, refuse-derived compost is as yet unmarketable. As a disposal method, it can have benefit.

A qualitative determination of biological processes is difficult. Normally, it is done by examining the individual parameters. The usual methods for testing the compost are as follows: determination of the degree of decomposition of the organic matter (the rate of decomposition per unit time indicates the digestion intensity); self heating test in the Dewar tank (because digestion is an exothermic process; a matured compost will no longer heat itself); determination of oxygen (O_2) demand by a given quantity of compost over a defined period of time. (The further the aerobic digestion process has advanced, the lower the O_2 demand); testing of nitrogen (N) present in its main form. (In fresh compost, N is mainly present in the form of ammonia, subsequently, it is first compounded as bacteria protein, and with subsequent digestion is increasingly mineralized, i.e. transformed into nitrates). The best indication of the degree of maturity of a compost is obtained from plant growing test with, for example, the sensitive and fast growing cress being ideal for the purpose.

Utilization and procurement specifications are ultimate determinants as to compost product fineness. Two criteria established by compost plant operators are (1) compost grade on the basis of moisture, impurities, ignition loss and application (see table below); and (2) the degree of maturity, i.e., pretreated, fresh, semi-matured, and matured compost.

CRITERIA FOR COMPOST PRODUCTS

Compost Grade	Mature Only	Mature Only	Fresh or Mature
moisture (% max.)	35	40	45
impurities (% max.)	1 per 4 mm mesh	1 per 65 mm mesh	1.5 per 8 mm mesh
ignition loss (% min.)	10	10	10
application	potting earth, sports lawns, piglet earth, etc.	horticulture	agri-, vini-, silvi-, fruiticulture, etc.

An important aspect in considering compost is the natural resource condition. In arid regions, compost fortified with fertilizer and equivalent water compared to a fertilizer only control, resulted in yield increases of 44 percent (cabbage), 53 percent (onions), 173 percent (tomatoes), and 270 percent (lettuce).

Calculations based on experimental results showed that processed town refuse without additives had fertilizer equivalencies of 43 percent for ammonium sulphate, 83 percent for thomas phosphate and 57 percent for manure peat.

composting, organics, Europe, Middle East, testing methods

465 Western, A. W.
Small Scale Papermaking.
Intermediate Technology Industrial Services (Intermediate Technology Development Group). Railway Terraces, Rugby, U.K. 1979. 217 pages. References.

This report evaluates small scale paper making in India. It presents information on a variety of mills which produce from one to thirty tons per day and use up to 100 percent secondary fiber. The history of paper, the influence of small economies of scale, current Indian state of the art, materials, processes and implications for developing countries are presented.

The economy of scale research concluded that the system must be appropriate for demand and consumption; supplies must be available; and that increasing plant size will create increased demands for capital and higher transportation costs and higher energy costs. Smaller mills are more flexible, require less training and skill to operate, cost less and provide greater employment per dollar. In a comparison between a 300-ton per day plant and 10 small mills of 30 tons per day, the smaller mills cost

50 percent less, generated twice as much employment and spread pollution on a wider basis, avoiding the problem of dealing with great amounts of pollution at one location.

paper, fiber, paper making, small scale industry, economics, India, cost analysis

466 Weygers, A. G.
The Recycling, Use, and Repair of Tools. Van Nostrand Reinhold Company. New York, U.S.A. 1978. 112 pages. Glossary.

This book is a practical guide to the repair and reuse of tools for small scale agricultural and cottage industries. How to salvage and recondition tools from scrapyards and landfills is discussed. Repairs are shown for simple and complex tools with the use of annotated illustrations. Lathes, chisels, and punches, bearings, grinding and drilling tools, and trip hammers are among the tools shown to be repairable.

tools, machine shop, reuse, ferrous scrap, nonferrous scrap, recycling, wood

467 Zaichik, T. S. R.
Automatic Bottle Washing Machine. Pishchevaya Promishlenost. Moscow, U.S.S.R. 1978. 129 pages. References.

This document describes bottle washing on the intermediate scale. Profusely illustrated, its five chapters describe: (1) machine design including design components, electrical schematics, resource requirements and parts; (2) installation, adjustment and service, including shakedown, bottle breakage reduction, and trouble shooting; (3) operation, including technology and processing, detergents, hardness reduction in water, and detergent recycling; (4) maintenance; and (5) safety, including requirements, operation and maintenance, hazards and hazard mitigation.

bottle washing, health and safety, Union of Soviet Socialist Republics, small scale industry

Economic Aspects

501
Iron and Steel Scrap: Its Significance and Influence on Further Developments in the Iron and Steel Industries. United Nations. Economic and Social Council. Economic Commission for Europe. Steel Committee. ECE/STEEL/24. 17 August, 1978. 223 pages. References.

This document reviews the role of ferrous scrap in iron and ferrous steel production. Ferrous scrap is becoming increasingly important because world production is derived almost equally from virgin ore conversion and remelting of scrap. Further, industrial dependence on scrap may increase because of changes in production techniques: abandonment of the Thomas process, marked decline of the open hearth process, increased utilization of electric furnaces, and increasing use of oxygen converters and rolling mill capacities.

The study outlines several considerations as a result including: sources, preparation, classification of scrap, economic and technical factors affecting the pig iron/scrap material balances, and the ultimate impacts on scrap market futures and investment prospects. The study also documents worldwide the flow of ferrous scrap.

ferrous scrap, recycling, economics

502 Butlin, J. A.
Economics and Recycling. Journal of Resources Policy. PC Science and Technology Press. Surrey, U.K. June, 1977. Pages 87-95. References.

This article documents the change from rural small scale agricultural based economies to urban, large scale industrial based ones, and discusses the economics of recycling. The opportunity cost of using the assimilative capacity of the environment to absorb the increasing generated waste has risen well above zero (the equivalent of treating the supply of environmental services as infinite); and is reflected in increasing costs and pollution.

Over time, the waste absorptive capacity of the globe has decreased in response to population and economic growth, and the technical changes which have altered the quantity and characteristics of generated waste. Past policies of raw material extraction have served their purpose and it is necessary to curb the current over-extraction of raw materials in order to utilize and invest in reclamation and recycling technology.

Aggregate collection of domestic waste solely for sanitation purposes poses great difficulty in terms of reallocating fiscal and technical resources away from disposal. Similarly, rapid depletion of exhaustible virgin resources by industry is built into economic practice by government economic policies.

Government regulatory measures are needed to reinforce socially desirable goals. Law enforcement is enhanced by positive social attitudes toward waste avoidance. Both can enhance economic conditions and reclamation practices, and make recycling viable. This will reduce local costs and improve the balance of payments.

The discussion applies to the United Kingdom but its approach can be applied to all industrialized and industrializing economies considering government intervention in materials flow and development.

economics, recycling, environmental management, United Kingdom

503 Claggett, R. E.
The Soda Ash Picture. The Glass Industry. New York, New York, U.S.A. December, 1981. Pages 28-31. Author: Texasgulf Chemicals Company, Raleigh, North Carolina, U.S.A.

This document examines developments affecting the production, consumption and distribution of soda ash in glass manufacturing. The United States may soon become the major world supplier of this key ingredient. Production from vast trona deposits in southwestern Wyoming has discouraged synthetic soda ash manufacturers from upgrading aging plants and covering the escalating costs of energy and strict environmental requirements. Syracuse, New York and Searles Lake, California are two other production areas using direct carbonation of natural brine with a combined capacity in 1981 of 2.3 million short tons/year.

In addition to the glass industry, soda ash is used in pulp and paper manufacture, soap and detergent manufacture, water treatment and air pollution control. United States export of soda ash is three times the level of domestic consumption, with Western Hemisphere countries (Mexico, Canada, Venezuela) leading consumers. Rail transportation is the predominant means of distributing natural soda ash to domestic markets and port terminals on the Gulf and west coasts for export. Manufacturers tend to maintain a 7 to 10 day supply to insure contained operation during bad weather which could disrupt delivery schedules. World production data are shown in table below.

WORLD SODA ASH PRODUCTION--1980

	1,000 short tons
United States	8,277
Western Hemisphere	1,233
Western Europe	7,534
Africa	257
Asia/Oceania	3,058
USSR/Eastern Europe	11,783
Total	32,142

soda ash, glass manufacturing, international trade

504 Grace, R.
Turner, R. K.
Walter, J.

Secondary Materials and International Trade. Journal of Environmental Economics and Management. Academic Press. London, U.K. Volume 5, Number 2, 1978. Pages 172-186. References.

This article discusses how international trade affects recycling. The sources of demand and supply that act as volume, composition and directional trade determinants are outlined. International material flows for secondary materials are described. A model case study on waste paper is focused on observed differences in various national recycling rates. The role of trade in reconciling those differences is presented.

The authors profile secondary materials flows as a complex mechanism. They describe home scrap as not important to international trade due to in-house use at individual plants. Present and post consumer scrap can play a role, though. Recovery is a function of concentration of supply, revenue over costs of collection, transport and separation, and alternative cost of disposal.

The price of virgin material acts as upper limit on secondary material price, although in some technical aspects, certain production processes demand selected proportions of scrap.

International secondary materials trade could prove to be a dynamic force in redistributing variations between countries of supply and demand.

institutions, secondary materials recovery, international trade, recycling

505 Henstock, M. E.

The Conflict Between First Cost and Recyclability in the Design of Manufactured Goods. Resources Policy. IPC Business Press. U.K. Volume 4, Number 3. September, 1978. Pages 160-165. References.

This article reviews the importance of product design to recyclability and the problems inherent in that strategy.

Many manufactured items cannot be recycled because they contain materials that contaminate each other. Moreover, modern construction methods often preclude simple and easy separation into usable pieces. Consideration, at the design stage, of subsequent recycling could facilitate a suitable choice of material and a mode of construction to aid reclamation. Such redesign is, however, likely to involve increased cost.

In addition, there are basic problems to overcome which can become institutional barriers if a clear cut strategy is not developed to eliminate or mitigate their effects. These include: prejudices by manufacturers and consumers towards secondary materials with which they may not have experience; the fact that certain grades of secondary materials lack the flexibility of high purity primary feed and are suitable for a restricted range of uses; and that only a fraction of the total demand for a material can normally be supplied from secondary sources. These factors encourage manufacturers to draw their principal supplies from primary producers except when there is a shortage of primary materials, or when prices in the secondary market are especially favorable.

The specification barrier is intensified due to product or material contamination inherent in product design. Contamination can be avoided by hand segregation, use of applications and products suited to mixed or contaminated characters, and design changes to reduce mixtures.

The nature of goods manufactured by modern, mass-production methods is such that self-contamination is, in many cases, almost unavoidable. Although redesign to avoid such problems is in principle possible, cost increases are very likely given the fact that most industries already manufacture at minimum cost and have substantial investment in existing manufacturing technology.

The author believes that consumers will not voluntarily pay a premium to ensure recyclability of products. Manufacturers are thus not likely to place themselves at a cost disadvantage relative to their competitors.

Design for recyclability will, it is generally conceded, come only as a result of legislation, as have other developments such as seat belts and catalytic converters for exhaust fumes.

source reduction, recycling, remanufacturing, product design

506 Lindberg, R. A.
Akagi, R. H.

Reclamation, 1975-2000: A Key to Economic Survival. Marketing/Management Services Division, National Credit Office, Dun and Bradstreet, Inc., New York, New York, U.S.A. November, 1974. 314 pages. References.

This document is an extensive economic forecast of the waste reclamation industry. The underlying concept is that the world economy must retreat from the current mode of linear production; that is, converting raw materials to waste through a single product state. "The human condition can no longer be maintained without a swift rise in the recycling of what we now call waste... Indeed, the very survival of the world culture may well depend on a quick and complete shift to the practice of returning materials at the end of product life to nature or to production. The world economy has loops to close. How quickly they are closed and how many materials they are closed for is likely to more profoundly influence the future of human history than any single event of the past."

The report deals with waste entering the public domain only. It is not concerned with waste recoverable in industrial plants. For example, mine tailings returned to mining pits are not included in the site, nor are any of the chemicals recovered in plant from process effluents. The demarcation is not precise, however. Agricultural wastes, which for the most part are not moved far from where they are generated, are dealt with in the study. Secondly, the study addresses itself to waste in any form that constitutes a major contributor to the waste total, not solid waste only. Heat and water, among other significant forms of waste, are also surveyed.

A key to the solution to the waste problem is to make parallel the growth in the supply of materials from reclaimed sources with the growth in population and consumption.

The authors are confident in the technologies for recovering energy from municipal solid waste, converting agricultural waste to proteins and fertilizers, as well as for manufacturing products from secondary materials. Among the assumptions made for forecasting economic trends are the following:

- The cost of energy will rise 300-400 percent above 1973 prices by the year 2000;

- Estimated costs of key fuels by the year 2000 are (1970 dollars):

Coal	-	$32 to $50 Standard Ton
Natural Gas	-	.85 to 1.10 Cubic foot
Oil	-	.15 to 20 Barrel
Uranium	-	9.25 to 14.80 Pound

Strategies for individual, government and international actions are discussed. The authors feel that comprehensive development of reclamation in the world economy can stabilize inflationary cycles.

"If mankind is to retain its present standard of living, it will be forced to reduce its rates of consumption of natural resources and production of goods and services must be stabilized at benign levels. This will require reclamation of consumed materials on an increasing scale. Should that, in turn, be accomplished, then waste conversion will likely have become the world's largest industry outside of agriculture by the turn of the century."

"The waste conversion industry cannot grow to a substantial size without deliberate, coordinated intervention. Despite the examples of the energy crisis and the shortages of raw materials such as fiber, manufacturers generally continue to look toward virgin materials to supply them with the ingredients for the products they create and have not yet seen the need to significantly alter their wasteful production, product design, and marketing strategies. Consumers still persist in their preference for newly used materials and their conspicuously consumptive ways. Govern-

ments, for the most part, remain indifferent to the potential disasters building up globally and in their own countries.

economics, agriculture, waste recovery, resource recovery

507 Page, T.
Conservation and Economic Efficiency. Johns Hopkins University Press. Baltimore, Maryland, U.S.A. 1977. 266 pages. References.

This author believes that the continued erosion of natural resource bases, which has been heightened in recent years, poses a great challenge to the world to provide and maintain a reasonable standard of living, and preserve a livable environment. Material wellbeing and the quality of the natural environment are integrally related; and policies established to address one will ultimately have an effect on the other. Complex interrelationships confuse and concern society, but the uneven distribution of resources, wealth and income, between developed and developing nations has far wider implications. The level of consumption of virgin materials, the reuse and recycling of materials, the durability of products, the substitution of materials and technological change, and the types and quantities of waste generated and subsequently discharged have profound impact on the level of per capita material wealth worldwide.

The book discusses: economic efficiencies (factors affecting virgin and secondary materials competition), long-term distributional implications (are we active enough to keep the resource base solvent for future generations), and then reconciles these diverse functions by combining the best properties of both.

The author concludes that resource depletion and waste generation are not market failures but distribution problems subject to equivalent macroeconomic policies used to treat unemployment and income distribution.

recycling, product durability, economics, conservation, government policy

508 Quimby, T. H. E.
Recycling, the Alternative to Disposal: A Case Study of the Potential for Increased Recycling of Newspapers and Corrugated Containers in the Washington Metropolitan Area. Johns Hopkins University Press. Baltimore, Maryland, U.S.A. 1975. 133 pages. References.

This book considers recycling as an economic phenomenon. In recent years, the focus on energy prices put more attention on mixed solid waste as a fuel substitute in thermal power plants or as a fuel in plants specifically designed to "recover energy" from mixed solid waste. This document points out cellulose fiber in the paper residuals of municipal solid waste will become more valuable in the future as a raw material for production of paper products than as a fuel. The relative values can change as a result of many factors including changing technology, tax policies, costs of other inputs, and costs of disposal. The generation and disposal of residuals is discussed in relation to cost alternatives with specific attention to the flow of paper from production to consumption.

The application of a least cost system analysis to solid wastes handling and disposal for the Washington, D.C., U.S.A. metropolitan area reveals the feasibility of source separation recycling of newspaper and corrugated containers. Recovery of the materials is feasible assuming relatively low 1971 prices and assuming no technological innovation or market alteration from the existing solid waste management system. A 10 percent diversion of total solid waste would result in a reduction in total annual disposal costs of 6 percent.

newsprint, cardboard, paper, United States, recycling

509 Streefland, P.
The Absorptive Capacity of the Urban Tertiary Sector in Third World Countries. Development and Change. Sage Publications. London, U.K. Volume 8. 1977. Pages 293-305. References.

This paper discusses aspects of the informal sector in absorbing workers. The author argues that the elasticity of the informal sector is regulated and restricted by a number of factors: urban environment; government policy; and capitalist penetration. Observations are based on literature and data collected during research among Christian Sweepers (CPS), who live in the Slaughterhouse area in old Karachi.

Due to their origins as "untouchables," and their particular work, the CPS are looked upon as second class citizens and are treated accordingly by the Moslem majority. The social position of the CPS is shown clearly in the comparative isolation in which they live, in restrictions on their behavior, and in the subordinate character of their interaction with the Moslems. Their economic position is quite strong, however, and they cannot generally be classified as the poorest economic strata. The work of the sweepers is indispensable. The result is a monopolistic situation that enables them to earn incomes often quite high compared to other unskilled laborers.

Some sweepers are employed by municipalities to perform several kinds of duties including waste scavengers, servants, kudimen (who attend the sewage system) and latrine cleaners. Scavengers work in squads and teams assigned to specific areas. Work is done by both men and women. Both municipal and private sweeper-work is hierarchically organized.

Mukyaddams or agents supervise the squads and teams, control recruitment, assignment, overall work situation (absenteeism, off-time) and job security.

Among themselves, sweepers speak of "ownership of a street" based on rules that have validity within their community. The "owner" may do work for himself or hire employees or grant share-contracts. It is easy to discern a class structure based on access to the main area of production, the street. "Big owners" who control several streets play an important role in Slaughterhouse politics.

The absorptive capacity of the urban informal sector is potentially limited by four broad groups of factors. One is reduced access to the control of resources either through ethnic, caste, and religious group monopolies. As a result, new migrants may face severe entry barriers. Within such groups, brokers (like the sweepers' mukyaddam) take on regulatory importance.

Another factor is the changing character of the urban environment such as new sewage and solid waste technologies which could eliminate the need for sweeper attendants and restrict physical access to salvagable materials.

A third factor is government policy restricting informal sector activities. One policy is the introduction of a licensing system. Another is a policy of shifting tertiary sectors population from one area to another.

Finally, the penetration of labor saving devices, irrepairable products, mechanical equipment and money lending by banks in competitive areas can have a potentially enormous negative influence on absorptive capacity. Capitalist penetration, as it is described by the author, may ignore the inherent flexibilities of native systems in the rush to maximize profit and ensure stable conditions necessary to long-term investment.

The absorptive capacity of additional labor in an even, relatively stagnant, urban economy is large, but limited. While the informal sector is elastic, various factors impact negatively. Investigation of impacts remains a priority area.

economics, informal sector, job creation, developing country, scavengers, waste management, Southeast Asia

510 Voorhoeve, J. J. C.
Organic Fertilizers: Problems and Potential for Developing Countries. World Bank Fertilizer Study, Background Paper No. 4. January, 1974. IFC-Office of the Economic Advisor. 15 pages. References.

This document considers the use of organics as fertilizer supplements. Organic fertilizers are generally associated with luxury concerns of organic agricultures. The subject is most important, though, when considered in face of high fertilizer costs, energy crises, foreign exchange limitations and soil erosion. These factors would appear to justify further attention.

It is estimated that total LDC production of soil nutrients (N, P, and K) from organic residues and wastes is approximately 7.8 times larger than consumption of commercial fertilizers by LDCs in 1971. Raw output of N, P, and K from just urban compost is estimated at 0.60, 0.48, and 0.71 million metric tons annually in LDCs.

An important source to defray costs of organic fertilizers is methane gas production. Methane gas can be produced from organic waste

without significantly reducing the fertilizer value of residue. Such a process for urban composts and sludges is now technically feasible.

Compost material and other organic fertilizers are considered more valuable as soil conditioners than as fertilizers (inhibit soil erosion and water runoff). In particular, erosion is a serious problem in LDCs because of minimal soil depth and silting of irrigation ditches. A comparison of topsoil loss with degree of compost added showed that applying 400 tons per hectare saved almost 95 percent of soil from eroding.

Problems for increased use of organic fertilizers include farmer resistance, lack of financial support, public health problems, economic return and lack of research in LDCs.

composting, soil amendment, soil conservation, India, Netherlands, Mexico, developing countries

511
Office Paper Recovery: Role of Sheltered Workshop. Environment Conservation Directorate of Canada. Ottawa, Canada. 1980. 53 pages. References.

This document describes the use of handicapped people to perform cost effective labor intensive sorting operations. Three Ortawa sheltered workshops participated by setting up facilities to sort waste paper on their premises. The handicapped assisted in collecting the waste paper from two designated government buildings. They sorted a variety of wastepaper materials and helped to deliver the sorted paper to a local dealer.

Based on the handling of 26,244 kilograms of various paper grades, the study concluded that (1) the project was economically viable based on market prices and sorting times required per paper grade: (2) material satisfied dealer specificaitons; and (3) workers enjoyed the sorting tasks. It was recommended that the federal government expand employment opportunities of thic type.

waste paper recovery, government policy, job creation, office building recycling

512
Plant Requirements to Set Up and Operate a Gray Iron Jobbing Foundry. Report prepared for the Agency for International Development. Prepared by George H. Andrews Engineering Associates, Inc. Washington, D.C., U.S.A. (PO-292-824) May, 1959. 29 pages. References.

This manual discusses how to establish a small gray iron foundry for a general or jobbing business, which produces about 8 tons per day of finished castings. This level is deemed to be an economical unit employing 30-35 workers. Manufacturing operations are described and illustrated, as is production equipment.

As a jobber, the foundry would get its business from many customers, ordering castings of varied shape and quantity. It is assumed that customers would supply their own patterns. The majority of castings would be in the 1/2 to 50 lbs. size, but sizes up to one ton are possible.

Details are provided for plant layout and site, building, power, water, fuel, supplies and materials. Direct and indirect labor needs, manufacturing costs, capital costs and sales revenues are projected, while budget operations, engineering, training, and safety are considered. Marketing, economic, legal and financial factor questions are raised, and a financial plan presented.

ferrous scrap, appropriate technology, small scale industry, developing country

513
Plant Requirements to Set Up and Operate a Small Steel Smelting Plant. Prepared by George H. Andrews Engineering Associates, Inc. Washington, D.C., for International Cooperation Administration. Washington, D.C., U.S.A. NTIS #PB 292 869. September, 1957. 26 pages. References.

This report describes a small steel melting plant which manufactures ingots or billets from scrap metal where demand exists and where such an operation would be feasible. For purposes of simplification only ingots were discussed. The market for this plant is a small steel rolling mill to produce bars, and merchant shops.

General assumptions, product specifications, operations, layout, resource requirements and an economic analysis are provided.

ferrous scrap, small scale industry

514
Recycling Poultry Waste as Feed. U.S. Department of Agriculture. Washington, D.C., U.S.A. Series #254. March, 1974. 46 pages. References.

The recycling of dried layer waste (DLW) as feed for livestock and poultry is examined in considerable detail. The cost of pollution abatement associated with alternative poultry waste management systems is also analyzed.

The cost of producing one ton of DLW is $25, $30, and $46 for flock sizes of 80,000, 50,000, and 20,000 respectively. Using available drying systems, farm processing and feeding of DLW does not appear to be economically feasible for the family sized (10,000 layer) operation. However, processing and feeding of DLW may be feasible for larger operations, which attained the highest net returns when DLW was fed as 12.5 percent of the ration.

Cost analysis of the alternative methods of waste abatement show land disposal and anaerobic lagoon treatment to be the least expensive. Mechanical drying, aerobic lagoon treatment, oxidation ditch treatment, and combined anaerobic-aerobic lagoon treatment fall within the intermediate cost range. Composting and incineration are the most expensive.

animal feed, cost analysis, waste recovery

515
Report on Compost Studies at the Pingtung Experimental Plant Organic Wastes Section. Taiwan Institute of Environmental Sanitation. Taipei, Taiwan, China. December, 1959. 39 pages.

This report documents an experimental composting plant constructed in Taiwan, China, in the 1950s to demonstrate feasibility of producing and marketing compost commercially. Technical and economic aspects are presented.

A one year trial was technically successful with 10 tons of organics processed each working day into 6 tons of marketable product. Of the 1,400 tons produced for sale, 400 tons were sold to government agencies and the rest to farmers at $NT40/ton, or US$1.10/ton. The facility operated at a slight loss (20 percent of the total operating cost), which was recoverable if compost price was increased slightly. Conclusions were favorable and resulted in construction of a 25 ton per day facility.

composting; economics; marketing; processing; organics; Taiwan, China

516
Small Brass Foundry. Report prepared for the International Cooperation Administration Office of Industrial Resources Technical Inquiry Service, by George H. Andrews Engineering Associates, Inc. Washington, D.C., U.S.A. (IR-26072-PR) October, 1960. 21 pages. References.

This report provides a general review of factors considered in deciding to establish a small brass foundry. All capital and operational costs are based on U.S. prices and conditions. Adjustments for local conditions must be made. It is assumed that power, water, and transportation are available and that the plant operates eight hours a day, five days a week, 50 weeks a year. Equipment and manufacturing operations are described and pictured.

Copper, aluminum, and nonferrous alloy casting may be substituted for brass production according to the report. The products for brass castings are building hardware such as hinges, hasps and locks. The plant is designed to produce 1,000 pounds of casting in eight hours.

Detail is provided for direct materials and supplies required, plant sites and layout, building specifications, power, water, and fuel needs; tools, equipment, furniture, and fixtures; and direct and indirect labor. Additional financial details include manufacturing overhead and cost, financing, fixed assets, working capital, capital requirements, and

sales revenues. Basic paperwork needed for operations, training, safety, and other work factors are discussed. Institutional factors such as marketing elements, laws, and regulations are also discussed briefly.

appropriate technology, developing country, foundries, nonferrous scrap, recycling

517
Study of Raw Material Costs for a Proposed Strawbased Pulping Mill in the Vicinity of Mobridge, South Dakota. Economic Development Administration. U.S. Department of Commerce. Washington, D.C., U.S.A. 1970. 40 pages.

This document shows that the cost to supply adequate straw and waste paper for a proposed mill in Mobridge would be at a competitve disadvantage to wood based and paper based pulp mills now operating in the midwestern United States and Mexico. Transportation costs of the finished product to market could also work against the mill's success. A study was initiated to see if economic advantage could be gained by using straw, an abundant and relatively little used resource, as a principal ingredient. A 250 ton per day capacity plant producing nine point corrugated medium would require 67,000 tons of straw annually and 60,000 tons of waste paper. Employment would be created for the community.

cost analysis, paper, pulp, waste paper recovery

518 Birkbeck, C.
Self-Employed Proletarians in an Informal Factory: The Case of Cali's Garbage Dump. Journal of World Development. Volume 6, Numbers 9/10. Pages 1173-1185. Pergamon Press. 1978. U.K. References.

This document presents data on the organization of work among the scavengers on the garbage dump in the city of Cali, Colombia. Garbage pickers can be characterized as working for the large industrial buyers of recovered materials, but as not being employed by them. Hence, their activities are organized, but in a special way. There is a certain degree of regularity in the hours and forms of work, and a certain amount of management by the dealers in waste materials. However, the majority of the garbage pickers work independently and are paid on a piece work basis. While this encourages competition, conflict between pickers is surprisingly rare. Garbage pickers have organized themselves to defend their right to work, but for a number of reasons are unlikely to press for improvements in their working conditions.

The author notes that low income workers in the "informal sectors" of LDCs have often been characterized as unskilled, unorganized, unproductive and unenterprising.

At the Cali garbage dump, "factory" workers are nicknamed "vultures" by the rest of Cali's populace--an allusion to the supposedly dirty and undignified work involved in sorting through trash. Yet these workers have very close ties that link garbage picking to industry.

Pickers are part of a recycling network which feed industries in Cali and other cities in Columbia and Ecuador. They are casual laborers, yet retain an illusion of being self employed. They "control" their work hours and habits (although everyone usually must pick during periods when trucks come in), but do not have any say in the critical factor of material prices.

Despite the apparent lack of written rules of overseers, there are internal and external factors which help organize and regulate the work. The above mentioned work hours issue and other informal machanisms have developed that contain the competitive tendencies that inevitably develop under the work conditions and temper the limited autonomy of the scavengers (e.g., no sick leave, social security, etc.).

Formerly the scale and nature of picking was oriented to poor people searching for cutlery, jewelry and clothing which were sold to second hand stores or brought into the low income household. Garbage picking in Cali has now evolved into a materials supply industry.

The work is both productive and efficient, although it is an efficiency based on poverty standards. The price paid to the pickers for waste paper, for example, is but one third the cost of pulp for the paper industry. The income of pickers averages only 80 pesos per day.

Birkbeck describes social conditions of the Cali dump workers. The age distribution of workers ranges from the very young to the old. Nearly half of the children have not gone to school beyond the second year. The length of time spent as a picker varies widely. As a refugee occupation, scavenging supports people with no other opportunities for earning a living. The author notes that many people prefer to "work for themselves" and profess no desire to leave, perhaps because they ard on good terms with a particular truck driver and have continued access to better materials.

The workers have developed skills and entrepreneur's instincts such as getting waste from factories and making new products, excavating for materials buried long ago, elevating themselves into buyers of materials, or starting partnerships and exclusive arrangements with factories.

Despite the conditions and nature of the"piece" work, conflict is very rare and the dump has witnessed impressive attempts at solidarity. There is almost a total lack of robbery of materials. The rest of the city continues to perceive the dump as an evil and lawless place.

Spontaneaous organizations of workers successfully warded off threats to close the dump to pickers by the city. Pickers' organization efforts have been concerned with the right to work, not the conditions of work. The only attempt to improve the terms of work originated outside the dump in the early 1960s by a local charitable foundation. A cooperative of 70 pickers was set up but closed down in the face of external pressure from the large companies and internal adminstrative problems.

Garbage pickers are not unskilled, or unproductive. Still these characterstics of entrepreneurship and innovation have not led, nor are

they likely to lead, to long-term solutions of their livelihood.

Specific policies which could help the workers include forming a permanent organization which would bargain with dealers for better prices and greater access to materials and the introduction of simple machines to improve productivity.

Columbia, community enterprises, economics, informal sector, recycling, scavengers, secondary materials recovery

519 Bromley, R.
Organization, Regulation and Exploitation in the So-Called "Urban Informal Sector": The Street Traders of Cali, Columbia. World Development. Volume 6, Number 9. Pages 1161-1171. Pergamon Press, U.K. References.

Cali's street traders are analyzed in relation to prevailng ideas of the "informal sector," and are shown to have various forms of economic and political organizations. Most traders operate illegally, but official regulation results in containment rather than eradication. Over half the traders are "self employed." The remainder fall into one or both of two increasingly important and potentially exploitative working relationships with larger enterprises: "commission selling" and "dependant working." Official intervention to promote selected small enterprises is highly problematic because of: negative official and elite attitudes; "illegality" of most enterprises; factional self interest of vendors' trade unions; "leakage" of benefits to large enterprises using commission sellers and/or dependent workers; and upward mobility by a favored minority accompanied by worsening conditions for the majority.

Analysis of the informal sector in LDC economies remains an ill defined research frontier between employment research and social pathology. Informal sector principal characteristics--transience, mobility, the lack of an establishment, and the poverty and relatively low education of most of its participants--make research very difficult.

Street traders appear as an important and typical occupation of the informal sector of urban labor markets.

A wide variety of social research methods, includling questionnaire survays, participant and nonparticipant observers, semistructured interviews with officials, leaders and informants, tape recorded life histories, street counts, and newspaper and documentary research were conducted.

The view of the urban informal sector which has been recently institutionalized by the Interantional Labor Office emphasizes the growth potential of small, labor intensive business (Employment, Incomes and Equality, A Strategy for Increasing Productive Employment in Kenya. 1972, Geneva) and recommends major official assistance to this sector.

The small businesses are considered to be independent, unorganized, almost unregulated, little related to authorities or to big

business and essentially honest, legitimate and entrepreneurial. Government and industry practices both support operations in the informal sector and limit the development of entrepreneurial instincts and capacities.

Colombia, informal sector, job creation, labor

520

Croke, K.
Baum, J.
Rosenberg, R.

Municipal Financing of Integrated Community Energy Systems. Argonne National Laboratory. Argonne, Illinois, U.S.A. 1977. 52 pages. Authors at University of Illinois, Chicago, Illinois, U.S.A. References.

The authors document the effects of increased energy costs on the availability of community services. This has created a need for communities to seek new methods of ensuring adequate energy at reasonbly stable prices. One method is the integrated community energy system, which consists of district heating and cooling central heat pumps, solar and coal powered networks, cogeneration and resource recovery.

Advantages and disadvantages of six financing options are examined. These are: municipal general obligation bonds, corporate bonding with guarantees, tax exempt industrial revenue bonds, special revenue bonds, state and federal financial support and formation of municipal joint action agencies.

Resource recovery case studies focus on financing, including amount of financing, facility ownership, repayment schedules, methods of managing revenues, selection of outside consultants, scheduling projects and monitoring projects.

economics, energy recovery, resource recovery

521

Dalzell, H. W.
Gray, K. R.
Biddlestone, A. J.

Composting in Tropical Agriculture. International Institute of Biological Husbandry, Ipswich, U.K. 1981. 36 pages. References.

This report presents economic and technical information on composting processes. Composting is simple in technique, applicable to many agricultural situations in developing countries, and can be conducted with manual labor.

The report is to be used as a manual. It is based on 10 years online experience of the Indian Agricultural Center, Medak and British Compost Studies Group, University of Birmingham. Suitable materials for composting are described. Composting can be done totally by manual labor. However, a high degree of mechanization can be introduced in municipalities

where this would be more appropriate. At present, many of the wastes available in tropical countries are poorly utilized.

An economic analysis of composting concludes that developing countries can make use of lower labor costs and lower transportation costs (animal power). Modification of the farming system to produce and use organic materials can make composting more efficient. It is assumed that three man days are required for the production and spreading of one ton of compost, based on recent experience and equipment outlined in this manual. In considering the supply of the three major nutrients, potash, nitrogen and potassium, compost may compete economically on a nutrient basis with the more concentrated fertilizers. There is little risk if simple procedures are followed. Composting can be carried out at any time and hence can be fitted into slack periods in the farming year.

agriculture, composting, economics

522 Doedens, H.
Feasibility of the Separating Collection (Source Separation) of Recyclable Components in Refuse. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 823-827. E. Freitag--Verlag für Umvelttechnik. 1979. References.

This article covers (1) separate collection of glass at depots; (2) separate collection for single fraction material (fiber--which costs 50 percent more than it returns through revenue); (3) comparison of intergrated and separate collection systems; and (4) recommendations for cities to follow in implementing recovery or collection systems.

A key conclusion concerns the development of recycling. The author finds factors which limit separate collection are not as much as the participation rate of citizens, but more the limited uses for waste derived materials.

The author recommends separate collection only in areas of good markets. Integrated collection makes payback and compensation of savings in diverted disposal costs much easier.

collection, economics, resource recovery, secondary materials recovery, separate collection, solid waste management

523 Flintoff, F.
Solid Wastes Management in Cairo and Alexandra and at Sites and SErvices and Upgrading Projects. Report to Egyptian Arab Republic, and the International Bank for Reconstruction and Development. Essex, .K. December, 1977. 85 pages. References.

This document reports on waste managemet policy in Egypt. Two important factors were identified which must preceed technology transfer and investment: (1) government agencies have to decide on the future role of private collection and disposal contractors and the future form of the

management structure for municipally operated services; and (2) small scale pilot projects should be initiated to determine the applicability and cost of the technology being introduced. This will aid the detailed planning necessary for further capital investment.

In Cairo it was found that although solid wastes were being collected from less than half the population, management attention was focussed on disposal, often involving a high level of mechanization. The state of the Egyptian economy is likely to indicate labor intensive solutions and intermediate technologies. This could be best handled by developing the current infrastructure.

A general review of waste management in Cairo is also presented. Costs methods and current efficiencies are discussed. Factors affecting decisions and policy issues are described, especially with respect to the Zabbaleen or Coptic Christian sect who scavenge and recycle a large amount of urban wastes. Typically, Zarrabs were reported to collect material related to income level as shown below:

Type of Area	Estimated Percent of Waste Collected	Estimated Percent Wastes Thrown onto Streets for Collection by Municipal Services
Wealthy	100	-
Middle Class	95	5
Lower Middle Class	50	50
Low Income Class	-	100

Among technologies considered for upgrading the system, composting receives high priority. Intermediate technology composting plants are preferable to high technology ones. Economic analysis indicated costs of intermediate composting technology are about the same as for high standard landfills and should be studied further.

collection, composting, economics, Egypt, informal sector, institutions, scavengers, solid waste disposal, solid waste management, Zabbaleen

524 LeSieur, H. A.
Appropriate Technology and Scaling Considerations for Developing Nations. Central American University. Jose Simeon Canas (UCA). El Salvador. For U.S. Agency for International Development. Washington, D.C., U.S.A. 45 pages. References.

This paper presents the viewpoint that most chemical engineers have been educated to believe that large scale and high technology are essential for a project's viability. Most do not consider that large economy of scale is not always appropriate, feasible or even possible in developing countries. High technology may be appropriate in certain cases, but more often intermediate or low technology is better, and fits with available resources. Four examples are cited, all based on salvaging

waste or underutilized raw materials for manufacturing food products or fertilizers: (1) banana waste, (2) the discharged sludge from palm oil processing (agricultural residues), (3) pryolytic conversion of rice hulls, logging, coconut, oil palm wastes, rubber and bagasse, and (4) mini fertilizer generator for farm use (the manufacture of modest amounts of fertilizer based on small, low quality phosphate and limestone deposits using alternate energy sources).

Emphasis is placed on "appropriate technology" as a process, rather than a prescribed formula for development. This process involves economic, environmental, and social priorities.

appropriate technology, economics, organics

525 Maung, M.
Composting of Municipal Wastes: UNIDO Experience. Presented at the Food and Agricultural Organization (FAO) of the United Nations Swedish International Development Agency Workshop on the Use of Organic Materials as Fertilizers in Asia. Held in Bangkok, Thailand. 26 October-5 November, 1976. Food and Agriculture Organization. Rome, Italy. 1978. Pages 287-300. References.

This document presents the important findings of municipal waste composting projects of the United Nations' Industrial Development Organization in Bujumbura, Burundi (1969), Conakry, Guinea (1970), Aden, People's Democratic Republic of Yemen (1971), Rabat, and Casablanca, Morocco (1974 and 1975). Technical and managerial problems are considered for sanitary disposal and reclamation of wastes for use in agriculture. A cost benefit analysis is included.

Plant size must be based on the availability and composition of raw materials. In developing countries an annual increase in refuse production is estimated at four percent (2.5 percent population growth and 1.5 percent increase in per capita refuse production, commensurate with the 1.2-1.75 percent per capita increase in GNP which is projected up to 1995). Characteristics of Moroccan municipal waste are contrasted with those of European cities. Differences include LDC to European country ratios as follows: moisture content (66-72 percent to 40 percent), density (.35-.45 to .18-.25), daily per capita production (.45 kilograms to .9 kilograms), and compostable material (range 70-85 percent to 35-55 percent).

For developing countries, the high bulk and low unit value of materials affects plant and choice of process. Quality of product often bears no relation to the degree of sophistication of machinery and process. The author notes that simplicity of plant design and composting process can reduce capital costs, increase labor intensiveness and encourage local production, repair and maintenance of equipment. Adapting composting to deal with the high amounts of organic matter and humidity is stressed.

One finding was that many municipalities are only prepared to pay a competitive price to the compost plant for accepting waste. However, no uniform method for economic evaluation of compost plants has been developed to establish this fee. One possible method is to consider economics on the basis of nutrient content equivalency. For Aden the minimum estimated value in terms of its contribution of nitrogen (1.12 percent) and phosphates (1.02 percent) to the soil is US$21 to US$47 per ton (1975 prices) for equivalent inorganic fertilizers. The value of potassium and other benefits such as improvements in soil structure and water retention, alleviation of the waste disposal problem, foreign exchange savings through reduction of fertilizer imports, creation of employment, etc., are not yet integrated. Another method is to estimate crop yield increments obtained through application of compost. Experience indicates that technical problems such as process adaptation, repair and maintenance of equipment are relatively minor and easily solved problems. There should be provisions for capital and working budgets, selection of plant site, organization of refuse collection to serve the plant, marketing , distribution and application of compost, and division of responsiblity between municipal and agricultural authorities in order to effectively start up a plant.

Composting plants using urban wastes can offer good opportunities for private investors, but assurances from municipal governments as to steady availablity and delivery of waste are critical to assure plant viability.

Urban refuse compost can meet only a small part of a country's fertilizer needs, but may be the only readily available fertilizer. National programs, as in Morocco, possibly with UNIDO's assistance, are recommended.

composting, economics, fertilizers, Middle East, Morocco, organics

526 Moser, C.
The Dual Economy and Marginality Debate and the Contribution of Micro Analysis: Market Sellers in Bogota. Journal of Development and Change. Sage Publications, Ltd., London, U.K. Volume 8. 1977. Pages 465-489. References.

This document discusses the dual economy debate with attention to macro and micro analyses. Itr presents insight into the informal scavenging sector, although it does not directly address that sextor. This document reports on the market system of the Plaza San Juan, Bogota, controlled and administered by the Empressa Distrital de Servicios Publicos, a public corporation responsible for public works such as slaughterhouses, garbage collection, cemeteries, street cleaning and public markets.

Sellers of scavenged waste operate with skill and intiative to build a secure economic base. Yet once recruited into this type of economic activity, few sellers can expand sufficiently beyond a low income level. There is only a minimal level of upward mobility, which empirically contradicts theoretical assumptions made by traditional economic

development analysts. Also, work histories and social characteristics show that sellers consititute a remoarkably stable work force, and are not a floating population of misfits and social outcasts, unwilling to or unable to cope with city life.

These characteristics are common not to a small marginal group in a peripheral urban profession, but are representative of a considerable portion of the working force. Selling, together with other service work, forms the basis of the urban informal sector--poorly paid labor producing the only means of livelihood for a considerable portion of the urban population. A principle constraint on increasing profits is the level of capital resources available to individuals. Sex and age are other critical factors in determining limits of upward mobility. Mobility, when it does occur, is in the direction of lucrative areas of self employment (show ownership and wholesale markets and not unskilled waste employment). Low income sellers provide a valuable service distributing cheap produce to sectors of the population at a cost which would double if the cost of their labor was taken into account. This occupation provides a minimal means of livelihood for those unable to enter the productive labor force. Thus, rather than a marginal occupation, this is an integral part of the urban economy, functioning within the constraints of an unequal exchange relationship with wholesale suppliers and consumers.

Micro studies highlight the internal dynamics of developing country urban economies. The long-term survival of "refugee occupations" is supportive rather than detrimental to the continuance of the existing urban economy.

economics, informal sector, scavengers

527 Neamatalla, M.
Solid Waste Management Practices in Cairo. Report No. 5. Solid Waste Component. First Egypt Urban Development Project. Prepared by Environmental Quality International for Governate of Cairo/Joint Housing Projects Committee/International Development Association. March, 1981. 120 pages.

This study (1) documents current refuse management activities in Cairo, including waste collection and utilization; (2) reports on several phases of a study of waste management practices including waste analysis, collection vehicles, economics of the informal recycling sector (Zabbaleen); and (3) presents data on several pilot projects.

The study focussed on the Zabbaleen waste collection and utilization practices. The ultimate objective of the study was to enable the Zabbaleen to upgrade their settlement at Manshiet Nasser. Ideas to increase productivity and provide better sanitation of waste collection and sorting procedures are detailed.

Economic analysis of the Zabbaleen system as of May 1980 showed that a net revenue of 2.8 LE/daily ton is available to the Zabbaleen. This

value was later used to estimate a "utility fee" to be paid for Zabbaleen service to poor sections of the city.

Egypt, municipal solid waste, scavengers, solid waste management, waste recovery, Zabbaleen

528

Rebong, J.
Elena, A.
Mangiang, M.

The Economics of Scavenging: Obscurity within the Recycling Business. Prisma. Institute for Economic and Social Research, Education and Information. Jakarta, Indonesia. December, 1978. Pages 36-45.

This report describes life among the "undesirables." Daily work activities, the actual pricing of materials, the intermediary agent system, and relations among the scavengers are detailed. In particular, it portrays the infrastructure as the "law of the jungle," interwoven with crime, violence and uncertainty.

The subject of scavengers is one that is repeated in many countries. In Jakarta, scavengers are considered problems and the city officials have attempted to forcibly move them outside the city. This has not been successful. In spite of their lack of status, "undesirables" can earn a fair amount of money and gain access to some segments of society. The authors conclude that scavengers are victims of urbanization who nonetheless contribute to urban economic life.

scavengers, Indonesia, informal sector

529

Rosenberry, P.
Knutson, R.
Harmon, L.

Predicting the Effects of Soil Depletion from Erosion. Journal of Soil and Water Conservation. Volume 35, Number 3. May-June, 1980. Pages 131-134. Soil Conservation Society of America. References.

Research was conducted at the Iowa Agricultural Experiment Station to predict the effects of current levels of soil erosion until 2020, and also to examine six methods of reducing erosion to tolerable levels. A tolerable level of erosion is that amount of land lost during the year which will not affect the sustainable yield.

Using four different crops and test plots, the Station computed the amount of fuel, fertilizer, pesticide and terraces needed to sustain yield. Soil depletion for each of the individual plots was estimated. To measure soil degrading, different soil phases (1-3) were used, with 3 being the worst. Reductions in yields, increases in the amounts of fuel, fertilizer, and pesticides to maintain sustained growth, were definitely tied to the lack of conservation. Almost 50 percent fuel use increase was estimated for a soil that degraded from phase 1 to 3.

For all soils an average cost of US$100 per acre was noted, although the authors caution that the figure may be conservative and could range upwards of several hundred dollars.

agriculture, fertilizers, organics, conservation

530 Shin, K. C.
Possibilities and Limitations of Refuse Treatment for Gaining Raw Materials and Energy. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 26-31. E. Freitag--Verlag für Umwelttechnik. 1979.

Refuse is not "useless" but a valuable, potential source of raw material as described in this paper. Recycling is limited due to environmental and economic factors. In order to create more recycling, legislative and economic measures must be implemented. Legislation involves subsidizing beneficial operations and enacting laws against processes which harm the environment. There needs to be an organized economic system to stabilize markets for "waste products."

Refuse utilization by separation (separate collection, separation with machines in central plants), is discussed. Also discussed are uses for recovered paper, glass, steel, nonferrous metal, and plastics; utilization by conversion (landfill gas, sewer sludge composting, pyrolysis). Factors which limit utilization are examined.

institutional barriers to recycling, organics, waste utilization

531 Shuval, H. I.
Economics of Composting Municipal Refuse. Journal of the Sanitary Engineering Division. Pages 47-56. American Society of Civil Engineers. July, 1962. New York, New York, U.S.A. References.

A preliminary study was made of the economic aspects of two composting plants in Israel operated on a concession basis. One is an existing 50 ton per day enclosed DANO biostabilizer plant in Haifa producing 15,000 cubic meters (m^3) of compost per year or one m^3 of compost for every ton of raw refuse handled. The other is a 500 ton per day plant. It grinds refuse in two stages with equipment manufactured by Dorr-Oliver of Holland and composting is done using open windrows turned every three or four days for a period of approximately three weeks. This plant in Tel Aviv expects to produce approximately 100,000 m^3 of compost per year or 0.7 m^3 of compost for every ton of refuse handled. Cost comparison to incineration is discussed.

The economic analyses point out that compost plants in the U.S. may be in the same cost range as refuse disposal by incinerators. If a market for compost could be developed, even at a nominal price, it could become an economic solution for waste disposal in many American cities.

composting, cost analysis, economic analysis, incineration, Israel

532 Smith, T. E.
Conn, W. D.
Product Durability--Economics and Related Aspects: An Annotated Bibliography. School of Architecture and Urban Planning. University of California. Los Angeles, California, U.S.A. 1976. 28 pages.

This document is an annotated bibliography on product durability. There are 32 citations which are divided into historical aspects, theoretical discussions of durabilty and market structure, theoretical discussions of the demand for durable goods, empirical studies, and policy decisions.

product durability, source reduction

533 Thomas, C.
The Paper Chain: A Report on the Production, Use, Reclamation, and Recycling of Paper in the United Kingdom. Earth Resources Research, Ltd. 40 James Street, London, U.K. 1977. 100 pages. References.

This book presents an overview of papermaking. Topics covered include manufacturing raw material, basic processes, mechanical and chemical pulping, bleaching, sheet making, and sheet properties; environmental impact (raw materials use, water and energy consumption, pollution); economics (world supply, the EEC, Britain); and consumption (quality considerations and consumer attitudes are discussed for a variety of products).

Most waste paper is now used for packaging products. For other paper products only limited amounts of high grade waste paper are used. U.S. experience indicates that using lower grade waste paper is technically feasible to produce writing paper and tissues.

Increased use of lower grade mixed papers requires removal of contaminants and lowering unnecessary quality standards.

Appendix II examines potential production capabilities of smaller paper mills. Recycling of waste paper could be improved by a wider distribution of smaller paper mills.

Intermediate level of production is defined as a range of five tons per day (tpd) to 70 tpd. Less than five tpd is characterized as community workshop technology with very low capital costs. Machinery is available in West Germany, India, and Britain, in the intermediate range. For example, Tomlinson, Ltd. has a less than one tpd capacity pulp packaging unit at a capital cost of 35-40,000 pounds.

Smaller mills generally employ more people per ton of paper produced and the capital cost per workplace is generally lower.

intermediate processing, paper making, resource recovery, United Kingdom, waste paper recovery

534 Tichenor, R.
Economics of a Small Rural Town Recycling System: Implications of a Case Study. University of New Hampshire. Durham, New Hampshire, U.S.A. 1976. 42 pages. References.

This report examines an intermediate processing plant in a rural town. It provides input requirements and corresponding cost and capacity limitations; waste characteristics data; and household attitudes toward separation at source.

For the plant, estimated input requirements are smallest (and thus, processing cost per ton is the lowest and capacity the largest) for glass, followed by newspaper, tincan, mixed paper, cardboard, and aluminum. Bases on average daily weight, over 50 percent of the source separated waste from sample households is made up of the above categories of recycled materials. Less than one fifth of the survey sample were opposed to the source separations system, and less than one fourth reported problems with source separation. More than half of the respondents reporting problems were still in favor of the system.

Data are presented for energy and labor costs, hourly requirements and combined requirements per ton. The results show that (1) glass, newspaper, steel cans, and mixed paper achieved greater efficiency than cardboard and aluminum based on labor wage rates and on comparative weights; (2) glass and newspaper were more efficient to recover based on tonnages to electrical rates; and (3) annual production was consistent with both of the above indices.

community enterprises, cost analysis, household wastes, recycling, resource recovery, solid waste disposal, source separation, waste composition

535 Ullman, B.
Recycling in Israel: The Potential of Secondary Resources. Israel Institute of Technology. Technion City, Haifa, Israel. October, 1980. 30 pages. PN 06/111/80. References.

This working paper is part of a project series on "Mineral Resources in Israel's Future." Israel does not have the natural resources to sustain its level of economic growth without some dependence on foreign supplies.

Secondary resources are described as an essential material base for many necessary consumer items. Nearly nine million tons of wastes were generated in the country during 1980 with mineral, industrial, domestic and agricultural sectors responsible for 45 percent, 10 percent, 13 percent and 32 percent, respectively. Only 19 percent of the industrial wastes are recovered and the other sectors show lower rates.

The author presents data that show US$130 million may be saved in imports by recycling. He believes that recycling will not happen on its own and advocates specific measures for promotion: (1) removing discriminating tax measures; (2) stringently enforcing environmental

regulations; (3) encouraging product design for recyclability and durability; (4) giving research allowances to industry involved in recycling; (5) using pollution charges; (6) creating trade forums and material exchanges; (7) developing source separation programs; and (8) providing incentives for returnable goods.

glass, Israel, metals, paper, recycling, secondary materials recovery

Environmental Aspects

601 Anderson, A.
Influence of Organic Fertilizers On the Solubility and Availability to Plants of Heavy Metals in Soils, Department of Soil Sciences. Grundfor Battring. Uppsala, Sweden. Volume 27, Number 4. Swedish University of Agricultural Sciences. 1975/6.
Pages 159-164. References.

This document reports results of laboratory and field experiments of organic fertilizers on the solubility and availability to plants of heavy metals including: manganese, zinc, copper, nickel, cobalt, chromium, lead, aluminum, mercury. Test plots received applications of compost derived from solid waste and anaerobically digested sewage sludge and manure.

It was found that organic fertilizers added to soils under certain circumstances may reduce the solubility and uptake in plants of heavy metals, despite high levels of them. Effects seem to be particularly strong in the case of lead.

Whether the solubility and availability to plants are reduced or not depends on chemical conditions affected by the organic matter of the fertilizer and the total quantity of heavy metals.

composting, heavy metal uptake, fertilizers, testing methods

602
Regional Symposium on Solid Wastes, Santo. Boletin de la Oficina Sanitaria Panamericana. Volume LXXIV, Number 5, Mayo 1978. Pan American Health Organization. Washington, D.C., U.S.A. 1978. 250 pages. References.

This document is composed of papers discussing trends in solid waste management written by technical experts and planners. Socioeconomic and environmental health implications of solid waste management are discussed. Technical descriptions of collection, processing, incineration, and sanitary landfill are discussed on a country and city basis, including case studies. Composting, materials recovery, and energy recovery projects are described. Institutional development and planning case studies are presented.

Inadequate solid waste management practices are viewed as a growing threat to public health and the environment. Adequately funded collection and disposal services are a necessary development. Pretreatment processes (compaction, shredding, incineration, transfer) are described as suitable in combination with energy recovery and final disposal in sanitary landfills. Energy recovery technologies (waterwall incineration, coal substitute, pyrolysis and small modular incinerations) could only be used after careful study because of them are still being developed. Composting processes also must be carefully studied for success and failure rates.

Commercial recycling of source separated industrial wastes is encouraged. Scavenging is discouraged due to its "high social cost."

Institutional development of local service agencies/corporations must be a major focus of any planning effort. A program to establish a national policy for solid waste management is presented.

solid waste management, Latin America, developing country

603
Sanitary Effects of Urban Garbage and Night Soil Composting in China Compost Science. Rodale Press, Emaus, Pennsylvania, U.S.A. Volume 18, Number 2. March/April, 1977. Pages 22-24. (Reprinted from Chinese Medical Journal. Volume 1. Number 6, November, 1975. Pages 407-412).

This report was prepared by the Department of Environmental Health, Institute of Health, Chinese Academy of Medical Sciences, Beijing,People's Republic of China on the sanitary effects of co-composting.

Co-composting is a simple method of garbage and night soil disposal. To evaluate its sanitary effects, one has to choose certain biological factors characteristic of composting. On the basis of practical observations and relevant data in the literature, the pile temperature, fly breeding and destruction of ascaris eggs were taken as important criteria for this evaluation, because they are representative and specific and require relatively simple testing procedures.

Two types of compost piles were used in the experiment. One compost pile consisted of 70 to 80 percent garbage and 20 to 30 percent night soil (by weight) with adequate mixing. The mixture was heaped in piles about 4 meters wide at the base, 2 meters wide at the top, 1.5 meters high and about 4 meters long. After piling about 30 cm high, sets of bamboo poles were laid horizontally on the pile in this form at every 1.5 to 2 meters, each set connected at the center with a bamboo pole held vertically. On completion, the pile was sealed with a 2 to 3 cm thick coat of 40 percent soil and 50 percent ash mixed with water. The day after piling, the bamboo poles were withdrawn, leaving flues for ventilation. The other type of compost pile had no flues. Eight piles were observed, the 4th, 5th and 8th with ventilation flues and the other five without.

High temperature fermentation was obtained when moisture content of the garbage and night soil mixture reached about 40 percent. Generally, compost pile temperature rose to over 50°C after 5 to 7 days. Also, the moisture content decreased gradually. On the 105th day, it dropped to 20 to 23 percent in all 8 compost piles. The directly available nitrogen content and total nitrogen content of the 8 piles during composting showed slight nitrogen loss in all piles during composting, probably because the piles were small and unsheltered.

The coliform bacilli and ascaris eggs were effectively destroyed. Maggots died rapidly at 50°C. Pupae survived and newly emerged adult flies were seen around ventilation holes. Biolytic heat produced in a given part of the compost pile often drove maggots to regions of lower temperature to complete their life cycle.

The newborn flies, too feeble to fly at once, were easily destroyed with a small amount of insecticide. Buried test samples containing bacillus dysenteriae and bacillus typhi were destroyed in laboratory conditions (uniform temperature in compost pile).

Garbage from the city of Beijing contained more ash and less organic material exhibiting low moisture content and nutrients needed by microorganisms. Since highly effective composting calls for proper control of moisture content, pH, ventilation and C/N ratio, it was necessary to add night soil to it. Experiments showed that a 40 percent moisture content gave better results with predominantly ashy garbage.

A pile temperature of 50-55°C is sufficient to accelerate putrefaction and ensure hygienic safety. Experience provide pile temperature can rise above 50°C, when basic composting conditions are strictly observed.

Activities centered on the extermination of pests and eradiction of disease. Sanitary control and proper disposal of garbage and night soil were among the basic measures taken to eliminate fly breeding.

organics, composting, health and safety, China

604
Selected Bibliographies and State of the Art Review for Environmental Health. International Health Planning Reference Series 2, PB80-18342. United States Department of Health, Education and Welfare. Prepared by Plog, Inc. for U.S. AID. Washington, D.C., U.S.A. (no date). 182 pages.

This combined literature review and annotated bibliography deals with environmental factors in health planning for developing countries. This is the second volume in a series of works known collectively as the International Health Planning Reference Series.

The Series was produced by the Office of International Health as requested by the Agency for International Development to provide AID advisors and national health officials in developing countries with critically needed references for incorporating health planning into national plans for economic development.

The literature in the field of environmental health is massive. For the purposes of this literature review and bibliography, the research focused primarily on the areas of clean water supply, wastewater and excreta disposal, treatment of disposal of solid wastes, and pest control including the use of pesticides.

Additionally, environmental health hazards were included on occupational health, radiation, air quality, food, sanitation, and housing issues relating to environmental health.

health and safety, solid waste

605
Solid Wastes Disposal and Control. World Health Organization. Technical Report Series No. 484. Geneva, Switzerland. 1971. 31 pages. References.

Solid waste management is detailed in this report. The effects of solid wastes on health and welfare are evaluated and special problems associated with developing and industrialized countries are discussed. The present knowledge and technology regarding sources, handling, treatment, recycling and final disposal are described. The planning and operation of solid waste systems are detailed and guidelines for policy and action are provided.

solid waste management, health and safety, developing country, waste composition

606 Bundi, U.
Wasmer, H. R.

Recycling: Fundamentals and Concepts. Journal of the International Solid Wastes and Public Cleansing Association. Number 18. International Solid Wastes and Public Cleansing Association. April, 1976. Zurich, Switzerland. References.

The theme of this paper is that the conversion of refuse to energy is just one aspect of recycling. Decisions concerning energy recovery can be reached only if viewed within a broad framework of overall energy and recycling problems. Correlations need to be drawn between the use of resources, environmental protection, economic, political and legal issues. Both national and international levels should be considered.

Recycling always raises the question of energy, eve if energy is not generated directly. A strategy is presented on how to reach a decision between recycling for energy or the material value.

In the past, recycling was mostly industrial and based on financial considerations to lower production costs, and as a source of additional income. Today it is seen as a way to reduce waste in the environment and preserve dwindling resources for everyone.

A comparison between initial mining and recycling is presented. Three major point are considered: conservation of natural resources, reduction of energy consumption, and reduction of wastes.

An international framework for decision-making is presented. The report concludes that the effects of recycling are limited (1) when resources are used in a dissipative way; (2) when it is conducted where clearly uneconomical or impractical; and (3) where due to growing consumption, only a fraction of the resources needed can be covered by recycling and benefits gained through recycling will soon be offset.

energy recovery, recycling, conservation, government policy

607 Conner, M. A.

Modern Technology for Recovering Energy and Materials from Urban Wastes--Its Applicability in Developing Countries. Conservation and Recycling. Pergamon Press. U.K. Volume 2. 1978. Pages 85-93.

This report examines three countries, Kenya, India and South Africa, which vary in population density, degree of urbanization, extent of industrialization and availability of domestic energy resources. For each of these countries the energy supply, use and distribution patterns, as well as current refuse disposal practices are described in this article. The future use of various refuse treatment methods, particularly those involving energy recovery, is examined for each country. The conclusions are generalized and applied to developing countries as a group.

The most important conclusion reached is that the use of high technology for refuse processing in developing countries is limited. Three of the main reasons for this are:

(1) High technology has been developed in areas where labor is generally expensive or organized and capital readily available. They are usually not appropriate for developing countries where capital is usually scarce, unemployment often severe and labor is cheap.

(2) In developing countries, a project's priority as far as the allocation of capital is concerned usually depends on the extent to which it contributes to providing employment, developing resources and infrastructure, and providing basic facilities needed by the usually rapidly growing population. Under such circumstances applications to introduce high technology methods of refuse disposal are likely to be assigned very low priorities.

(3) In most developing countries cheap disposal of refuse on the land is still possible. There is therefore little incentive for local authorities to invest in capital intensive and largely unproven technology.

Two methods of refuse disposal (other than disposal on the land) are presented. These are composting and the use of refuse as a supplementary fuel. Both of these methods are relevant to problems in developing countries: composting provides a soil conditioner which can improve soils deficient in organic matter, and use of refuse as a supplementary fuel can reduce pressure on resource development.

composting, government policy, technology, fuel, energy recovery, India, Kenya, South Africa

608 Gerretsen, F. C.
On the Content and Value of Trace Elements in Urban Refuse Compost. International Research Group on Refuse Disposal Information Bulletins. References. Sekretariat: Eidg. Anstalt Für Wasserversdrugung Abwasserinigung und Gewasserschultz, Zurich, Switzerland.

Although urban refuse compost is valued chiefly for its organic content, it also contains numerous trace elements indispensable to normal plant growth. A single application of compost may be valuable for many years, especially in soils which are deificient in one or more trace elements or possessing them in a form not assimilated by plants. This report discusses numerous investigations in which trace elements are shown to be components of most enzymes. Manganese, for example, was found to be a component part of at least 13 enzymes.

Boron has special significance for those parts of the plant in which intensive cell division occurs. Plants become stunted or even die due to lack of boron.

Higher plants do not grow without copper. Wheat, oats, peas, and beets and carrots require more copper than such plants as buckwheat and serradella (European legume). The so-called "cultivation disease" (Urbarmachung-Skrankheit) is found not only on newly cultivated heath soils but also in older humus-rich sandy soils in which copper is in insoluble combination, and difficult to assimilate. It has been shown repeatedly in the Netherlands that a copper deficiency can occur without characteristic external evidence accompanying it. In such cases, application of copper sulfate or urban refuse compost results in considerable yield increases.

Molybdenum is important in the plants' assimilation of nitrogen from nitrates and in the enzymatic reduction to ammonia as the first step in protein formation. The element is also important in the fixation of atmospheric nitrogen into bacterial proteins by means of Azotobacter and other N-fixing bacteria.

Zinc is a vital trace element for legumes, grains, onions, and other plants, particularly horticultural plants. The great success with the use of one application of VAM compost in a few orchards in Wijster, resulting in 15% greater yields than plots receiving only fertilization, is likewise ascribed in part to the addition of trace elements. Deficiency in Zinc has been found to inhibit the formation of auxins (growth substances) and of chlorophyll. The term "zinc-yellow disease" (zinkgelbsucht) has been coined.

The Laboratory for Microbiology, State University, Groningen, Netherlands, determines various trace elements, in soils and plant materials, by the aspergillus method. Chemical analysis, using complex ions, is a new method which determines trace elements. The mycelial weight of the fungus aspergillus is closely related to the amount of magnesium, zinc, molybdenum, iron, and manganese contained in the nutrient medium. Spore color varies from black through brown to yellow and white, according to the copper content. Trace elements in minute amounts can be detected by

this method. Limits of analysis are 0.2 to 15 millionths of a gram for copper, and about 0.001 millionths of a gram for molybdenum.

Amounts of trace elements always vary in summer and winter compost. Results show that compost is not only a valuable organic manure but can supply plants with inorganic nutrients, resulting in increased yields in many cases, even where no trace element deficiency is suspected. A single application of compost provides a whole series of trace elements without risking yield reductions by trace element deficiencies.

agriculture, composting, crop yields, land application, municiple waste, nutrients, soil amendment

609 Giordano, P. M.
Movtvedt, J. J.
Mays, D. A.

Effect of Municipal Wastes on Crop Yields and Uptake of Heavy Metals. Journal of Environmental Quality. Volume 4, Number 3. Pages 394-399. American Society of Agronomy, Crop Science Society of Wisconsin, U.S.A. References.

In test situations, application of rather high rates of garbage compost and sewage sludge resulted in increased yields of corn although tissue concentrations of several heavy metals were higher. In contrast, sludge treated plots had lower yields of beans, possibly due to the greater sensitivity of beans to zinc. Although no differences in zinc solubility were detected, plant concentrations of zinc were always higher with sludge.

Repeated applications of waste products no not necessarily result in proportionally higher concentrations of heavy metals in plants, but the potential for toxicity still exists.

heavy metals uptake, health and safety, organics, composting

610 Gunn, T. L.

The Energy Optimal Use of Waste Paper. Energy Research Group. University of Illinois at Urbana-Champaign. Urbana, Illinois, U.S.A. 1978. 177 pages. References.

Mixed and other grades of waste paper can be burned as a fuel or used as a feedstock material. This document discusses burning and recycling waste paper to minimize energy use. The study was done in the U.S. in 1974.

Five cases are analyzed as to how the energy in wood and paper are treated. In one case, both wood and paper are assumed to have an energy value. In another, neither wood nor paper is assumed to have an energy value. In the other three cases, paper, but not wood, is assumed to have energy value which is utilized differently in each case. It was found in all cases that as much highgrade de-inking waste paper as can be

collected should be recycled. How much of the other grades of waste paper could be recycled depends on which of the various energy accounting schemes is used. The greatest energy savings are accomplished when both wood and waste paper are acknowledged to have an energy value. The greatest energy savings attainable in any case would be 30 percent of the energy actually used by the system. A government tax credit program was advocated to stimulate new capacity to produce recycled paper and to encourage the use of wood as a fuel.

Energy savings data are detailed in 11 technical appendices including paper recycling, energy conservation, paper manufacturing, energy recovery.

waste paper recovery, energy savings

611 Hannon, B. M.
System Energy and Recycling: A Study of the Beverage Industry. Center for Advanced Computation. University of Illinois at Urbana-Champaign. Urbana, Illinois, U.S.A. 1973. 39 pages. References.

An energy analysis was done on containers for soft drinks, beer and milk. The study shows that the energy required to deliver a unit of beverage to the consumer is about three times more in throwaway glass containers than in returnable bottles or bimetallic cans. The energy cost of recycling glass (collecting, separating and remelting) is less than the comparable cost of mining materials for new bottles. All aluminum cans are about 38 percent more energy intensive than bimetallic cans. Retail costs are about 30 percent more for soft drink throwaways, and slightly higher if litter and solid waste disposal costs are added.

If the beverage industry were converted entirely to returnable containers, the 1970 container system energy, which accounts for 0.48 percent of the total U.S. energy demand, would be reduced by about 40 percent. The energy savings in 1970 would have supplied the total electrical needs for Washington, D.C. Pittsburgh, San Francisco and Boston for about 5 months, or about 30 billion kilowatt hours.

An economic and labor study in the beverage industry was made for Illinois. If returnables were totally used, consumers would save 75 million dollars and a net increase of 1,500 jobs would result. Although jobs would be lost in the steel and container industries, more lower paid jobs would be created at the wholesale and retail levels.

Extrapolating data to the national level implies an increase of 130,000 jobs and an increase in consumer savings of US$1.4 billion. If the savings developed and the consumer spent the savings on average personal consumption, then about half of the estimated energy savings or 15 billion kilowatt hours would be realized.

To complete this study, it was necessary to examine the metal, paper, glass and plastics industries in considerable detail. Energy ratios

(energy used in returnables [15 fills] vs. throwaway) were calculated for varying container materials. A summary of the energy calculations derived in this report is presented.

This document provides a quantitative method for analyzing complex industrial-commercial-environmental problems.

energy, returnable containers, job creation, conservation

612 Kinako, P. D. S.
City Refuse Dumps: A Multi-Dimensional Environmental Problem of Nigerian Urban Areas. Journal of Environmental Management. Academic Press, Ltd., London, U.K. Volume 9, Number 3. November, 1979. Pages 205-212. References.

This document is a report on the roadside dumps common in Nigerian cities. Using Port Harcourt as the focus of the study, an environmental survey was conducted which determined that there is an average of 7 refuse dumps per km of road. The situation is described as critical. The dumps are breeding grounds for rats, flies, cockroaches and mosquitoes. In addition, the dumps block gutters and streets, causing serious flooding during the rainy season. Recommendations to improve the solid waste management system include new taxes, establishing transit depots where householders would bring their refuse, and educating the communities to recognize the scope and urgency of the problem.

Nigeria, city refuse dumps, health and safety, pollution, solid waste management, raw refuse factor, transit depots

613 Kurihara, K.
The Use of Industrial and Municipal Wastes as Organic Fertilizer. United Nations/Swedish Industrial Development Organization. Workshop on the Use of Organic Materials as Fertilizers in Asia, held in Bangkok, Thailand. 26 October-5 November, 1976. Food and Agriculture Organization. Rome, Italy. 1978. 18 pages. References.

This document reports that municipal wastes contain not only essential plant nutrients but toxic substances, including heavy metals and organic compounds. If it is not possible to eliminate these harmful compounds by pretreatment, special attention must be paid to land application rates on food chain rates of application on crops. The three most important criteria concerning municipal wastes are: (1) to ensure an absence of substances that are injurious to the environment; (2) to maintain high content of organic matter and plant nutrients; and (3) to lower content of its undesirable substances. The important consideration that limits the land application rate for sludge is its high nitrogen content. Excessive use might result in fewer crops due to salt injury and ammonia physiological toxicity, as well as the pollution of water by nitrate nitrogen.

More than 30 composting plants were constructed and operated in relatively small cities in Japan in 1963. In recent years, construction has slowed due to a failure to make composting an accepted disposal method for urban wastes. Factors include government policy to increase incineration as the disposal method, marketing (farmers' refusal of product due to unwelcome and dangerous ingredients such as glass, plastic, and metal, and insufficient maturity of product for direct application to crop land), economic aspects (the economic imbalance between production costs and sale prices) and institutional lacks (no education by agricultural researchers and authorities concerning the value of compost).

Only seven plants remain producing 20,000 tons of compost annually, or one percent of the total urban waste generated. Renewed efforts are being initiated by private and government agencies to overcome the problems. The National Institute of Agricultural Science, Tokyo, has begun a study in conjunction with the government to compare the properties of chemical constituents of municipal compost. Preliminary findings of unwelcome substances, including toxic heavy metals, are presented. It is emphasized that in order to use urban wastes as fertilizers their heavy metal content needs to be reduced.

composting, Japan, hazardous wastes, fertilizers, government policy, municipal wastes, nutrients

614 Kusik, C.
Kenahan, C. B.

Energy Use Patterns for Metal Recycling. U.S. Department of the Interior. Bureau of Mines. IC 8781. Washington, D.C., U.S.A. 182 pages. References.

This study, conducted for the United States Department of the Interior, Bureau of Mines, provides data intended to increase the recycling of selected metals. Data were collected on energy requirements to recycle prompt (in plant) industrial and obsolete (post consumer) scrap for nine metal commodities: iron/steel, aluminum, copper, lead, nickel alloys, zinc, titanium, tin and stainless steel. Process routing for recycling was considered beginning with collection through enduse smelting equivalent to a primary metal. Energy balances for scrap reprocessing were detailed.

ferrous/non ferrous recovery

615 Love, P.

Net Energy Savings from Solid Waste Management Options. Solid Waste Management Branch, Environment. Canada. Toronto, Canada. 1976. 26 pages. References.

This document addresses the energy balance of different solid waste management options. Specifically, will energy be saved by using agiven ton of waste paper as an input in production rather than disposing of that ton through energy recovery or landfill?

An essential difference between solid waste management systems lies in their treatment of the large paper component. The study reveals that in the majority of cases considered for southern Ontario, net energy savings are attributed to recycling waste paper rather than using it as a source of energy. The following energy cost factors were considered: paper reclamation, wood harvesting, transportation, disposal, paper production, energy values of wood and paper, net savings from waste paper reuse.

It was also found that recycling waste paper could result in a net decrease in air and water pollution. Energy savings attributable to reducing of solid waste generation at the source are presented. Packaging reduction, for example, could have conserved 40.68 millions BTUs in Canada, had measures been in place in 1975.

Findings are expected to assist solid waste management decision makers to choose options that would have positive effects on macro level natural resource utilization, labor, capital, pollution and product quality issues.

waste paper recovery, energy savings, solid waste management, Canada

616 Nagar, B. R.
Energy Crisis, Food Crisis, Desertification and Organic Recycling. Journal of Scientific and Industrial Research. Volume 40, Number 3, 1981. Pages 147-208. Council of Scientific and Industrial Research. New Delhi, India. Author at School of Environmental Sciences, Jawaharial Nehru University, New Delhi. References.

This article presents organic recycling as a partial solution to the pending energy, food and desertification crises. Estimates based on current consumption, growth and energy price increases indicate that developing countries could be facing a sixfold increase in costs.

World Bank data show the potential for worldwide organic recycling has a total value of $20 billion (U.S.). Citing a documented shortfall in India for replacing organic constituents, the development of organic composting and other programs becomes very important.

A new strategy is presented. It includes selected agricultural program initiatives with increasing use of compost, biomass systems, and sewage sludge. A holistic, cooperative view of the problems and solutions to the world crisis is recommended.

organics, recycling, fertilizers, composting, economics, sludge, environmental management, India

617 Neudecker, Ch.
Toxicological Long-Term Feeding Studies on Carrots Cultivated with Composted Garbage and Sewage Sludge. (Langzeit-Tierfutterungsversuchzur Toxikologischen Prufung Mullklarschlammkompost-Degungter Mohren.) Qualitas Plantarum: Plant Foods for Human Nutrition. Volume 28. Number 2, 1978. Pages 119-134. Dr. W. Junk Publishers. Hague, Netherlands. Exhibits. References.

It has been reported that high levels of toxic heavy metals and carcinogenic substances (3,4-benzpyrene) can be present in composted garbage and sewage sludge. A long-term four generation study using over 900 Sprague-Dawley rats was performed to ascertain whether carrots cultivated with composted garbage and sewage sludge (MKK) induce toxic or carginogenic effects. The annual intake per rat was 3.6-5.0 kg carrots containing approximately 1 ppb benzpyrene. Four groups of rats were fed the following diets: Commercial (Altromin) diet (standard group, A); Altromin and untreated carrots (control group, B); Altromin and MKK-treated carrots(test group, C); Altromin and 10 ug 3,4-benzpyrene administered weekly to females (comparative group D). The level of benzpyrene in diet D was 25-30 times higher than in diets A, B and C. The parameters studied include food intake, body weight gain, fertility, reproductive performance, organ weights, average lifespan and tumor incidence.

After 28 months (F1 generation) and 24 months (f2 generation) no increased carcinogenic or chronic toxic effects were noted in the test animals fed carrots cultivated with composted garbage and sewage sludge in their diets compared to the control groups. No significant increase in tumour incidence was noted in the female rats (group D) fed additional benzpyrene.

health and safety, composting, sludge, heavy metal uptake

618 Ospina, F.
Final Disposal of Solid Waste in Medellin: Another Aspect of Environmental contamination. (Disposicion Final de las Basuras de Medellin: Otro Aspecto de la Contaminacion Ambiental.) Empressas Varias. Medellin, Colombia. 1975. 23 pages. References.

This document is a report to the Mayor of Medellin and the directors of a local municipal sanitation corporation. It outlines a recommended study and project goals to solve pressing problems of solid waste disposal and environmental pollution.

Approaches to solid waste managment are traced from 1955 to 1975. Population growth, economic development, and rising per capita income are correlated to an increasing solid waste problem. Dumping of untreated waste into the Medellin River and at the central city dump have led to air and water pollution and apparently contributed to the spread of disease. About 500 scavengers work at the two dumps recovering materials.Children, women and men comprise 36 percent, 14 percent and 50 percent of the workforce, respectively. Several cooperative organizations have been formed.

A 180 ton per day compost plant was started in the early 1970s but never became operational. The city dump is rapidly reaching capacity limits.

Possible solutions include incineration, composting and sanitary landfill which are not necessarily mutually exclusive. The preferred approach is to integrate the interests of the scavengers into the future solid waste management system. A solution is urgently needed, as the solid waste and contamination problems are directly affecting the quality of life in Medellin and the Aburra Valley.

Colombia, city refuse dumps, solid waste management

619 Sotomayor, I. R.
Solid Waste Compost as a Source of Organic Fertilization Compared with Chemical Fertilizer. (Compost de Basura como Fuente de Fertilizacion Organica Comparado con Fertilizante Quimico.) Agricultura Technica. Pages 152-157. October-December, 1979. Santiago, Chile. Exhibits. References.

Chemical fertilizers have replaced organic materials as the primary source of nutrients owing to improved short-term effects on cultivation. Organic farming enthusiasts have advocated increased use of organic fertilizers which they contend improve soil productivity over the long term. A permanent field experiment was undertaken between 1971 and 1975 at La Platina Experimental Station, close to Santiago, Chile, to evaluate the efficiency of mineral versus organic nutrition in terms of soil productivity.

Several vegetables were intensively cultivated using either urea and superphosphate (the mineral fertilizers) or composted solid waste (the organic fertilizer). Previously cultivated and unfertilized land was used. Two doses of nitrogen (200 and 400 kg/hectare/year) were used from either of the two sources, thus providing four different combinations.

The principal conclusion reached after the first four year cycle was that the anticipated accumulated effect of the organic materials did not manifest itself during the continuous use test. Mineral fertilizer proved a superior fertilizer. All high dose treatments for each fertilizer type yielded better results than low dose ones.

fertilizers, composting, Latin America, solid waste

620 Webber, L. R.
Incorporation of Nonsegregated, Noncomposted Solid Waste and Soil Properties. Journal of Environmental Quality. American Society of Agronomy. Madison, Wisconsin, U.S.A. Volume 7, Number 3. 1978. Pages 397-400. References.

Field experiments were conducted in Guelph, Ontario, to determine the effects of applying as much as 376 metric tons/hectare of raw, non-segregated, shredded solid waste plus 4.6 cm of anaerobically digested

sewage sludge on soil. Physical properties, soil nitrogen and carbon, and the yield of corn were examined.

Shredded waste and sewage sludge were applied to plots in July, 1971 and again in August, 1973. Corn was grown in 1972, 1974, 1975, and 1976 with chemical fertilizer being applied the last two years. Physical determination were made on soil samples collected prior to corn planting in 1976.

Soil carbon and nitrogen and water-stable aggregation increased, while bulk density decreased with increments of solid waste added. Soil moisture, expressed volumetrically (cm^3/cm^3) and retained at pressures of 0.04, 0.33, and 15 bars and available water, was not significantly affected by waste additions. No consistent relationship appeared to exist between kinds and amounts of wastes added and corn grain yields for four harvestings.

solid waste, nutrients, soil amendment, sludge

621

Zobac, J.
Zubr, J.

Agronomical Effectiveness of Commercially Produced Composts. (Agronomicka Ucinnost Prumyslovych Kompostu.) Hostlivna Vyroba. Volume 23, Number 9. Prague, Czechoslovakia. Pages 977-984. 1977. References.

A field experiment was performed on soil at the Brilice Station, Czechoslovakia between 1972-1976 to study the effects of applying composted household wastes and pig slurry to land in separate application or in combination with organomineral fertilizers. Rotated crops (beans, winter wheat, and spring barley) were tested. All variations were found to exert a positive influence upon the agrochemical properties of soil, on gross production, dry matter yield, uptake, and utilization. In separate applications, excellent results were obtained with composted household wastes. Combined organomineral fertilizers and compost showed no statisticaly significant differences from that in the organomineral dressing with compost from household wastes and pig slurry. Increasing application rates of commercial fertilizers above 52 kg for Nitrogen, 48 kg Phosphorus, and 96 kg for Potassium per hectare with organic fertilizers did not show any increased yield. This was probably due to plant limitations on uptake.

fertilizers, Czechoslovakia, composting

Cultural Aspects

701 Keyes, S. J.
Keyes, W. J.

Manila Scavengers: The Struggle for Urban Survival. Institute of Philippine Culture, Poverty Research Series No. 1. Manila University. Quezon City, Philippines. 1974. 51 pages. References.

This study is part of the urbanization, poverty and population policy research sponsored by the Asia Foundation in Tokyo, Japan. Scavenging is seen as an occupation symbolic of mass poverty in Manila neighborhoods. Research was oriented to both social-anthropological and economic questions; e.g., the adaptiveness of scavengers to variable market factors in the larger industrial economy; the comparative distribution of the economic benefits to scavengers, middle agents and factories.

Based on experiences in the Barrio Maligamgam, Sampaloo, scavenging reflects the basic human instinct for survival amidst high urban unemployment. Scavengers earn a borderline subsistence. Income is constrained by competition for materials by other small businesses, absence of leverage within the market place, unsympathetic government policies and lack of responsibility on the part of manufacturers to their scavenger/suppliers.

The report focuses on the actual path of scrap paper from scavengers, and through middle agents, to factories. Group and personal profiles, from each level, are based on interviews which highlight generalized findings. Daily work schedules, material values, industrial and labor relations and earnings as well as attitudes and aspirations are documented. Typically, a scavenger wants to move on to other, particulary formal full time occupations.

As long as urban poverty exists, the authors conclude, scavenging should be recognized as an industrial occupation. Changed social policy toward scavengers requires increased consciousness among the economically powerful. Practical and immediate changes include ending government prohibitions and restrictions on scavenger activity. Business policy toward the "scavenging problem" could recognize benefits of feedstock supply and pay for appropriate social costs.

Progressive thinking manufacturers could benefit from broadening their area of responsibility toward scavengers.

scavengers, Philippines, economic analysis, government policy, informal sector

702 Lowe, R. A.
Lee, C. S.

Proposed Composting Strategy. City of Seattle, Washington, U.S.A. Recycling and Resource Recovery Program. January, 1980. References.

After a brief review of the composting process, this document describes and evaluates three types of projects.: backyard, neighborhood and centralized composting.

Backyard composting may be cost effective for the individual homeowner and provide valuable soil enrichers for gardens. If not properly maintained, there can be problems with odors, vermin, and flies.

Neighborhood composting is carried out by residents taking their wastes to a central location and operating the project cooperatively. Advantages include a practical education for individuals and a medium for developing community spirit. Disadvantages include lack of organizing information, individuals dropping out of the program, and more difficulty in maintaining quality control.

Centralized composting involves a four step process of separation of compostables from waste, chipping, composting, and marketing. Advantages include service to citizens who can't compost and the capability to handle a wider range of feedstocks. Disadvantages include increased difficulty in maintaining quality control and the continuing need to haul waste to a central location.

A priority list is developed in the order of home, neighborhood, and central (if feasible) operation for the city of Seattle. Strategies for implementation emphasize public information, education, and market development.

composting, United States, community enterprises

703 Overby, C. M.

Remanufacturability and Repairability of Durable Products; Technology More Appropriate for Both Developed and Developing Countries. Presented at International Symposium of Engineering Technology Appropriate to Underdeveloped Countries. Jose Simeon Conas University. San Salvador. February, 1979. 42 pages. References.

This document explores remanufacturing and repairability for durable goods. Remanufacturability and repairability are important design criteria for both LDCs and DCs now facing resource and environmental constraints. Materials and energy are conserved and waste and pollution are reduced. Remanufacturing and repairing are more labor intensive than equipment manufacturing, and have obvious job creating potential. An overview of contemporary remanufacturing is presented. Questions from both public and private perspectives are presented. There are some indications of increased activity and interest in several countries. Much study and analysis remains to be done, however. If developed countries, driven by

resource and environmental constraints, were to produce durable goods that could be remanufactured and repaired in greater numbers, this technology model could be followed by developing countries.

Products designed with remanufacturability and repairability as critical design criteria can have immediate impacts on local economies. For example, one author has documented the savings in foreign exchange and the labor intensity dimension of using welding technology to repair and remanufacture worn and old parts in paper making machines in Peru. By salvaging and reconditioning these parts, quantity of "new" spare parts required was substantially reduced. The remanufacturing process (building up worn components with weld material) used local labor skills which were enhanced in the process.

The author suggests the need for further assessment in the following specific areas: (1) What is the character and nature of present remanufacturing and repairing activities in LDCs? How does it differ from that in DC?; (2) How do licensing and in general other technology transfer mechanisms relate to remanufacturing and repair in LDCs?; (3) Is it appropriate to conceive of national governmental control of technology transfer in terms of remanufacturability and repairability -- for example, with an instrument such as Mexican Technology Transfer legislation?; and (4) Do, and/or should national and international technical standards-setting organizations have a possible interaction with remanufacturability and repairability in the technology transfer process?

government policy, remanufacturing, economic analysis, product design

Institutional Aspects

801
City of Tacloban, Philippines Situation Report: Managing Energy and Resource Efficient Cities. U.S. Agency for International Development. Washington, D.C., U.S.A. 1980. 277 pages.

As part of the Managing Energy and Resource Efficient Cities Project of U.S. Agency for International Development (AID), a situational analysis was performed on the solid waste sector of Tacloban, Philippines, (population 103,433) reviewing historical data and trends. Topics include expenditure breakdown, waste generation by origin, waste variation, storage, collection and disposal, the role and effect of scavengers, average annual fuel consumption, equipment maintenance. Conservation problems and opportunities were described.

To improve waste collection efficiency, the report recommended dividing service areas into smaller sectors and initiating a preventive maintenance program for vehicles. Health and environmental consciousness could be increased through an effective public education program, coupled with enforcement of existing ordinances against dumping solid waste on streets. Resource recovery of organic waste via composting was suggested as a way to manage 50 percent of the city's waste. City parks, plazas and farms are potential areas for end use. Compilation and analysis of accurate composition data and coordination of private disposal site (possibly through government acquisition of its own dump site) were also recommended. An overall strategy matrix is presented.

waste composition, scavengers, landfill, Philippines, Asia

802
Pre-Test for Managing Energy and Resource Efficient Cities: Preliminary State of the Art Review. U.S. Agency for International Development. Washington, D.C., U.S.A. Prepared by Coopers and Lybrand, Inc. 1981. 180 pages. References.

This state of the art literature review covers several areas essential for managing the resources and energy of cities including land use, transportation, energy and electric power systems, water and sewer, solid waste management, building design and materials.

The solid waste management section reviews pertinent literature and introduces the importance of managing solid waste in LDC metropolitan areas. A complex combination of land, labor, capital, management and planning skills are required for proper sanitation. Environmental low cost protection alternative techniques are often overlooked in favor of more capital intensive, mechanical approaches. Often cities have not developed a master plan for solid waste that can be followed and will allow for equipment alternatives and changes.

Categories of solid waste include: household garbage and rubbish, commercial refuse, institutional refuse, street sweeping, construction and demolition debris, sewer sanitation residues, industrial wastes. Waste characteristics in LDCs include high organic fraction, lower per capita generation rates as compared to industrialized nations (0.5-0.6 kg vs. 1.25kg) and higher compaction of waste which make equipment designed for volume reduction by compaction unjustifiable.

Social and cultural customs affect solid waste management including levels of community cooperation, prevalence of "untouchable," and psychological and religious objections to using waste. The informal scavenging networks are a traditional activity which also affect solid waste management. Planners must integrate local conditions with functions of delivery and quality of service (e.g., levels of service). Techniques for service delivery include separate unit storage, communal storage, collection by human-powered, animal-powered or motorized vehicles; large or small scale transfer stations; open dump and sanitary fill disposal, institutional arrangements, financing arrangements, selection of appropriate technology. Implementation issues and strategies include development of the planning process, establishment of acceptable service, selection of technology, development of institutions, arrangement of financial resources and budget planning, and providing for public participation and education programs.

solid waste management, state of the art

803
Report of the Technical Official Level Meeting to the Ministerial Level Meeting, International Forum on Appropriate Industrial Technology, Part Two--Summary of the Twelve Industrial Sectoral Working Group Reports. United Nations Industrial Development Organization. New Delhi, India. November, 1978. 86 pages.

This document examines industries which contribute to better use of natural resources and provide a stimulus to upgrade employee skills. Analysis takes into account direct and indirect employment potential, industrial movement to urban fringe and rural areas, and provision of adequate impetus for the growth of a broad-based industrial structure. Reports are presented on policy aspects including a program of action for each sector.

Results indicate a need to reorient industrial and technological strategies so that benefits reach as large a segment of the population as possible. The possibilities of dispersal of small scale industry are found to be much greater than conventionally thought. The exploration of such possibilities should be undertaken by developing countries in a systematic manner through appropriate policy and institutional mechanisms. Fiscal, industrial, trade and other economic policies which could significantly contribute to or adversely affect the policy objectives of appropriate industrial and technological development are noted. Emphasis is placed on strengthening the technological capabilities in developing countries and the development of a wide range of technological services for consultancy,

design and engineering, standardization, evaluation of technology, national capabilities for research and development.

Sector reports as detailed below stress (1) the need to compile, process and disseminate information, and (2) the need for greater cooperation among developing countries and for exchange of experience. Specific projects for further research and investigation are suggested.

Industrial sector reports include: iron and steel, chemicals and fertilizers, drugs and pharmaceuticals, textile industry, sugar industry, construction and building materials, food storage and processing, agricultural machinery and implements, light industries and rural workshops, oils and fats, paper products and small pulp mills, energy for rural requirements, and low cost transportation for rural areas.

technology, appropriate technology, developing country

804
Solid Waste Management in Cuba: Prospects for Recycling and Waste Utilization Systems. Presented at First National Conference on Cuba. New York, New York, U.S.A. 1979. 19 pages.

Solid waste management in Cuba is on the threshhold of formalization. However, no national system exists for solid waste management. Instead, responsibilities are divided among several agencies, most notably the Poder Popular and the Ministry of Public Health. However, as the costs and impact on the health and environment have increased, these agencies are increasingly aware of the need to develop a coordinated approach. They need a system that is reliable, meets public health needs, disposal requirements and conservation objectives.

Increases in the standard of living have caused an increased generation of waste.

This study presents data including: background information on Cuba; historical data on solid waste management; characterization of solid waste; review of current collection practices; resources availability; recycling and reuse activities; markets analysis; and legal developments and current issues.

solid waste management, waste composition, recycling, Cuba

805 Baldensperger, H. L.
Dollars in City Dumps: The Making of Money and Men Through the Chicago Salvage System. The American City. Bettenheim Publishing Corporation. New York, New York, U.S.A. Volume XVII, Number 4. October, 1917. Pages 305-308.

The Chicago House of Corrections employed prison labor to salvage materials from municipal waste. After one year of operation a return to the city equal to 50 percent of the maintenance cost of the institution had been realized.

This method of employing prison labor replaced the contract system. Conversion to salvage work coincided with demand for materials created by World War I. Materials were repaired and/or processed for resale to consumers. Products included light bulbs, shovels, and platinum. Prisoner counselling, and family welfare programs were supported by revenues. Prisoner attitudes were enhanced toward creative employment.

prison employment, salvaging, United States, historical

806 Baranson, J.
Boyle, N.
Harrington, A.
Hellinger, S.
Hellinger, D.

Informal Small Scale Enterprise Sector of the Urban Economy: Problems and Suggested Approaches. U.S. Agency for International Development. AID/CU/1A IA 147-518. Washington, D.C., U.S.A. March, 1976. 90 pages. References.

The global problem to improve the condition of the poor is addressed in this document. The problem is seen as formidable due to (1) vast numbers of people needing help; (2) geographic dispersion; (3) cultural barriers; (4) the lack of political leverage available to poor; and (5) lack of favorable political climates conducive to change. The project appraises potentially useful activities to be undertaken by international development agencies based on field studies. Analysis and resulting proposals focus on small, labor intensive enterprises, marketing systems for small producers and other institutions which enable the urban poor to fully participate in economic and social development of their country.

Key difficulties and deficiencies are noted as the need to (1) devise and implement new training models; (2) effect grass roots initiatives; and (3) develop networks more effective in serving the urban poor.

informal sector, appropriate technology, developing country, labor, marketing

807 Basalo, C.

Beneficiation of Organic Matter Contained in Household Refuse for Agricultural Use: Position in France. United Nations Environment and Settlement Division. March 1, 1975. Paris, France. 11 pages. References.

A brief history of organic waste use in French farming is presented. Data indicates a significant dropoff after 1850 when studies of mineral feeding of plants were published leading to an increasing use of chemical fertilizers. However, from 1935 on, compost usage was important in champagne viniculture. Tower composting had anaerobic problems, leading

to development of mechanical turning processes after 1960. Over promotion of nutrient value of compost plus presence of impurities such as glass, led to reduced demand for product.

In 1972, 350,000 tons of compost were sold in France with 77% going to vineyards and mushroom production. The average selling price in 1973 was FF 19 per ton for accelerated and FF 7 per ton for natural compost.

In 1938, 4 out of 6 disposal systems accepted by the Ministry of Public Health were compost processes. Since that time (1966, 1972, 1973, 1974) various regulations have set standards on organic products.Technical concerns include composition variability of urban organics, C/N ratio determinations, need for putrescibility testing standards, and soil improvement details.

Special uses such as mushroom culture and soils reconstitution need to be investigated. Pathogen control favors accelerated composting techniques. Advantages of compost include attraction for small municipalities, conservation of soils, enhanced food production, and positive reuse by phosphates rather than negative impact of discharges into natural waters.

composting, organics, France, costs, agriculture

808

Berke, J. G.
Hudson, C. H.

Procurement of Products Containing Recovered Materials: A Summary of Activities in Seven States. U.S. Department of Commerce. National Bureau of Standards. Office of Recycled Materials. Washington, D.C., U.S.A. 1981. 73 pages. References.

This document summarizes reports from seven states and one county within the United States on the procurement of products containing recovered materials, as specified in the U.S. Resource Recovery and Conservation Act (P.L. 94-580) and its amendments (P.L. 96-482).

The study identifies legal, institutional, economic, and technical barriers encountered by state agencies when they attempt to purchase such products. A list of products that contain recovered materials is included.

Many states do purchase products containing recycled materials although the purchasing agent is sometimes not aware of this fact due to inadequate labeling of the product. Many vendors choose not to disclose recycled contents of a product for fear that the product may be considered inferior.

Some states indicate that the lack of standards and specifications for recycled products inhibits procurement of products containing recycled materials. The importance of the link between products containing recycled materials and energy conservation is noted by several states.

The report is accompanied by volumes which detail the procurement practices for products containing recycled and recovered materials. They contain sample contracts, sample bids, legislation, agency memoranda, product specifications, and model motivation programs. Each report lists the top ten commodities procured by the state in dollars plus a list of products that have a high potential for the use of recycled or recovered materials. Each report also includes a list of recommendations or suggested actions that could be taken to potentially improve the manufacture, distribution, and procurement of products containing recovered or recycled materials.

product design, institutional barriers to recycling, government policy

809
Product Life Extension and Design in the Context of Materials Balance. School of Architecture and Urban Planning, University of California. Los Angeles, California, U.S.A. 1976. 18 pages. References.

This document is a policy analysis of the product lifetime issue. A review of existing literature determine the status of current knowledge and research projects. Factors which affect product life including direct regulation and indirect market pressures are discussed. Product life extension can significantly reduce the use of natural resources and promote general economic welfare. Life extension of one product may result in an increase in the overall material flow if consumers spend extra income on additional products. Attempting to influence product lifetimes is a first step toward resource recovery.

product design, product durability

810 Conn, W. D.
Urbanization and the Environment: Waste Reduction--Issues and Policies. Presented at the International Symposium on New Problems of Advanced Societies. (Hamburg, Germany. May, 1976). University of California. Los Angeles, California, U.S.A. 1976. 31 pages. References.

The State of California assessed proposed measures for reducing waste. This document analyzes the work of the Source Reduction and Packaging Policy Committee, of the State Solid Waste Management Board, established for this purpose.

Waste reduction (source reduction) is defined as the prevention of waste at its source, either by redesigning products or by otherwise changing patterns of consumption or waste generation. This is distinguished from resource recovery. Objectives include reduction of solid waste, management costs, adverse environmental impacts, litter, and conservation of natural resources. Conflict between different objectives was expressed by committee members reflecting private sector, environmental and government views. Three basic recommendations to reduce waste were made: reduce the quantity of material in packaging, increase product

lifetime, and substitute reusable packages for disposable ones. Effects on the solid waste stream, materials and energy utilization, environmental impacts, government revenues/costs, industry, and employment, fiscal incentives and voluntary efforts are presented.

Reducing waste may not be easily accomplished as benefits do not come without costs. Even if some waste reduction measures are justified as a way to restore market efficiency, there is still room for disagreement on the nature and scale of the "corrections" necessary.

waste reduction, solid waste management, source reduction, United States

811 Furmaier, B.
Necessity and Possibilities of Waste Treatment and Waste Recovery for Reuse: Shown by the Domestic Waste Disposal Program of Bavaria. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 145-151. E. Freitag--Verlag für Umwelttechnik. 1979. References.

This document reviews the Bavarian, FRG Domestic Waste Program and the Hazardous Waste Program. The program sees the treatment and reutilization of wastes as a long-term objective.

Waste composition analysis reveals changes in the waste stream marked by the following features: (1) decrease of the mineral constituents of fine-grained waste from 57 wt % (1950) to 12 wt % (1980); (2) increase of paper and board from 14 wt % (1950) to 39 wt (1980); (3) a nearly constant proportion of organic kitchen wastes of about 16 to 18 %; (4) increase of the proportion of glass from 2.5 wt % (1950) to 9.5 wt % (1980) and (5) increase of the proportion of plastics from 2.3 wt % (1950) to 7.7 wt % (1980).

The following points need to be considered when choosing a waste disposal plan: (1) the strain on the environment should be minimal; (2) the plan should be adapted to local conditions; and (3) the system should be flexible.

A chief objective of waste management is to minimize the increase of waste on a long-term basis.

The following measures can help minimize the strain on the environment in the field of waste disposal: (1) recovery for reuse as far as possible; (2) to reduce the volume of waste as far as possible; and (3) using methods which allow for quantifying inputs and outputs.

The following proven methods of waste reutilization are available: (1) separate collection of the single waste components (e.g., glass, paper); (2) composting of domestic waste for the purpose of biological reutilization of the easily decomposable fractions; and (3) incineration of domestic waste with heat recovery to save primary energy.

Whereas in rural areas the deposit of untreated waste may represent an acceptable long-term solution even under ecological aspects, waste treatment and reutilization must be planned for cities and in areas with intensive land use.

In order to stimulate innovation, Bavaria integrated resource recovery into its planning and provided low interest loans for development of conventional and new technologies.

waste composition, government policy, waste recovery, Germany (Fed.Rep.of)

812

Goen, R. L.
Steele, R. V.
Samogyi, L. P.
Fishman, N.

The Potential for Reusable Homogenous Containers. National Science Foundation. Washington, D.C., U.S.A. 1977. 48 pages. References.

The widespread use of disposable packaging not only constitutes a large use of energy and materials, but also contributes to rapidly growing solid waste problems. The introduction of reusable, homogenous containers into the packaging industry could make a significant contribution to alleviating these problems. This document examines the feasibility of reusable containers for food. Beverages are not included. Concepts are formulated for reusable containers, including configuration and type of material. Comparisons are made of the amount of energy needed to produce reusable containers versus that needed for disposable containers.

In 1967, total direct and indirect energy use in the package related sectors (paperboard containers, metal cans, glass containers and plastics) was approximately 30 percent of the nation's primary energy consumption (1.6×10^{15} Btu). A change in packaging that resulted in reducing energy use by 50 percent would save the equivalent of over 500,000 barrels of oil per day. Energy savings can be accomplished via new container designs, use of returnables, and lower transportation distances. Food (wet, dry) container requirements can be met. The retortable pouch (made of laminate of aluminum foil and plastic) in which food can be sterilized and cooked, and the use of freeze-dried processes for foods instead for the canning process are alternative methods reducing material use for containers. Food packaging accounts for nearly half of the dollar volume of packaging in the United States. Packaging contributes 35 percent of the residential and commercial solid waste, or 55 percent of the nonfood product waste.

reuse, returnable containers, energy savings, costs, waste reduction

813 Gunnerson, C. G.

Debris Accumulation in Urban Areas--A Study of Municipal Lint. Appropriate Technology for Resource Conservation and Recovery. American Society of Civil Engineers. New York, New York, U.S.A. October, 1979. 46 pages. References.

This paper focuses on debris accumulation in cities which results when people carry more into their communities than they carry out. Options at the household, community, commercial, and industrial levels are to sell materials, give or throw them away, pay to have unwanted materials hauled away, or convert them to secondary use.

Debris accumulations in urban areas from Neolithic and Bronze Age communities to contemporary times vary from 5 to 150 cm (0.15 to 5 feet) per century but are not necessarily increasing over time. Bronze Age Troy and modern Manhattan, New York, U.S.A. have equivalent rates of 140 cm (4.7 ft.) per century, although the latter has a more efficient collection and disposal system which reduces accumulation.

Debris accumulation is represented mostly by inorganics, which are the least valuable materials. Catastrophic events, man made and natural, account for incremental debris accumulation but have little long-term effect.

Alternatives to debris accumulation involve recycling which recently tends to be more acceptable in developing countries than in industrial ones. The industrial view that high or capital intensive technology will solve all is still prevalent in many countries.

Resource recycling requires environmental, institutional, economic, and technological approaches. Also, finite national resources, shortages of professional and managerial skills in developing countries, and the need for public access are factors to be considered.

The author concludes that it is important to internalize the marginal costs of convenience, employment generation, and shadow pricing of costs in developing countries, and evaluate the full impacts of economic development.

For technology, it is concluded that greater sorting efficiencies of hand operations would make them more cost effective than machine operations and economies of scale tend to disappear when system stability or flexibility is considered. A conservation ethic, most importantly, has multiple positive impacts.

recycling, appropriate technology, developing country, sorting, municipal waste

814 Haynes, K. E.
El-Hakim, S. M.

Appropriate Technology and Public Policy: The Urban Waste Management System in Cairo. The Geographical Review. American Geographical Society. New York, New York, U.S.A. Volume 19, Number 1. January, 1979. Pages 101-108.

Issues concerning solid waste management and recycling in Cairo, Egypt are presented in this article. Policy considerations, problem solving and technology assessment efforts at the local level are detailed. Conclusions are that: (1) antagonism exists between the informal sector and the city as scavengers are frequently forced to move from temporary housing; (2) some government agencies desire importing sophisticated technology at the expense of the informal sector; (3) using appropriate technology can benefit agriculture, energy, water and the environment; and (4) policy considerations can help developing countries use appropriate technology to maximize resource recovery.

recycling, informal sector, appropriate technology, government policy, solid waste, composting, institutions, scavengers, Zabbaleen, Egypt, solid waste management

815 Julius, D. S.

Urban Waste as an Economic Good In: Sanitation in Developing Countries. Edited by Arnold Pacey. John Wiley and Sons. The Gersham Press. Old Working, Surrey, U.K. 1978. Pages 194-200. References.

The author explores goods and waste to develop theoretical implications of use in understanding and promoting environmental protection and waste recovery.

Three variables are noted as affecting the demand for consumer goods: price, substitutes, and consumer preference. The author also indicates that the income of the consumer may form a fourth determinant. As income increases, so does the demand for better of more expensive products. Conversely, the demand for inferior goods should decrease as the consumer income increases. This has been proven in Kyoto, Japan where farmers initially dropped low value organic fertilizer in favor of chemical fertilizer as country and individual wealth increased. However, the alleged effects of soil depletion are encouraging some farmers to return to low cost organic fertilizer. The author backs up this case study with income data and demand curves for organic fertilizers in Korea and Taiwan.

While the other three factors have demonstrated effects on demand as shown in several examples, the author notes that consideration of income level must be integrated into decision making. Currently, most developing nations have relatively low incomes, making selection of low cost technology seemingly correlative. However, another conclusion might be reached. If the current emphasis on developing low technology continues with improvements in the standard of living, then the biggest obstacle to continued use of new low technology, especially for waste utilization, may

be the response that waste derived products are inferior, therefore constraining use. In that case, a strategy of stressing the environmental and ecological benefits could present a positive approach to increasing waste recovery.

institutional barriers to recycling, economics, organics, health and safety, fertilizers

816

Kim, J. I.
Robinson, D. E.
Bazar, A. R.
Gump, B. H.

Solid Waste Resources from the Fresno-Clovis Metropolitan Area. Final Report, Volume II. Fresno-Clovis Metropolitan Solid Waste Commission. Fresno, California, U.S.A. 1981. 200 pages. References. Authors at California State University, Fresno, California.

The practicality of recovering resources, energy as well as materials, from solid wastes is governed not only by the availability of suitable markets for the recovered products, but also by the volume and composition of the waste. Operational costs for centralized processing facilities are particularly sensitive to seasonal variations of the quantity and quality of the waste and to the distribution of the waste sources. Planning for future needs, process improvements, and initial capital outlay must account for population growth and for per capita generation of wastes. This document is a comprehensive analysis of these factors conducted so that Fresno County, California, could implement an effective resource recovery program.

Over a nine month period, a waste characterization analysis was carried out by conducting weight and composition surveys of the refuse received at several disposal sites.

This information was used to develop an integrated resource recovery system and to reduce landfill demand. Mechanical (including compost, waterwall, pyrolysis) and source separation options were evaluated and compared.

Industrial markets for energy (electricity, steam, oil, gas) were examined with respect to stability, availability of waste, and technical difficulties. Material markets were explored for the following materials: ferrous (pig iron production (blast furnace)), steelmaking (basic oxygen open-hearth and electric furnaces), ferroalloy production, gray iron foundries, detinning, and copper precipitation; aluminum (secondary smelters, primary producers, fabricators and foundries); waste paper (paper and paperboard production, newsprint deinking, corrugated containers, highgrade pulp substitutes, highgrade deinking, mixed paper products, energy production, (combustion), composting, animal feed (cattle, sheep), soil conditioner, mushroom growing medium, fruit box lining material, and egg carton manufacturing material); glass (bottle manufacturing (amber, clear, green), wool-foam insulation, and wall panels); organics (soil additive, mulch, and animal feed supplement).

A market survey was conducted to identify actual firms willing to purchase specific amounts and quality of materials. Market trends and technological innovations were included for all materials.

secondary materials recovery, markets, energy recovery, pyrolysis, composting, deinking, energy, ferrous/nonferrous recovery, glass, organics, technology

817 Langer, H.
Strategies for the Use of Waste Paper Outside the Paper Industry. Proceedings of the International Recycling Congress (Recycling Berlin '79). Berlin, Federal Republic of Germany. Pages 1159-1165. E. Freitag--Verlag für Umwelttechnik. 1979. References.

Innovative uses of waste paper are examined in this paper.

Waste paper recycling has been standard for years in the industry. However, the introduction of paper hybrids has complicated the recycling process by increasing heterogenity in the lower or mixed grades.

Low grades of paper have traditionally been used in roofing, felt manufacture, and wallboard. However, saturation has occurred at some levels so these lower grades are no longer effectively utilized. The price/revenue for these papers also hinder recycling due to transportation costs.

Potential new uses for secondary mixed fibers include: alcohol production; biotechnical uses; insulation; molded parts; plant containers; fuel extraction (burning). Marketing concepts, possibilities for product substitution, and policy considerations are enumerated.

fiber, fuel, marketing, product substitution, waste paper recovery

818 Lomnitz, L.
Networks and Marginality: Life in a Mexican Shantytown. Academic Press. New York, New York, U.S.A. 1977. References.

This book describes patterns of social relationships between the shantytowns and the formal urban economy. Field data are taken from several Mexico City shantytowns.

The industrial economy has not developed fast enough to keep pace with the demand for jobs from rural migrants. Labor union closed shops and rising educational requirements for industrial jobs effectively barr migrants from access to skilled jobs.

Two types of relationships are explored: (a) exchange among equals, and (b) patron-client relationships. Of great interest is the latter form where research shows the highest flow of reciprocal exchange in the shantytown occurring usually between close neighbors related by kinship.

The kinfolk network can be organized into a labor "gang" with a wide variety of wage rates, work conditions, industrial relations; e.g., partnerships, patronage, brokerage, production brokers, political brokers. This does not, however, exclude a relationship with the dominant formal economy. Thus, the shantytowns are connected with the national system in their role as markets, as producers, and as sources of cheap labor and political resources.

scavengers, informal sector, Mexico

819 Melosi, M. V.
Garbage in the Cities: Refuse, Reform, and the Environment, 1880-1980. Texas A & M Press. College Station, Texas, U.S.A. 1980. 268 pages. References.

This book is a history of refuse management in the United States during the era of industrialization and urbanization. The author describes the growing awareness of environmental problems caused by open dumping in oceans and waterways. The rise of the professional sanitation bureaucracy, and impact of grassroots environmental organizations, and various technologies employed to manage and/or recycle wastes are also covered. Street cleaning, collection and disposal practices are detailed.

The author notes the origins of the public health vs. recycling debate and describes Col. George E. Waring, Jr.'s experimental efforts to start a resource recovery system. Waring constructed the first sorting plant in the U.S. based on primary separation at households. Failure is attributed to elimination of informal scavenging networks, and insufficient development time due to the political boss system.

Other aspects discussed are the affect of European practices on U.S. development, implementation of inappropriate high technology grease recovery and combustion systems, differences between professional sanitary engineers and grassroots organizations, and the role and composition of public interest groups. Post-1920 developments in the U.S. are briefly discussed.

historical, United States, Europe, waste management, pollution, environmental management

820 Milgrom, J.
Incentives for Recycling and Reuse of Plastics. U.S. Environmental Protection Agency, Office of Solid Waste Management Programs. Washington, D.C., U.S.A. Prepared by Arthur D. Little, Inc. 316 pages. References.

This study had two objectives: (1) to develop a descriptive model of the plastics cycle; and (2) to develop strategies for promoting the recycling and reuse of plastics. The study is reported in five parts. Part I contains a discussion of the technology of plastics, which provides the basis for understanding the technical problems of recycling. Part II describes the economics of the plastics industry needed to develop and assess the strategies for recycling plastics and discusses the market for

both virgin and secondary materials. Part III describes the entire plastics cycle beginning with petrochemicals until the plastic becomes a consumer product. Part IV analyzes the existing state of the art of methods that isolate plastics from the solid waste stream and of uses for the scrap material. In Part V strategies for promoting recycling and the reuse of plastics are described in detail.

One strategy useful to improve secondary resins would have them meet industrial standards set by the American Society for Testing Materials.

Another action that the plastics industry could take to promote recycling would be to set up an inventory of all sources of scrap plastic. This inventory would describe the availability, location, physical, and chemical forms, etc., of the scrap, and be a resource for manufacturers interested in purchasing secondary material.

Because offgrade virgin resins, especially surplus, compete with secondary resins, an effective tactic would be to reduce the available volume of this surplus resin. If government and industry can cooperate to develop a program for monitoring and reporting virgin resin inventory levels, this will go a long way towards stabilizing resin prices and, therefore, prevent the production of large volumes of surplus off-grade resin.

A worthwhile use of some tax revenues would be to further research and development specifically directed to make reprocessing technically and economically more attractive. For example, research programs that develop new uses for scrap materials will be very helpful to the reprocessor and should promote recycling. Research to develop new technologies for collection and disposing of scrap plastic is another approach.

Often, the government itself impedes recycling because it uses purchase specifications that do not allow the use of secondary resins, in spite of their limited effect on performance in certain applications. Therefore, governments are in an excellent position to take the lead by relaxing these restrictions wherever possible, and thus open up additional markets. Governments spend billions per year for a large array of products and, therefore, by modifying procurement policies, they can increase the recycling of secondary materials. By specifying the use of secondary materials in purchase, the government would not only open up new markets, but, more significantly, their actions would have an important positive effect on many segments of industry.

government policy, plastic recycling, secondary materials recovery, state of the art

821 Ming, C.
Organizational Techniques in Retrieving Waste Materials. Conservation and Recycling. Pergamon Press. U.K. Volume 3, Number 3/4. Pages 319-325. 1979. Presented at Second Recycling World Congress. Manila, Philippines. 20-22 March, 1979. Author at Shanghai Materials Recovery Company. Shanghai, People's Republic of China.

The structure for collecting, processing, and selling waste materials in the greater Shanghai area is described in this document.

Founded in 1957, the Shanghai Materials Recovery Company (SMRC) has 12 urban and several suburban branches with 16,000 employees (850 collecting, 11,000 processing and sorting, 1,850 transporting residues, and 2,300 neighborhood agents). Rural cooperatives and shops work on a commission basis.

Materials recycled include metals, rubber, plastics, paper, hemp, cotton, chemical fiber residue, animal bones, human hair, glass containers, broken glass, old machines, parts and accessories, acidic solution, oil and grease.

Collection is carried out by 24 purchasing agencies for industrial wastes and, under them, purchasing stations (one for 20,000 households) for residential and commercial wastes. There are both centers and mobile collectors for urban and rural residents. Collection is enhanced by an active propaganda campaign waged to encourage increased participation.

Processing is carried out in 70 factories (8 for metals, 21 for machines, appliances, hardware, 33 for sundries, 8 for chemicals) and include sorting, repairing, remaking, and refining.

Marketing includes close coordination with user production schedules, waste exchanges (example: acidic discharge of chemical works is used to clean rolled steel and reused by pharmaceutical plants to make iron protosulfide) and sales departments with sample display areas where potential users can make their selections.

recycling, remanufacturing, China, collection, processing, marketing

822 Purcell, A. H.
Tin Cans and Trash Recovery: Saving Energy Through Utilizing Municipal Ferrous Waste. Technical Information Project. Washington, D.C., U.S.A. 1980. 26 pages. Supported research by U.S. Department of Energy Appropriate Technology Small Grant Program. References.

The booklet explores the feasibility of using ferrous waste in local foundries. It is an established system for using material which minimizes transportation costs and which is compatible with nonhomogeneous material that varies in both quality and quantity. Foundries produce few types of materials, mostly grey iron (lower grade cast iron used in applications such as pipe, grates and covers). Metallurgically, this product is distinguished by microscopic flakes of carbon throughout its

structure. The use of ferrous scrap can significantly reduce the costs of feed to foundries. Recommended mixes of 75 percent pig iron (standard foundry material) and 25 percent municipal ferrous waste would result in a 17 percent cost reduction based on test application. High quality cast material approaching ductile iron could be produced by adding small amounts of noduloy, a commercial master alloy containing cerium and magnesium.

Identified obstacles to increased ferrous scrap recycling include the level of tin contamination for steel furnace processes, numerous grades of steel with their unique and delicate furnace chemistry requirements, unavailability of detinning facilities, and high transportation costs.

Fundamentals of material collection, preparation and foundry melting are described. A check list for municipal ferrous waste foundry melting, bibliography and list of 200 foundries in the U.S. are provided.

foundries, tin cans, ferrous scrap

823 Risch, R. W. K.
The Raw Material Supply of the European Community: The Importance of Secondary Raw Materials. Resource Policy. Science and Technology Press, Ltd. U.K. Volume 4, Number 3. September, 1978. Pages 181-188. References.

This document considers the availability and security of raw materials which have recently taken on a new political dimension. These issues influence the economic and political rank of nations, affecting their independence, their standards of living and the competitive position of their industries. Recent awareness of the risks of shortages of most essential materials, the limitation of nonrenewable resources, and in particular the awareness of the permanent and growing dependence of Europe on primary raw materials, have stimulated interest in the recovery of wastes and the rational use of natural resources. This concern has brought some economists and philosophers to consider secondary materials as a potential main industrial feedstock. In particular, for economies lacking primary raw materials, this would extend the availability of natural resources. Some economists are speaking of a future "society of secondary raw materials."

Waste management will become important for countries lacking natural resources as all wastes and residues represent the most secure raw materials source. This will help to reduce dependence on imported raw materials, to realize considerable energy savings and to contribute to environmental conservation. Waste management can become a new dimension of economic policy, constituting a link between environmental and economic policy. The objectives of waste management policy cannot be restricted to the safe disposal of waste, but must also include its prevention, reduction and increased processing.

secondary materials recovery, government policy, Europe, developing country, international trade, raw materials

824 Rolz, C.
Particular Problems of Solid Waste Reclamation in Developing Countries. Applied Research Division, Central American Research Institute for Industry. Guatemala. 1977. 40 pages. References.

This study investigates issues and problems faced by developing countries in the area of solid waste reclamation. Differences in approach between developed and developing countries are identified and a common need advanced: the imperative to utilize byproducts and wastes as possible sources of fiber, fuel, and feed/food products.

In developing countries, the least costly method is generally adopted. Collection, scavenging, and dumping are common. Land reclamation through landfilling is a common waste utilization method. An important point is that technology should not displace human labor. Otherwise, a technical problem is solved but a social one is created.

Selected high technology should not be totally rejected, but evaluated on the basis of each nation's individual requirements and realities.

collection, developing country, landfill, land reclamation, scavengers, solid wastes

825 Schumacher, E. F.
The Work of the Intermediate Technology Group--Africa International Labour Review. International Labor Organization. Geneva, Switzerland. Volume 106, Number 1. Pages 3-20. 1972. References.

The Intermediate Technology Development Group was formed in 1966 by people in the professions and industry in the United Kingdom in response to worldwide dangers inherent in the buildup of unemployment taking place in virtually every poor country. This document reviews the purposes and accomplishments of this agency.

The Group's goal is to compile practical data on intermediate technologies, to field test them and to disseminate them. Panels of experts are assigned to each research project. Work is performed both in developed countries and developing countries. Projects include building construction materials and processes in Nigeria and Kenya; water projects in Botswana; agricultural tools and equipment in Zambia, Nigeria and Tanzania; small scale industry development in Nigeria; and food technology in Liberia and Tanzania. Consultancy assignments have been undertaken for the International Labor Organization, United Nations Economic Commission for Africa, and United Nations Industrial Development Economic Commission for Africa, and United Nations Industrial Development Organization through the Group's subsidiary Inter-Technology Services. Technology, equipment manufacture management training and local financing and marketing tasks were undertaken.

The Group's research and development program relies upon research grants and donations. The panel method of operation has proven successful as a means of bringing together three essential elements for a successful project: identifying gaps that can be filled by intermediary technology, assembling the necessary practical data, and engaging in field trials to demonstrate their uses. These so-called ABC elements of development are the administrators, the business and industrial community and the communicators, or academic fraternity.

The work of the Croup is seen as an important contribution to technological choice for developing nations. Low cost technology efforts to date represent an insignificant fraction of total aid expenditure.

appropriate technology, developing country, small scale industry, job creation, research and development, institutions, technology

826 Seldman, N. N., Ed.

Final Report: National Recycling Research Agenda Project. National Science Foundation. Washington, D.C., U.S.A. 1979. 126 pages. References.

One hundred and eleven waste experts were identified and they addressed short and long-term research needs in the area of post consumer solid waste recycling projected funding needs.

The Project addressed nine technical problem areas: markets for secondary materials, compatability of recycling and combustion, technology and equipment, project initiation, waste reduction, participation, institutional barriers, hazardous wastes, and waste utilization.

Participants voiced strong support for more research and funding in areas of cost effectiveness, environmental impact, community and small business development, and general education on conservation. The Project recommended up to US$76,915,000 or R & D programming over the next 5 years to be supported by various federal agencies.

research and development, recycling, secondary materials recovery, technology, equipment, hazardous wastes, institutional barriers to recycling, United States

827 Taira, K.

Urban Poverty, Ragpickers, and the "Ants' Villa" in Tokyo. Economic Development and Cultural Change. University of Chicago, Chicago, Illinois, U.S.A. Volume 17, Number 1. January 1, 1969. Pages 155-177. References.

This case study of Japanese ragpickers shows how they were able to organize themselves into a productive cooperative known as "Ants' Villa"located on the waterfront of Tokyo Bay. Scavenging was organized on a communal basis with different teams in charge of collecting, processing, sorting, etc. The community built their own homes, restaurant and store.

824 Rolz, C.
Particular Problems of Solid Waste Reclamation in Developing Countries. Applied Research Division, Central American Research Institute for Industry. Guatemala. 1977. 40 pages. References.

This study investigates issues and problems faced by developing countries in the area of solid waste reclamation. Differences in approach between developed and developing countries are identified and a common need advanced: the imperative to utilize byproducts and wastes as possible sources of fiber, fuel, and feed/food products.

In developing countries, the least costly method is generally adopted. Collection, scavenging, and dumping are common. Land reclamation through landfilling is a common waste utilization method. An important point is that technology should not displace human labor. Otherwise, a technical problem is solved but a social one is created.

Selected high technology should not be totally rejected, but evaluated on the basis of each nation's individual requirements and realities.

collection, developing country, landfill, land reclamation, scavengers, solid wastes

825 Schumacher, E. F.
The Work of the Intermediate Technology Group--Africa International Labour Review. International Labor Organization. Geneva, Switzerland. Volume 106, Number 1. Pages 3-20. 1972. References.

The Intermediate Technology Development Group was formed in 1966 by people in the professions and industry in the United Kingdom in response to worldwide dangers inherent in the buildup of unemployment taking place in virtually every poor country. This document reviews the purposes and accomplishments of this agency.

The Group's goal is to compile practical data on intermediate technologies, to field test them and to disseminate them. Panels of experts are assigned to each research project. Work is performed both in developed countries and developing countries. Projects include building construction materials and processes in Nigeria and Kenya; water projects in Botswana; agricultural tools and equipment in Zambia, Nigeria and Tanzania; small scale industry development in Nigeria; and food technology in Liberia and Tanzania. Consultancy assignments have been undertaken for the International Labor Organization, United Nations Economic Commission for Africa, and United Nations Industrial Development Economic Commission for Africa, and United Nations Industrial Development Organization through the Group's subsidiary Inter-Technology Services. Technology, equipment manufacture management training and local financing and marketing tasks were undertaken.

By organizing themselves on a communal basis the scavengers were able to exert more control over supply and demand for their products. In addition, they gained considerable self respect for themselves and from society.

Ragpicking is the least preferred form of gainful employment. Many of the poor would rather beg or steal than pick rags. Data indicate that the earnings from ragpicking are far below those from other activities of which the poor are capable. Ragpicking is on the borderline between employment and vagrancy. Closely related to ragpickers are ragbuyers who buy waste materials from households using capital advanced from the ragdealer. Ragdealers provided shelter in the junk yard for a nominal rent. Dealers sold materials to "processors" who specialized by category of material and who sold materials to factories.

These elements constitute the "resource regeneration industry" which conveys the sense of a dynamic process characteristic of the industry. It has favorable implications for the ragpicker who is regarded as an agent of resource regeneration. This psychological dimension is critical as one who regenerates resources may eventually regenerate oneself. The industry has demonstrated remarkable staying power, expanding in post World War II years to peak employment in 1952. Bicycle pulled carts, small three wheeled motor vehicles and trucks are commonly used tools of the profession.

The personality problems of ragpickers are revealed by voluntary admission that their unfortunate conditions are due to personal deficiencies and hence largely of their own making. The story of the "Ants' Villa" in Tokyo is one of the few examples of psychological rehabilitation, spiritual growth, and economic success among ragpickers.

Ants' Villa was a community of 50 households located on reclaimed land at the waterfront of Tokyo Bay, Toko-Ku administrative district. Daily scavenging work was organized on a thoroughly communal basis, beginning and ending with group prayer. Work was rationalized: large quantity collection for major business concerns in central Tokyo, transport to workshops, sorted out by teams, packed by machines and delivered to commercial processor. This organization compares favorably with any efficient small scale business firm. It supports a clean community with recreational and guest houses, restaurant and store.

Japan, scavengers

828 Thomas C.
Material Gains: Reclamation, Recycling and Reuse. Earth Research, Ltd. London, U.K. 1979. 130 pages. Exhibits. References.

This book presents a discussion of the issues related to national recycling materials policies: conservation, resource limits, waste reduction, reuse, packaging, reclamation and recycling. The impacts of reuse and recycling on environmental quality are detailed in terms of raw materials, energy, pollution, waste disposal, and general considerations with regard to European Economic Community countries. Current recycling

practices, waste management legislation and public policy are discussed. Future options for waste processing and utilization are reviewed including material collection, material separation, pyrolysis, composting, and refuse derived fuels.

recycling, Europe, waste utilization, reuse, waste recovery, conservation, fuels, sorting, pyrolysis, composting, collection, government policy

ANNEX I

ADDITIONAL BIBLIOGRAPHY

Some of the magazines and journals published on recycling include:

Biocycle, a Journal of Waste Recycling, the J G Press, Inc., Box 351, Emmaus, Pennsylvania 18049, United States.

Muell und Abfall Beseitigung, Erich Schmidt Verlag, 48 Bielfefeld, Federal Republic of Germany.

Resources and Conservation (formerly Resource Recycling and Conservation), Elsevier Scientific Publishing Company, P. O. Box 211, 1000AE Amsterdam, The Netherlands.

Conservation and Recycling, Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, New York 10523, United States.

The Journal of Resource Management and Technology, Iraj Zandi, editor, University of Pennsylvania, 220 S. 33rd Street, Town Building, D3, Philadelphia, Pennsylvania 19104, United States.

Back issues of the Bulliten, published from 1971 to 1981 by the National Center for Resource Recovery, available from U. S. Conference of Mayors, 1620 I Street, N. W., Suite 600, Washington, D. C. 20006, United States.

There are a number of regularly scheduled specialty conferences on recycling, with published proceedings, including:

International Recycling Congress, held in Berlin, proceedings published by E. Freitag--Verlag für Umwelttechnick, Berlin.

National Waste Processing Conference, convened by the American Society of Mechanical Engineers, New York.

A N N E X I I

GLOSSARY

ABS: acryloni trile butadiene styrene.

Absorptive Capacity: Ability of informal sector to create employment and skills training, thus reducing economic and social pressures caused by rural immigration and urban population growth.

Agents (intermediates): Informal/formal secondary commodity buyers who resell to brokers, dealers or factories.

Aggregation: Accumulation of waste commodities prior to processing and/or shipment to markets or disposal.

Appropriate Technology (intermediate or low technology): Technology that requires low capitalization and overhead, and is matched to local resource materials and human resources to produce goods and services for local consumption. Refers to institutional aspects as well.

Back End System: The portion of a high technology resource recovery facility where materials are recovered from the incinerated residues of refuse.

Back Haul: Unused transfer capacity returning to place of origin can carry secondary materials at low cost.

Bangalore Method: Low cost compost method devised in Bangalore, India. Involves the alternative layering of refuse and night soil with dirt. Digestion takes place under anaerobic (without oxygen) conditions during a four to five month retention time.

Batch Operation: Process which is run on a noncontinuous basis.

Bio-Conversion: The conversion of organic waste via biological decomposition to produce usable gas, liquid fuels, or compost products.

Bottle Bank: Beverage bottle return system devised by European glass bottlers and adopted throughout Europe. Specially designed containers (skips) are placed at convenient locations for people to "drop off" bottles for later collection.

British Thermal Unit (BTU): The amount of heat necessary to raise the temperature of one pound of water one degree farenheit. 1 BTU = 1055.1 Jouhes.

Brokers: Purchasers of materials who sell materials to factories or mills without processing.

Buy-Back Center: A facility where materials are purchased from suppliers and which may or may not be subsequently processed for delivery to market.

Capital Intensive: Indicates that a relatively large percentage of the total cost of production is associated with the initial cost rather than the operating cost. Also used to differentiate from technologies which are labor intensive.

Caste: Subgroup of cultural society which for religious and/or ethnic reasons has been economically segregated from mainstream society. Typically, low status castes often provide waste collection and street cleaning services. In turn, the caste system may preclude higher castes from recycling participation.

Cellulose: Fibers derived from wood sources. Can be used in alcohol production, paper manufacturing and/or energy production through combustion.

Cellulose Insulation: Insulation material made from shredded waste paper (newspaper, corregated) and treated with a fire retardant (boric acid). It forms a fluffy fiber product which is blown in walls and roof interiors.

Christian Punjab Sweepers: Network of workers in Karachi, Pakistan who perform street and sewer cleaning services and scavenging under contract with the city. As a minority group which performs tasks that Moslem majority rejects, these workers have a monopoly over scavenging.

Classical Recycling: The use of secondary materials to produce new products, as opposed to reuse or remanufacturing of secondary products.

Closed Loop System: Ideal production arrangement wherein the product of one process is the feedstock for another product process.

Collection Center: A place or facility designed to accept waste commodities such as glass bottles or cans. The term may also be used to mean a dropoff location for waste commodities collected by government or private agencies.

Combustible Fraction: Solid waste which can be incinerated with or without supplementary fuel.

Combustion: A process by which organic material is burned in the presence or near absence of air (i.e., stoves are a combustion device).

Commercial Fertilizer: Refers to nitrogen, phosphorus or phosphate fertilizers manufactured from virgin raw material feedstocks.

Commodity: A product or material which can be reused, repaired, remanufactured, recycled, processed, or disposed.

Communal Storage: A form of storage for multifamily dwellings or points of human aggregation.

Compost: The end product of the compost process. Variously referred to as humus, organic compost, and soil amendment.

Composting: The designation given those processes that involve decomposition of organic matter. Aerobic composting take place in the presence of oxygen. Anaerobic composting takes place in the absence of oxygen. The product of the two processes is the same in terms of conditions of the product; namely, a biologically stabilized residue.

Cost Reduction: Savings achieved through system efficiencies based on the recycling, reuse, or remanufacturing of secondary commodities.

Cottage Industry (small scale): Manufacturing and processing undertaken in small, often household scale, production units.

Crumb Rubber: Small grain rubber ground mechanically or tread cryogenically from old tires. Used in manufacture of roadways, construction material and industrial flooring. Differs from reclaim rubber in that it is vulcanized.

Cullet: Uncontaminated broken glass that is substituted for soda ash in glassmaking to reduce energy requirements, lower pollution and extend raw material supplies.

Cullet Dealer: Dealer who specializes in secondary glass materials.

Dealer: Entrepreneur who obtains and adds value to secondary commodities through processing prior to resale of commodities to an end user.

Deposit: Returnable fee paid by consumers when purchasing commodities.

Desertification: The process by which deserts are created. This term was originally used by a French scientist to describe the northward advance of the Sahara in Algeria and Tunesia. In human activities, slash and burn, intensive logging, overgrazing and soil mining contribute to desertification. Declining groundwater tables, salinary action of topsoil and water, reduction of surface waters, unnaturally high soil erosion, and desolation of native vegetation are noted impacts.

Discard: Residual following personal use or consumption of a product. Discard may still have original use value.

Economy of Scale: The scale of operation where the benefits per production unit exceed the unit cost.

End User: Entity (mill, factory, farm) which uses secondary commodity to produce product.

Energy Recovery: A form of resource recovery in which the organic fraction of waste is converted to some form of usable energy. Recovery may be achieved through the combustion of processed or raw refuse to produce steam (e.g., as supplemental fuel in electric utility power plant boilers or as the primary fuel in incinerators), through the pyrolysis of refuse to produce oil or gas; and through the anaerobic digestion of organic waste to produce methane gas.

Equity Option: Arrangement which allows for workers, community organizations and/or residents to acquire ownership and control over work products and operations.

Feasibility Study: Technical evaluation to determine economic or social viability of an industrial process, collection service or intermediate processing system.

Feeder Mechanism: Network of individuals, communities or businesses which generates secondary commodities to a recycling or remanufacturing process.

Feedstock (furnish): Raw material input to a process.

Formal Sector: Commercial and industrial sector which provides full time employment, social security, and other fringe benefits (see Informal Sector).

Front-End System: A system of labor intensive or mechanically intensive activities which subject solid wastes to physical or chemical action. These actions are designed to change commodity as received attributes.

Garbage: The household fraction of municipal refuse typified by kitchen residues and other organic wastes.

Generator: Producer of residual materials.

Glass: Vitreous material made from the high temperature fusion of sand (silica) and additives to form an impermeable, transparent, sanitary product. Colored glass is obtained by adding small amounts of selected metals, salts, or oxides.

Grading: Sorting of a uniform material into homogeneous categories by hand or using hand tools. (See Sorting).

Hazardous Waste: Residual of industrial process or individual consumption which is potentially dangerous to humans and/or the environment.

HDPE: High density polyethylene.

High Technology: Advanced, or sophisticated technology requiring large capital outlay and highly trained technicians for operation and management.

Home Scrap: Materials of a known quality generated at the manufacturing site that are reintroduced in the production process.

Horizontal Integration: Production process which includes one or more feedstocks or one or more end products; e.g., production of paper products for newsprint, insulation and alcohol.

Inferior Good: Low value commodity which has an inverse relationship to income in terms of demand.

Informal Sector: Extensive economic activity which takes place beyond the boundaries of formal sector activity. Activity is small scale, labor intensive, unregulated and competitive. Employment and income is irregular with no social security benefits (See Formal Sector).

Infrastructure: Equipment and organizational requirements for efficient collection, processing and end use of secondary materials.

Integrated Curbside Collection: A residential area service combining collection of source separated, recyclable materials and refuse simultaneously.

Integrated Resource Recovery: The recovery of materials and energy from waste in different sectors of the society which are compatible with each other.

Intermediate Processing Center: Operation which receives a variety of secondary materials and prepares (e.g., shreds, bales, crushes) them for end use processes.

Labor Intensive System: The maximization of labor in all resource recovery activities. For example, recyclables can be separated without sophisticated machinery in a collection center.

Lapale: Indonesian term for scavenger sorting site.

LDPE: Low density polyethylene.

Life Cycle Cost: Total cost over the lifetime of a piece of equipment or material; includes capital, operating and maintenance costs.

Litter: Haphazard disposal of waste along streets, roads, and alleys.

Marginality: Socioeconomic concept defined by two characteristic features; lack of formal access to urban industrial production processes, and chronic insecurity of employment and income.

Market: Processor or end user (e.g., factory, mill) of a waste commodity.

Marketing: Processing by which buyers and sellers are brought together.

Material Grade: Specific classification of one category of waste commodity (See Grading).

Material Specification: Exacting requirements set by secondary materials end users to be met by providers of raw materials.

Materials Handling: Activities involved in aggregation, storage and shipment of waste commodities.

Materials Recovery: Extraction of waste commodities from solid waste by manual, mechanical or combined means.

Mechanical Separation/Recovery: Mechanical means (magnet, shredder, air classifier) to segregate mixed waste into material categories for recovery.

Metal (ferrous): Metals which are predominantly composed of iron. Most common ferrous metals are magnetic. In waste commodities forms usually include "tin" cans, automobiles, old refrigerators, and stoves.

Mixed Waste: Residues from a variety of products which are mixed together for disposal. This reduces value of individual products and materials to lowest common denominator.

Municipal Solid Waste: Waste generated from households, commercial and industrial facilities.

Nonferrous Metal: Metal commodities composed of various elements; e.g., brass, copper, aluminum.

NPK: Refers to nitrogen, phosphorous and potassium.

Obsolete Scrap (post consumer waste): Materials returned for recycling after commodity consumption. Usually the most difficult materials to recycle due to dispersal of generators and contamination by contrary materials.

Oil: Petroleum based products used as a fuel or lubricant. Used oil can be rerefined or cleaned for use as a fuel.

Open Dump: Nonsanitary landfill or disposal area which results in environmental degradation and public health dangers. (See Sanitary Landfill)

Organic Waste (garbage, putrescibles): Fraction of solid waste which is organic in nature; e.g., food scraps, and garden clippings.

Partial Feedstock: Virgin or secondary material used in addition to primary feedstock in an industrial process.

Pelletizer: Hydraulic mechanism for densifying mixed waste or homogenous materials into pellets or cubes to argument combustion or animal feed operations.

PET: Polyethylene Terephthalate.

Plastics: Roughly 40 families of polymers (petroleum derivatives) which are increasingly being used as substitutes for glass, metal, wood, leather, etc. They are divided into two types: thermosets (nonremeltable) and thermoplastics (remeltable).

Pollution Abatement: Planned reduction of pollutants from an industrial process which can be accomplished by technological additions (pollution control via electrostatic precipitator, wastewater filtration, etc.) or management actions (the substitution of secondary commodities such as cullet for soda ash, the deletion of an offending element, etc.).

Primary Feedstock: Virgin or secondary material used in largest amount in an industrial process.

Primary Materials Industry: Production of products from materials extracted from virgin resources.

Product Charge: Surcharge imposed on the purchase price of consumer product used to disperse the cost of disposal among the population. A product charge on automobiles for instance, guarantees funds for removal of abandoned auto hulks.

Product Design: Integrating factors of reusability, repairability, recyclability and remanufacturability into the initial design of a product.

Prompt Scrap: Scrap of a known quality generated at the raw material production stage and sold to intermediates for foreign plant consumption.

Recyclable: Waste commodity which can be utilized readily in similar or altered form.

Recycling: The collection, processing, transportation, and end use of a waste commodity. Material recycling refers to the use of secondary materials to form new products. Product recycling refers to keeping an item in its original form for reuse, repair, or remanufacturing.

Refugee Occupations: Available work for populations arriving from countryside to urban areas. Scavenging is a common refugee occupation.

Refurbish: The process where products are brought to a central facility for disassembly, cleaning, and reassembly.

Refuse: Mixed waste materials discarded by households and commercial establishments.

Refuse Compaction Vehicles: Collection vehicles equipped with hydraulic system to compress voluminous waste materials enroute.

Refuse Derived Fuel (rdf): Material derived from processed mixed waste used as a primary or partial feedstock to incineration.

Remanufacturing: The process in which large quantities of similar product cores are brought to a central facility and disassembled. Parts from a specific product are not kept together. New products are assembled from parts which are cleaned and/or repaired.

Repair: The process of bringing individual products back to a functional state on a one-at-a-time basis.

Residue: The materials remaining after completion of a chemical or physical process, such as burning, evaporation, manufacturing, distillation, and filtration.

Resource Recovery: A general term referring to any method for reclaiming materials or energy from municipal waste.

Roll-Off Bin: Specially designed storage container which can be hydraulically pulled onto the bed of a vehicle for efficient transport.

Roofing Felt: Heavy construction paper that is impregnated with asphalt for use as a roofing material. Generally comprised of 55% secondary fiber.

Rubber: A natural or synthetic elastic material comprised of polymers. Chemical treatment can enhance properties required for tires, shoes, insulation and other products.

Salvage Industry: Infrastructure of formal and informal enterprises engaged in recovery and processing of secondary commodities.

Sampling: Methodological analysis of representative portions of municipal waste which indicates quantity and quality characteristics.

Sanitary Landfill: Site specifically engineered for disposal of waste on land which minimizes potential air and leachate pollution. Operations include layering, compaction and soil cover at the end of the day.

Sanitation: The process of collecting, transporting, and disposing of waste materials in a hygenic manner.

Scrap: Segregated waste commodities suitable for recycling (See Home Scrap, Prompt Scrap, and Obsolete Scrap).

Secondary Materials: Wastes which are channeled back into a production process.

Separate Collection: Scheduled or nonscheduled collection of source separated commodities by service other than regular refuse collection.

Sorting: Separation of secondary commodities into uniform categories (e.g., glass, metals, etc.). Also, separation of recyclable commodities from nonrecyclable commodities.

Source Reduction (waste reduction): The reduction of waste generation at the source, or site of manufacture, via new production techniques, product package redesign and/or institutional design.

Source Separation (source segregation): The separation of waste commodities by generating households, agencies, and industries.

Sustainability: The concept of contributing to the long term viability of the environment.

Thermal-chemical Conversion: The conversion of organic waste into energy through combustion or chemical processes.

Transfer Station: Aggregation point for efficient transfer of waste materials to distant disposal sites.

User Fee (tariff): Surcharge imposed on individuals or group who pay for service level.

Value Added: Incremental value of labor or energy by processing of material or improvement of commodity.

Vermicomposting: The use of earthworms to digest raw or stabilized organic waste.

Vertical Integration: Operation of a production system along successive stages of flow of commodities from source through manufacturing to distribution; e.g., integrated pulp and paper mill.

Virgin Material: Raw materials extracted from natural resources used in manufacturing.

Waste Management: Public role of assuring proper collection and disposal of municipal waste to insure efficiency and public hygiene.

Waste Utilization: Transformation of waste commodities into new products.

White Goods: Appliances comprised primarily of ferrous metal, such as refrigerators, stoves, and washing machines.

Wobo (World Bottle): Experimental bottles designed by Heineken Breweries for use as interlocking building units after contents are consumed.

Zabaleen: Generic term for several Christian minorities in Egyptian cities who are responsible for collection, recycling, and disposal of solid wastes.

KEY WORD INDEX

GEOGRAPHIC INDEX

AUTHOR INDEX

World Bank Publications of Related Interest

Laboratory Evaluation of Hand-operated Pumps for Use in Developing Countries

Consumers' Association Testing and Research Laboratory

An invaluable guide for selecting water pumps. Paper rates 12 pumps on basis of rigorous testing to determine their strengths and weaknesses. Pumps rated for packaging, condition as received, installation, maintenance, repair, and overall desirability.

Technical Paper No. 6. 1983. 89 pages.

ISBN 0-8213-0133-0. Stock No. BK 0133. $3.

Laboratory Testing, Field Trials, and Technological Development

Contains results of laboratory tests carried out on twelve hand pumps for the World Bank and presents recommendations for improvements in performance, safety, and durability.

1982. 122 pages (including 3 appendixes).

Stock No. BK 9190. $5.

Meeting the Needs of the Poor for Water Supply and Waste Disposal

Fredrick L. Golladay

Examines economic, political, social, and cultural obstacles to meeting the needs of low-income people for water supply and waste disposal. Proposes steps to reduce these obstacles. Notes that communities organize and manage resources to carry out activities that cannot be profitably undertaken by households. Proposes methods to facilitate the formation and operation of community organizations to carry out these functions.

Technical Paper No. 9. 1983. 66 pages.

ISBN 0-8213-0238-8. Stock No. BK 0238. $3.

A Model for the Development of a Self-Help Water Supply Program

Colin Glennie

Presents one version of a practical model for developing, with high community participation, water supply programs in developing countries. Consideration is also given to sanitation program development and practical guidelines for program development are included. One of a series of informal Working Papers prepared by the Technology Advisory Group, established under UNDP's Global Project, executed by the World Bank.

Technical Paper No. 2. 1982. 45 pages (including 2 annexes, references).

ISBN 0-8213-0077-6. Stock No. BK 0077. $3.

Municipal Water Supply Project Analysis: Case Studies

Frank H. Lamson-Scribner, Jr., and John Huang, editors

Eight case studies and fourteen exercises dealing with the water and wastewater disposal sector.

World Bank (EDI), 1977. 529 pages.

Stock No. IB-0655. $8.50 paperback.

Notes on the Design and Operation of Waste Stabilization Ponds in Warm Climates of Developing Countries

J. P. Arthur

Practical design criteria for pond systems to fit various ambient temperature and reuse requirements, such as irrigation. Offers suggestions for start-up procedures, operation, and trouble shooting.

Technical Paper No. 7. 1983. 106 pages.

ISBN 0-8213-0137-3. Stock No. BK 0137. $5.

Ventilated Improved Pit Latrines: Recent Developments in Zimbabwe

D. D. Mara and Peter R. Morgan

Describes designs and materials for latrines, one for peri-urban areas costing about US$150, and a US$8 version for rural areas. Some 20,000 of the ventilated pit latrines have been built in Zimbabwe. They have been found very effective in eliminating odors and controlling fly breeding.

Technical Paper No. 3. 1983. 48 pages.

ISBN 0-8213-0078-4. Stock No. BK 0078. $3.

Village Water Supply

Describes technical aspects, costs, and institutional problems related to supplying water for domestic use in rural areas and proposes guidelines for future World Bank lending in this sector.

A World Bank Paper. 1976. 98 pages (including 4 annexes).

Stock Nos. BK 9099 (English), BK 9100 (French), BK 9044 (Spanish). $5.

Village Water Supply: Economics and Policy in the Developing World

Robert J. Saunders and Jeremy J. Warford

Addresses the problem of potable water supply and waste disposal in rural areas of developing countries where the majority of the poor tend to be found. Emphasizes the economic, social, financial, and administrative issues that characterize villae water supply and sanitation programs.

The Johns Hopkins University Press, 1976. 292 pages (including 4 appendixes, bibliography, index).

LC 76-11758. ISBN 0-8018-1876-1, Stock No. JH 1876, $22.50 hardcover.

French: L'alimentation en eau des communautes rurales: economie et politique generale dans le monde en developpement. Economica, 1978.

ISBN 2-7178-0022-0. Stock No. IB 0549, $7.

Spanish: Agua para zonas rurales y poblados: economia y politica en el mundo en desarrollo. Editorial Tecnos, 1977

ISBN 84-309-0708-4. Stock No. IB 0532. $7.

Water Supply and Sanitation Project Preparation Handbook

The three companion volumes guide planners, engineers, and community development and public health specialists working in projects related to water and sanitation in developing countries and help users prepare project reports. Case studies illustrate each phase of project development: identification, prefeasibility, and feasibility. Suggests approaches and methods of project evaluation to guide project team members.

Volume 1: Guidelines

Brian Grover

Technical Paper No. 12. 1983. 190 pages.

ISBN 0-8213-0230-2. Stock No. BK 0230. $5.

Volume 2: Case Studies—Identification Report for Port City, Immediate Improvement Project for Port City, Prefeasibility Report for Port City

Brian Grover, Nicholas Burnett, and Michael McGarry

Technical Paper No. 13. 1983. 352 pages.

ISBN 0-8213-0231-0. Stock No. BK 0231. $15.

Volume 3: Case Study—Feasibility Report for Port City

Brian Grover, Nicholas Burnett, and Michael McGarry

Technical Paper No. 14. 1983. 308 pages

ISBN 0-8213-0232-9. Stock No. BK 0232. $15. Stock No. BK 0367. 3-volume set: $25.

World Bank Studies in Water Supply and Sanitation

The United Nations has designated the 1980s as the International Drinking Water Supply and Sanitation Decade. Its goal is to provide two of the most fundamental human needs—safe water and sanitary disposal of human wastes—to all people. To help usher in this important period of international research and cooperation, the World Bank has published several volumes on appropriate technology for water supply and waste disposal systems in developing countries. Since the technology for supplying water is better understood, the emphasis in these volumes is on sanitation and waste reclamation technologies, their contributions to better health, and how they are affected by water service levels and the ability and willingness of communities to pay for the systems.

Number 1: Appropriate Sanitation Alternatives: A Technical and Economic Appraisal

John M. Kalbermatten, DeAnne S. Julius, and Charles G. Gunnerson

This volume summarizes the technical, economic, environmental, health, and sociocultural findings of the World Bank's research program on appropriate sanitation alternatives and discusses the aspects of program planning that are necessary to implement these findings. It is directed primarily toward planning officials and sector policy advisers for developing countries.

The Johns Hopkins University Press, 1982. 172 pages (including bibliography, index).

LC 80-8963. ISBN 0-8018-2578-4, Stock No. JH 2578, $12.95 paperback.

Number 2: Appropriate Sanitation Alternatives: A Planning and Design Manual

John M. Kalbermatten, DeAnne S. Julius, Charles G. Gunnerson, and D. Duncan Mara

This manual presents the latest field results of the research, summarizes selected portions of other publications on sanitation program planning, and describes the engineering details of alternative sanitation technologies and how they can be upgraded.

The Johns Hopkins University Press, 1982. 172 pages (including bibliography, index).

LC 80-8963. ISBN 0-8018-2584-9, Stock No. JH 2584, $15 paperback.

Number 3: Sanitation and Disease: Health Aspects of Wastewater Management

Richard G. Feachem, David J. Bradley, Hemda Garelick, and D. Duncan Mara

Summarizes knowledge about excreta, night soil, and sewage and their effects on health. Describes the environmental characteristics of specific excreted pathogens and the epidemiology and control of the infections these pathogens cause.

John Wiley and Sons (U.K.). 1983. 528 pages.

ISBN 0-471-90094-X. Stock No. IB 0558. $39.50 hardcover.

Appropriate Technology for Water Supply and Sanitation

The following volumes have been published in a less formal format. Some are abridgments of the three foregoing volumes.

Volume 1: Technical and Economic Options

John M. Kalbermatten, DeAnne S. Julius, and Charles G. Gunnerson

Reports technical, economic, health, and social findings of the research project on "appropriate technology" and discusses the program planning necessary to implement technologies available to provide socially and environmentally acceptable low-cost water supply and waste disposal.

1980. 122 pages (including bibliography), Stock No. BK 9186. $5.

Volume 1a: A Summary of Technical and Economic Options

John M. Kalbermatten, DeAnne S. Julius, and Charles G. Gunnerson

A summary of the final report on appropriate technology for water supply and waste disposal in developing countries, a World Bank research project undertaken by the Energy, Water, and Telecommunications Department in 1976-1978.

1980. 38 pages.

Stock No. BK 0049. $3.

Volume 1b: Sanitation Alternative for Low-Income Communities—A Brief Introduction

D. Duncan Mara

Describes in nontechnical language the various low-cost sanitation technologies that are currently available for low-income communities in developing countries and presents a general methodology for low-cost sanitation program planning.

1982. 48 pages.

Stock No. BK 9189. $3.

Volume 3: Health Aspects of Excreta and Sullage Management—A State-of-the-Art Review

Richard G. Feachem, David J. Bradley, Hemda Garelick, and D. Duncan Mara

Provides information on the ways in which particular excreta disposal and reuse technologies affect the survival and dissemination of pathogens. It is intended for planners, engineers, economists, and health workers.

1980. 303 pages (including 14 appendixes, references).

Stock No. BK 9187. $15.

Volume 10: Night-soil Composting

Hillel I. Shuval, Charles G. Gunnerson, and DeAnne S. Julius

Describes a safe, inexpensive treatment method for night-soil composting that is ideally suited for developing countries because of its simplicity in operation, limited need for mechanical equipment, low cost, and effectiveness in inactivating pathogens.

1981. 81 pages (including bibliography, 2 appendixes).

Stock No. BK 9188. $3.

World Bank Research in Water Supply and Sanitation—Summary of Selected Publications

A bibliography summarizing the papers in the Water Supply and Sanitation Series, as well as the World Bank studies in Water Supply and Sanitation published for the World Bank by The Johns Hopkins University Press.

1980.

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