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Future Trends Which Will Influence Waste Disposal

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The disposal and management of solid wastes are ancient problems. The evolution of practices naturally changed as populations grew and sites for disposal became less acceptable. The central search was for easy disposal at minimum costs. The methods changed from indiscriminate dumping to sanitary landfill, feeding to swine, reduction, incineration, and various forms of re-use and recycling. Virtually all procedures have disabilities and rising costs. Many methods once abandoned are being rediscovered. Promises for so-called innovations outstrip accomplishments. Markets for salvage vary widely or disappear completely. The search for conserving materials and energy at minimum cost must go on forever.

Winston Churchill once remarked, in a speech at M.I.T. (1949), that our problem in public affairs is "to discipline an array of gigantic and turbulent facts." This well characterizes the solid waste challenge. As others have already noted at this session, and need not be repeated here, we have a "gigantic" accumulation of solid wastes and an equivalent collection of real and imaginary facts. Of real data, we are always in short supply when we attempt to convert principles into reality.

The Not-So-Distant Past

Before recklessly prophesying the future, a look at the past is relevant. It is a cliche to assert that those who ignore the past are destined to repeat its mistakes. It should disclose practices now rediscovered, list reasons for failure, and seek to do better in resurrecting them. Diagnoses of failure, theoretically, should provide wiser therapies than those of decades ago. Recycling and re-use are new names for old wines figuratively in new returnable bottles. Their fate is here examined.

Solid wastes were once described as "matter in the wrong place." This definition implicitly recognizes that such wastes are really never disposed of. They are converted into something else, which ultimately must be taken care of. The materials which concern us have a wide spectrum of hazard—from odors, rats, and flies all the way to potential poisons and explosives. Their contents have changed over time as our way of life has changed. Technology has modified composition and concentration in heroic ways.

The evolution in processes of disposal is enlightening. They moved from simple dumping on land or sea, to burial, sanitary landfill, feeding to swine, reduction, incineration, and various forms of composting. In all of these, a first priority was to place material out of sight at minimum cost. The second was to find some value in it, which would help offset increasing costs. And lastly, a cost-effective industrial approach was necessary through salvage. It was recognized that "recycling" and "re-use" were built-in aspects of disposal. They were not, then or now, alternatives to or substitutes for disposal, but supplements to management of materials. These do not disappear by sleight-of-hand or by new semantics.

A few examples of the methods pursued will suffice to show why so-called successful procedures failed. More important are the lessons then learned which are being repeated today.

Return to the Land or Water

This ancient procedure was common at the turn of the century. Its failures were many, dominantly due to less than intelligent management. Dumping at sea, practiced by large coastal cities, was a disaster. Placement on land moved gradually toward a new terminology of "sanitary landfill," but too

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many places continued relatively uncontrolled dumping. The charm of the method, of course, was in low cost. Site selection has become one of the major indoor and outdoor sports of a militant public.

Feeding to Swine

One of the earliest conscious efforts to recover values from a waste material was in the provision of a food supply for hogs. It was an ancient, as well as an assumed modern, beneficial process, practiced by a number of major cities. Why has it disappeared? The case history of Los Angeles is one of significance.

This region was favored by a swine farm site some 50 miles from the city loading plant. The farm operated for many decades, handling at one time 60,000 hogs. Their garbage food was supplemented by grain, soybean, fish meal, and green cut alfalfa. At one time (1944-1945) some 9,000,000 lb (4.1 Gg) of pork was sold annually. The farm was run by private contractors, who, for some time, paid the city a significant sum per ton of the garbage. This amount was reduced on each contract renewal, as the food content of garbage decreased substantially, because of the advent of food refrigeration and packaging. Finally, the contractor demanded and received a per ton payment from the city, instead of the reverse.

In the meantime, epidemics of hog cholera and other swine diseases, swept the farm, with the loss of some 1600 hogs. To top off the historically successful re-use effort and its decline, the farm had to be moved even further away, because the existing location, in a one-time desert, became too populated. The operation no longer survives.

This history carries within its chronology all of the lessons to be relearned regarding re-use, namely change in technology, change in people habits, disappearance of appropriate sites, problems of disease, misuse of control, and cost-effectiveness.

Demonstrations of sound objective were paralleled in the New York City–New Jersey metropolitan area, Baltimore City, and over 10,000 smaller urban centers. The process has been largely relegated to the history books.

Reduction

Presumed values in solid wastes were diligently sought by many major cities of the U. S., after the public and the Courts declared indiscriminate dumping at sea and on land, poorly executed for the most part, totally unacceptable. This led to the adoption of a process known as reduction: essentially subjecting garbage to pressure cooking and skimming, with drying of resulting solids. The end products were a low-grade fertilizer, grease, and an evil liquid difficult to get rid of. The hope was that such a process would produce marketable substances, at a price to offset somewhat the costs inherent in handling. And, for a while, so it did, but under uncomfortable circumstances. My own city, Baltimore, was among the major cities using it. Its record is written indelibly in my mind, because no small part of my time was spent in and out of the courts of justice on suits against the city. New York, Chicago, Rochester, Detroit and others kept us company, with varying degrees of success and failure.

What happened at this peak of reduction process use during the 1930's to the end of the 40's? Aside from the troubles encountered with the separation of glass, metals, rags and paper, stack gases were vile. They did not lend themselves either to removal or treatment. In fact, the application of the Yandell-Henderson method (dominantly chlorination) made matters worse. Cooking at some 90 psi (620 kPa) pressure posed many problems.

If all the mechanical and chemical difficulties had been resolved, the process would have collapsed because of the ever present inexorable forces of the market place. These still plague the recycler today!

Tankage fertilizer values in nitrogen, phosphorus, and potassium were low and not competitive with increasing availability of chemical fertilizer. Prices dropped from about 4 dollars per ton ($4.40/Mg) to zero. The market evaporated. Grease prices reached a high of $0.33 lb ($0.73/kg), with only one buyer, who used it to make glycerine. When glycerine was synthetically produced, both the buyer and the price disappeared.

With this experience confronting the city, coupled with persistent complaints, law suits and damages, the officials ultimately abandoned what had looked like a sensible, conservationist's dream. Cities searched diligently throughout this period for more acceptable methods of handling solid wastes. Some cities had already decided that the best thing to do was to "burn the stuff up," rather than struggle with it. Baltimore began this method as far back as 1925, accompanied by hand picking of salvageable glass and metal. Actually, true incineration did not ensue because of relatively low furnace temperatures. The first high temperature incinerator, for mixed garbage and rubbish, went into operation on January 1, 1933. Subsequently, others were built or renovated up to the present unhappy struggles with pyrolysis. Throughout this period, landfill areas were essential for "spill over" materials of whatever origin. Materials salvaged varied from 7 to

nearly 10% of refuse annually—fluctuating sharply with market prices. Eventually markets disappeared.

In a review of the situation in 1942 (*1*), the following comments have high relevance.

> "Any decision as to salvaging methods which should or should not be employed, or whether to salvage at all, can hardly be considered a financial one, as the net gain from salvaging compared with other items of costs of refuse disposal is more or less negligible."
>
> "Salvaging should be continued, irrespective of the economic cycle, to separate materials . . . which are harmful to the furnaces."
>
> "Salvaging other materials not harmful to the furnaces, except in periods of high scrap prices, . . . is unprofitable."
>
> "Under present war conditions . . . decision as to what . . . are to be salvaged . . ., the needs of the military forces and the civilian population must be given consideration, irrespective of price and cost factors. Under peace time conditions, America has been and probably will continue to be a nation of plenty. Usually it has been assumed that it was economically more advantageous to create new supplies than to salvage old materials. However, under emergency conditions resulting from war, or under a post-war development of an older and more stable economy, the necessity for decreasing destruction of basic materials becomes increasingly great." (*1*)

Strangely prophetic for a view 35 years ago!

The Prospect: A Dim Beacon

While one must not forget the past, one should not be constrained by it. Success may be on the horizon in the revival of old processes, modified by new technology, greater efficiency in management, and new tools for rapidly identifying the pros and cons of alternative choices. Theoretically these should lend some conviction to the contention that past failures are correctable or avoidable.

Present practices, illustrated here, tend to provide no great optimism for the enthusiasms of the day. Aside from Madison Avenue predictions of the millenium in solid waste management, aided and abetted by some government agencies, it would be foolhardy to promise beleaguered urban officials that their wastes are gold and silver mines. If they are, corporate miners are not falling over each other to corner the rights to their development. A few examples may suffice to demonstrate the dilemmas in which we find ourselves in the eternal search for the potential Holy Grail. The search must continue (*2, 3*).

Devotion to the Sanitary Landfill

The countryside is literally dotted with landfills. Most of them are neither sanitary nor fills. All of them are cheap—a most valuable asset in these days of urban near-bankruptcy. Even if they were not cheap, they are in fact badly needed, not only for emergency over-spill, but as depositories for demolition wastes, ash, and other noncombustible materials.

Because of their value, diligent search goes on to make something of them. As potential building sites, they have a long history of less than satisfaction. Recent efforts to improve their potential for building have been successful only at excessive costs. I should rate as quite low the probability of wide use for buildings, even with the ingenious and costly collection of objectionable gases to central points for disposal.

Since methane is one of the normal products of decomposition of materials in a fill, imaginative engineers in California decided to capture the gas. Wells were put down in the fill and gas was released. A user contracted to buy the by-product, calculated to be available in significant amounts. More wells were sunk. First yields were exciting, declined day by day and finally reached an apparent stationary amount, too little to be commercially useful (*4*).

The undertaking is a most laudable response to salvaging as much energy as possible from an otherwise waste product. The initial results were disheartening. The fill was estimated to produce 425 billion BTUs (448 TJ) or 68,000 equivalent barrels (10,800 m^3) of oil. Actually, only 24 billion BTU (25 TJ) resulted in a calculated equivalent of 4,000 barrels (636 m^3). The discussion need not be burdened with listing unexpected and uncomfortable technical problems. Whether these will be resolved remains to be demonstrated. The author of the review supplies us with some very cogent advice, which is shared with the reader, because it is universally applicable to all those anxious and hopeful to conserve.

Dair proposes two commandments (*4*): "Thou shalt not assume that untested resource recovery processes will perform as planned." "Thou shalt not promote prior to proving." He suggests caution with any energy production scheme dependent on marketing a sub-standard energy product for its success. In short, he said, resource recovery is not easy.

These commandments for decision making are also not easy to follow, when viewed in a climate of public hostility to virtually any location for a fill, an incinerator, a transfer station or what not.

Other Methods for Energy Production

Many decades before the oil crisis, attention was directed to the production of energy from solid

wastes. The incinerator at Atlanta, Georgia, was selling steam over 30 years ago. Few cities followed this example to the degree exemplified by Atlanta. The reasons essentially were unfavorable economic analyses projected in many studies elsewhere.

The energy crunch of today revives a strong interest in developing energy sources wherever they may be found. The thermal energy in solid wastes, actually not so high, seem to offer a promising development field. Interest was great and promises even greater. How do we fare? A few examples should be noted.

The principle of oxygen-free combustion, known as pyrolysis, was an immediate candidate for innovative solution. Theoretically sound, its promise captivated public agencies and private corporate enterprise. An apparent successful pilot plant was built. Then Baltimore City was chosen to demonstrate the validity of a 1000 ton (907 Mg) per day operation. Its doleful 20 million dollar experience, since its beginning, need not be recapitulated here. The plant violates both commandments promulgated by Mr. Dair. Its rehabilitation by the city, at a cost of more millions of dollars, is now under way. The experiment failed, but the principle remains to be validated. The desertion, by a major corporate entity, of the plant it designed and operated, leaves an unexplained black mark against the responsibility of private enterprise.

Another example of a totally different nature is the failure of a highly touted and convincing effort in St. Louis. There solid wastes were to be injected directly into furnaces as fuel for the production of power for a major public utility. Joint agreements had been signed by responsible parties. The project fell apart, not because the idea was not good, but because the citizenry could not agree on the right location for a transfer station for the trucking of the wastes.

The third example is at Saugus, Massachusetts. That project needs special mention because of its skillful development and consumation of a regional program, involving private and public groups. So well was this evolved that the enterprise was awarded a national environmental prize.

It is reported to have problems both in design and operation, which hopefully may be resolved.

The gap between idea and actual use is long familiar in any technologic advance. In the case of solid wastes conversion, the gap unfortunately is still wide and may dishearten the diligent advocate. Seattle presents a good case history of second thoughts leading to long deferment of an intriguing proposal (*5*).

In November 1976, the city initiated feasibility studies for a $100 million resource recovery project to produce marketable anhydrous ammonia. Pyrolysis units were to be used. Construction was to be started in 1978 and production to be on stream by late 1980.

By early 1977, Seattle abandoned the program for pyrolysis resource recovery from 1500 tons (1.4 Gg) of refuse per day and turned to investigate alternative technologies. The city's decision resulted from further cost analyses indicating plant investment might reach $200 million by 1981. In addition the value of the pyrolysis gas might be $4 per million BTU ($3.80/GJ), compared to a national market value of $1.50 ($1.40/GJ).

Examples need not be extended. Energy recovery from wastes is both encouraging and disappointing. Transition from idea to pilot plant to full scale is not only difficult, but too often a failure. Capital and operating costs are high, often two to three times as high as alternative acceptable orthodox processes.

In spite of all these considerations, society demands, and should receive, a continuing pursuit of resource recovery. Many of us hoped, for more than a half a century, that solid waste disposal might well follow a factory approach. The raw materials conglomerate is such that the accomplishment still eludes us.

Recycling Hopes and Realities

Never in recent history has the public been so aroused as to press for recycling waste matter, e.g. cans, bottles, newspapers, rags. For a long time, the only recyclers were the city departments and the itinerant collector, now almost extinct. The concerned citizen has the stage at this moment. How long his interest will last is unpredictable. While it does, the pressure for recycling may go on. The headline in the Baltimore newspaper of August 29 is symptomatic of that concern. It read: "Woman Recycles Bottle No. 1 Million," when she returned it to the Carling National Brewery. The Brewery pays 1 cent a bottle, and 10 cents a pound for steel and aluminum cans once containing a favorite beverage, beer.

These efforts are paralleled by others buying newspapers, rags, and metals. This activity is one side of the shield. The other side displays the familiar historical market place picture. Paper salvage is a good illustration. There is a market, unfortunately volatile. The Sunday New York Times weighs a little over 5 lb (2 kg). Its collection and disposal (2 kg) costs run into millions of dollars a year. It should not be thrown away, but who wants it? In paper, as well as other recovery, business is only fair, highly variable, and disappointing.

Recycled paper consumption is stagnant and low. Most nonferrous scrap metals are still only marginally above very low levels in 1975. Aluminum is better than holding its own. Waste textiles are very low in recapture. Synthetic fibers particularly pose recycling problems. The market for iron and steel scrap will probably be less than in the depressed year 1975. Steel producers are relying on iron ore. It has been aptly said that nonferrous metals, like iron and steel, tend to roll with the economy. And this is true with the other recyclable products, as it was 30 or 40 years ago (*6*).

If it is true, as some insist, that solid waste may be a resource disguised as a nuisance, then supplementary aids for its successful continuous recovery must be discovered. The obvious ones are governmental subsidy, more favorable freight rates, adjusted tax benefits. These routes are geared to affect the behavior of the market place. While not the subject of this paper, it may be noted that this is not the first time that conservation policy may run head on against economic constraints!

Table 1. Sources of hazardous wastes categories.

No.	Categories
1	Heat-treatment cyanides
2	Metal finishing
3	PCB and analogs
4	Mineral oils
5	Solvents
6	Halogenated hydrocarbon solvents
7	Mercury wastes
8	Arsencials (and antimony and selenium)
9	Pharmaceutical, including steroids and hormones
10	Medical and infected
11	Pesticides, fungicides, herbicides
12	Tarry wastes
13	Asbestos
14	Phenols, cresols, and derivatives
15	Miscellaneous organic compounds
16	Metals and their compounds. Manganese, lead, zinc, boron, nickel, cadmium, beryllium, etc.
17	Aerosols
18	Salts
19	Chelating compounds
20	Explosives
21	Radioactive

More Hazardous Materials

Solid wastes in general are potentially dangerous. Some materials are more dangerous than others and require much more care in management of their collection and disposal. Classification of more hazardous substances reflects the time, place, and attitudes of lay and responsible official agencies. Public Law 94-580 of 1976 requires EPA to define and list hazardous wastes, leading to assumption by the States of the duty of monitoring and managing them. California, Illinois, and Texas have already formulated such guiding definitions more elaborately than the Federal government itself (*7, 8*). Texas has developed several ingenious indices to assist decision makers on methods of control. A "hazardous index" has been developed which embodies considerations of toxicity and waste components. It is directed toward obtaining some kind of estimate of potential environmental risk. Great Britain, and to some extent West Germany, have long regulated management of such substances. Internationally, the World Health Organization has concerned itself with some 90 of them.

What are some of these? Anybody's list is intimidating when culled from the activities of an industrialized society. Table 1 (*9*) provides suggested origins sufficient to make the point that something must be done with them, either at the source or by careful management for retention, disposal or reuse. Proposals for and activities in their control, as with any other wastes, presuppose legal sanctions, monitoring, record keeping, specialized equipment, institutional management, and education in industry and public alike. All of these have been practiced in Western Europe and to some extent in the United States.

What is happening now is a conscious national effort to regularize, expand, and universalize the handling of hazardous materials. Uniformity of purpose should not lead to uniformity of disposal, since methods of safe disposition are as varied as are the materials in Table 1.

Even a cursory examination of procedures in use or in consideration makes clear that easy answers are not at hand, nor are they likely to be. Fortunately, ever-growing literature on the subject threatens to equal the tonnage of the hazardous wastes. Labeling of materials during transport will become compulsory for all those of hazard. Universal information systems on accidents will be required, such as are reasonably well practiced in accidental pollution of rivers. Tankers travelling in national waters may well be required to institute both labeling and standard information systems.

Subsurface storage for toxic wastes has always had an attraction as out of sight and out of mind. For many years, deep well disposal for oil brine wastes was a normal procedure. Today, it is being re-examined to determine whether it continues to be wise. Only recently, investigators in U. S. Geological Survey added some reassurance on careful use of subsurface storage (*10*). They pointed out that some of these environments, in the Atlantic Coastal Plain from North Carolina through New Jersey "may have the geologic potential for the storage of

toxic waste." It is not a quick and easy solution. "As any other resource, the nation's underground space is limited." Its use must be understood, to avoid misuse.

Many objectionable materials have been and still are deposited on the surface or shallow buried. In too many instances, their fate has not been monitored or assessed. Cyanide wastes and acids have frequently been so handled. Their sites are now being reviewed and the findings will undoubtedly lead to more careful specification for control. Hazards to ground and surface waters are ever present with shallow surface dispersion, whether in ground or in pools.

Incidentally, the holding of toxic wastes in large pools, to be periodically released intentionally or otherwise during floods in receiving rivers, has not proven to be an unmixed blessing. Spills have been too frequent and simply confirm the fact that actual control is less than satisfactory.

A number of aspects of these problems are elaborated, for many wastes of potential damage, in a document recently released by the American Society of Civil Engineers. The studies therein are directed to possible re-use in industrial process or public works. History so often repeats itself (*11*). One of these papers reports on studies of the possible use of wicks to dewater dredged material. Forty years ago this was tried, in the Baltimore area, on a full-scale airfield built on dredged material. It was a dismal failure, because planes landing on it sank!

A discussion of this subject in Los Alamos would hardly be complete or even neighborly, if no mention were made of radioactive wastes. A third of a century ago, on one of my recurring visits to this site, I had breakfast with one of the principal atomic energy developers. The major topic of conversation was high level radioactive wastes. I was assured that any concern with this hazard was exaggerated and unwarranted—in fact, essentially a nonproblem. The position he voiced was rather generally that of officialdom. For a long time, budget allotments for resolving the problem were meager and reluctant. That point of view held the seed for the emotional battles we now see with respect to these by-products.

Since that time, a great deal of effort and money has gone into examination of the problem. Investigation was undertaken on a small scale and continued for many years, within the laboratories of the Atomic Energy Commission. In total, in spite of some internal skepticism regarding the problem, much information of great value was accumulated. Data are available and of high significance in realistically appraising the situation. Calm discussion is considerably clouded, however, by the introduction of fears of terrorists' use of nuclear materials.

Atomic wastes have always offered a grand opportunity for less than balanced debate. They are exotic, difficult in terminology, coupled with Hiroshima, and sufficiently mysterious to present a marvelous subject for acrimonious battle. The management of radioactive wastes is the victim of orderly and disorderly public contests. A balanced consideration of the central issue of disposal has become difficult. For the moment, their management is reasonably effective. What about tomorrow?

Few people realize how little volume these wastes represent. Most estimates agree that the military inventory is much higher, but more dilute, than the civilian. This difference will be greatly reversed from now on, on the bases of projections to 1985. About 150,000,000 gallons (570,000 m^3), from both sources, are now being held in storage (*12*). ERDA estimates that, by the year 2000, the total national inventory of high level solid wastes will account for some 600,000 ft^3 (17,000 m^3). If stored in one place this would be equivalent to an 85 ft (26 m) cube. The critical substances would be strontium, cesium, and plutonium, all with long half-lives.

A vast amount of study has been undertaken on the ultimate disposition of these materials. Much of this information is buried in AEC files and is gradually being rediscovered. Reference to this and recent elaborate inquiries disclose that opportunities for protected disposal are available. All of the studies presuppose, for the time being, that the radioactive wastes can be solidified, packaged, and permanently deposited in appropriate geological formations. Problems of safe transport have been exaggerated in the heat of public discussion and fears. Earlier experimental deposit in a salt mine was peculiarly inept and ill-prepared. The failed effort added to public suspicion.

In any event, the studies at the Savannah River Plant site (*13*), solidification processes which developed over the years at AEC laboratories, ERDA review of alternatives (*14*), and Royal Commission (*15*) examination in Great Britain all indicate that practicable, safe, but costly methods are at hand. The decisions must run the test of public acceptance, in a climate scarcely adaptable to deliberation.

Virtually all of these studies agree that permanent storage in geological formations, e.g., salt mines and/or bedrock, is practicable. Bedrock methods show a low combination of cost and risk and the lowest budgetary costs. The parameters governing possible mechanisms of migration of radionuclides in geologic formations have recently been assessed.

The results are salutary, in that they disclose, theoretically, that releases through a glass matrix

would be very slow and the choice of a suitable geological formation would be less difficult. For additional safety, an artificial geochemical barrier might reinforce the confinement (*16*).

Of greater significance are recent calculations of the relative migration ratio of plutonium and americium in various rocks. The finding is that little of either, under radioactive decay, "can reach the external environment from a well-designed and isolated geological repository site" (*17*). Unfortunately, one of the disabilities in permanent confinement is that retrieval sometime in the future would be costly and in some instances impracticable.

Final decision by DOE on selection of repository sites and on acceptable processing of materials to be so sequestered is expected by 1978. Too leisurely approach in the past decades needs to be reemphasized, so that the issue is not again deferred for ever endless debate. The British Royal Commission (*15*) summarizes the situation most aptly: "The picture that emerges from our review of radioactive waste management is in many ways a disquieting one, indicating insufficient appreciation of long-term requirements either by government departments or by other organizations concerned. In view of the long lead times that will almost certainly be involved in the development of appropriate disposal facilities, we are convinced that a much more urgent approach is needed, and that responsibilities for devising policy and for executing it need to be more clearly assigned."

An excellent summary (*18*) of past, present, and future aspects of high level waste management is now available in recent testimony by Lieberman, Rodger, and Baranowski, before a commission in California. It is required reading for anyone concerned with this pressing and fascinating problem. For the diligent historian, the files of AEC are rich in reports and papers on the subject by dozens of dedicated workers, among whom the names of Gorman, Christenson, Newell, Moeller are only illustrative of the forgotten investigators.

The European Lesson

A footnote on European practice (*19, 20*) is important, because those countries have experienced shortages of materials and of energy longer than we have. Throughout their centuries of activities they have had more pressing reasons for conservation of food and other substances. Their solid waste inventories show less metal, glass, and paper. Salvage, particularly of paper, has a long record of successful implementation. Garbage and other organic materials are surprisingly low, in comparison with U. S. concentrations.

A great deal of research is being carried out throughout all the countries, directed toward re-use for building materials, for paper return to mills, for better handling of plastics, recapture of metals, and more efficient composting.

Incineration, and production of energy, are almost commonplace. Some insist that their incinerators are far more efficient than ours.

The general impression of their technology and its management is that of greater care, less real waste, and higher efficiency. Their practices confirm the adage that necessity is truly the mother of invention. We are late comers on this stage!

Conclusion

The management of solid wastes remains a continuing challenge to the ingenuity and imagination of responsible scientists and technologists. The material is complex and everchanging. It has implicit values and potentialities generally difficult to salvage and often less than anticipated. Salvage and re-use have a long history—promising and disappointing. The economic forces of the market place, coupled with equally wide variations in the composition of the wastes, account for both promise and non-fulfillment.

In recent years, a conscious public and private drive toward conservation has given rise to the development of processes for energy production and re-use. They have no striking innovations beyond earlier familiar methods. Success and failure characterize their application. In some instances, process has been useful in off-setting costs of disposal. In others, major innovations have fallen short of expectations.

In the case of the more hazardous materials, past management has been less than diligent and protective of public safety. Under federal pressure, practice should be strongly upgraded in transport, identification, and controlled disposal.

The major lesson from past and present methodologies is that the pursuit of new processes and of recycling must continue unabated. Waste products should become less than waste. The scientific and technologic adjustments required to reach more effective goals must be sought and brought to fruition. Improvements will result, but the millenium of complete recapture of values is unlikely to appear very soon.

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