IC 8549

Bureau of Mines Information Circular/ 1972

Energy Potential From Organic Wastes: A Review of the Quantities and Sources

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8549

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By Larry L. Anderson
Formerly With the Division of Coal, Washington, D.C.

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

BUREAU OF MINES
Elburt F. Osborn, Director

This publication has been cataloged as follows:

Anderson, Larry L

Energy potential from organic wastes: a review of the quantities and sources. [Washington] U.S. Dept. of the Interior, Bureau of Mines [1972]

16 p. illus., tables. (U.S. Bureau of Mines. Information circular 8549)

Includes bibliography.

1. Fuel. 2. Agricultural waste. 3. Refuse and refuse disposal. I. Title. (Series)

TN23.U71 no. 8549 622.06173

U.S. Dept. of the Int. Library

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ENERGY POTENTIAL FROM ORGANIC WASTES: A REVIEW OF THE QUANTITIES AND SOURCES

by

Larry L. Anderson [1]

ABSTRACT

Enormous quantities of organic wastes are produced each year in the United States. The total amount is in excess of 2 billion tons and at least 880 million tons of this is moisture- and ash-free organic material (dry organic solids), representing a potential energy source of significant magnitude that is not being utilized. Bureau of Mines scientists have developed methods for converting these wastes to convenient energy forms.

This report itemizes and evaluates for the first time in detail the quantities and sources of moisture- and ash-free organic material contained in manure, urban refuse, industrial wastes, sewage solids, and agricultural wastes in the United States. Furthermore, estimates are presented for amounts of organic wastes collected or concentrated. The potential for fuel, either oil or gas, from both the total organic wastes generated and those collected or concentrated is also estimated.

BACKGROUND

The productive economies and high standards of living of the developed countries of the world are dependent, to a large extent, on the availability of abundant, inexpensive energy. In the United States the total energy input for 1970 was estimated at 68.8×10^{15} Btu (23),[2] and future needs are expected to be even greater. For example, energy needs are expected to double in the United States in the next 15 years. In 1970, 96 percent (25) of our energy was supplied by oil, gas, and coal. The reserves of these fossil fuels, although formerly in abundant supply are expected to decline severely in the next 30 years; indeed some shortages of the most desirable fuels are already occurring.

Some of our future energy will come from nuclear sources, but nuclear energy is expected to supply only 23 percent of our energy needs in the year 2000 (23). Clearly we are dependent, and will remain to be, for at

[1]Physical scientist, on leave from the University of Utah.

[2]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

least several decades, on energy from fossil fuels. However, another source of energy is available from material that is becoming an overwhelming pollution and nuisance problem. Unlike coal, gas, and oil, this source is continuously replenishable. It is the organic waste material produced by our industries, our livestock, and our population. In the past, most of this material was viewed only as a problem of constantly increasing solid waste disposal. In view of the energy shortages facing the Nation and the disposal problems created by organic wastes, we can and must look upon organic wastes as new sources for clean energy. The chief constituent of these organic wastes is cellulose; this material, continuously made by photosynthesis from water and atmospheric carbon dioxide, is the most abundant renewable raw material in the world. Riley has estimated the total organic carbon production of the earth to be $146 \pm 87 \times 10^9$ tons per year (16). Of course much of this carbon in the form of cellulose is so dilute in the terrestrial environment that it cannot be considered reasonably as an energy source available to man.

The cellulose produced by photosynthesis on the earth is the chief basis of all fossil fuels. These fossil fuels are only a small fraction of the living material that was formed in the past. By special conditions and entrapment, coal, oil shale, petroleum, gas, and bituminous sands have been preserved. Most of the organic materials that formed in past ages have long since been converted by oxidation back to carbon dioxide and water.

When this oxidation takes place in our streams and rivers, water pollution results. When inefficient combustion of organic materials takes place air pollution ensues. A more desirable method of returning organic materials to the raw materials for photosynthesis is to convert the presently considered waste to a useful material. One possibility is to convert organic wastes to a usable form of energy. This would not only increase the energy supply when there are shortages to be faced but it would also contribute to the preservation of a clean environment by disposing of large quantities of waste materials.

Research has shown that organic wastes can be converted to fuels--either oil or gas. These fuels could be burned to produce electric power while simultaneously the carbon and hydrogen would be returned to the environment as carbon dioxide and water vapor.

Manure, crop wastes, and other organic materials can be simply burned as fuel. These materials, however, do not burn efficiently and they have low heating values ranging from 3,000 to 6,000 Btu per pound. Furthermore, some of these wastes are accumulated only at certain times of the year making their supply interruptible as direct energy sources.

CONVERSION OF ORGANIC MATERIAL TO OIL OR GAS

The Bureau of Mines is concerned with the vital problem of energy shortage in the United States and the preservation of our environment. One method of utilizing coal, our most abundant fossil fuel, in a manner which is compatible with the environment is to use it as a liquid fuel that is low in sulfur.

While engaged in research to develop methods of converting coal to such a low-sulfur oil, Bureau scientists discovered that urban refuse, waste paper, sewage sludge, and other organic materials could be converted to oil. The reaction to produce oil consists of treating the organic material with carbon monoxide and water at 250° to 400° C and 2,000 to 5,000 psi pressure (2-3). Results given in the cited publications indicate that the oil produced, a brownish-black liquid or a semisolid at room temperature, has a heating value of 15,000 Btu per pound. The sulfur content in the product oils from various wastes was as follows:

	Percent
Pineneedles and twigs	0.10
Sewage sludge	.64
Municipal refuse	.13
Cow manure	.37
Cellulose	.003-.2

Oil yields of more than 33 percent have been obtained from runs using a continuous system. This yield would mean 2 barrels of oil could be produced from each ton of dry organic material processed.

Preliminary calculations show that approximately 0.75 barrel of this oil would be required to provide energy for the process (drying, compression, and CO production). This calculation was based on a CO usage of 0.5 pound of CO to process each pound of dry organic refuse. Thus, 1.25 barrels of oil could be realized from each ton of dry organic waste. This oil could be further processed to refined products. However, a more likely use, which would require little or no further refining, is to use the oil as a fuel to generate electricity. Because of its low sulfur content, this oil would make a desirable replacement for high-sulfur coal or residual fuel oil, which is becoming increasingly scarce.

Another process for converting organic wastes to a more usable form of energy involves gasification to a pipeline quality gas. The Bureau of Mines has considered this method of conversion and indications are that at least 5.0 standard cubic feet of methane (net) could be produced from each pound of metal- and glass-free urban refuse (7). Urban refuse has an obvious advantage over other feed materials for synthetic pipeline quality gas: the supply is greatest in or near large cities where the demand for natural gas is highest.

QUANTITIES AND SOURCES OF ORGANIC WASTES

The most abundant waste materials containing organic solids are manure, urban refuse, and agricultural wastes. The total of these various organic wastes generated yearly in the United States is over 2 billion tons. The largest portion of this waste is manure and other agricultural wastes. Urban refuse (including domestic, municipal, and commercial) and industrial wastes constitute also a significant portion. (Industrial wastes are those resulting from an industrial operation or establishment, especially those not collected as part of the urban refuse.)

The quantities of organic waste generated in the United States have been given by several authors during the past several years. The basis of calculating these quantities has not always been uniform. In the following sections the quantities calculated are "dry organic solids." In many publications by authors in agriculture the term "volatile solids" is used. This is defined as the solid material volatilized in a furnace at 650° C (9). This term has been assumed to be synonymous with "dry organic solids," that is, moisture- and ash-free organic material.

Manure

The total quantity of animal wastes has been given in several ways. Manure or animal waste production has been described to be "in excess of 1.7 billion tons (15), approximately 1.7 billion tons (19), 2 billion tons (12, 14, 24), or 1,562,721,000 tons (6).

These quantities describing the amount of "manure" produced by various farm animals may represent different things. Loehr (14) has reviewed this problem in detail as follows:

> A review of a large number of publications reveals that the term "manure" may mean any one of a number of things: (1) fresh excrement including both the solid and liquid portions, (2) total excrement but with enough bedding added to absorb the liquid portion, (3) the remaining part of the total excrement after most of the liquid has drained away, (4) the remaining material after liquid drainage, evaporation of water, and leaching of soluble nutrients, or (5) only the liquid which has been allowed to drain from the total excrement. The water content of each of the preceding materials is highly variable.

The important point is that most of the values given for "manure" or "animal wastes" include water ranging from small percentages to 87 percent. When evaluating these materials as energy sources, the water must be excluded. The organic solid materials which can be converted to oil or gas for fuel turn out to be much smaller quantities than those described in the first paragraph under Manure.

Minimum quantities of animal wastes can be calculated from data available on the physical and chemical characteristics of animal wastes, the quantities produced by each animal species, and animal population statistics. Loehr (14), Miner (15), and Taiganides (18) have all tabulated data on fecal waste production by various kinds of livestock. Table 1 summarizes the waste generation by major farm animals. Estimating how much waste animals generate is complicated by the fact that waste production may vary much depending on the conditions of confinement, type of feed, and other conditions. The data in the table given by Loehr takes this into account and this results in a range of values for dry "volatile solids" (14). A reasonable minimum value of the total organic solids produced from major farm animals as shown in table 1 is 200 million tons per year. A maximum value for organic wastes from this source, based on characteristics of animal manures and total quantities generated, is approximately 390 million tons. As a waste disposal problem, however, the amount of wet manure produced and therefore in need of disposal or processing is approximately 1.7 billion tons (14-15, 19, 24), as previously stated.

TABLE 1. - Wastes generated by major farm animals, 1971

Animals	Number of animals in the U.S., 1971,[1] thousands	Daily wastes, lb/animal		Organic solids/year (moisture- and ash-free)	
		Solids	Organic solids	Tons/animal	For all animals, million tons[2]
Cattle	114,568	10.25 ([3]9.5-11.4)	8.20 (7.6-9.1)	1.50 (1.39-1.66)	172 (159-190)
Hogs	67,540	1.2 (0.8-1.6)	0.91 (0.68-1.36)	0.166 (0.124-0.248)	11.3 (8.4-16.9)
Sheep	19,560	0.56	.46	.084	1.64
Poultry	[4]1,116,680	.06 (0.05-0.10)	.047 (0.04-0.077)	.0086 (0.0073-0.0141)	9.54 (8.1-15.6)
Total					194.5 (177-224)

[1] (20).

[2] Assuming average live weight of cattle, 1,000 lb; hogs, 167 lb; sheep, 67 lb; and chickens, 3.44 lb (15).

[3] Figures in parentheses are ranges which are values given by Loehr (14) and account for the fact that the amount of manure produced by animals is dependent on such factors as confinement conditions, type of feed, size of animal, etc.

[4] Includes all hens, pullets, breeder hens, turkeys, and total number of broilers, divided by 4.5, which corrects for the life span of only a few months for broilers.

Agricultural Crop Wastes

The generation of field wastes by major agricultural crops is high. The solid wastes generated from major agricultural crops in 1966 was estimated to be 550 million tons (10). Cornstalks, pea vines, sugarcane stalks, leaves, stubble, prunings, and similar wastes from other plants constitute most of this waste. Much of this material is now burned to prevent the spread of plant diseases or is left on farmland to prevent wind and water erosion. Since this waste is, to a large extent, not available at centralized location, it is a doubtful source for conversion to other energy forms. There are some exceptions, however, such as bagasse from sugar mills, stalks and cobs from corn, and some milling wastes from wheat, rice, and other grains. Because of increased mechanization and constantly improving methods of harvesting crops, less waste is being taken from the fields to central processing plants. This trend will continue as further improvements are made. It is estimated that 70 percent of the solid crop wastes are organic solids and that this amounts to 390 million tons of organic solids per year (6).

Urban Refuse

Urban refuse is being generated constantly. The domestic, municipal, and commercial components of this waste amount to 3.5, 1.2, and 2.3 pounds per capita per day, respectively (4). The total amount of this waste in 1971 is estimated at 260 million tons, of which at least half is dry organic material (4, 17). At present approximately 90 percent of this refuse is disposed of in landfills, while most of the remainder is burned in municipal incinerators. The quantity of refuse per capita is expected to increase in the future and land filling and incineration are now being attacked as methods of disposal since pollution of either ground water or air results while available space for landfills is running out. Conversion of urban refuse to oil or gas for fuel would appear to be an ideal method of disposal. The energy source represented by this waste is constantly renewable. The quantity of organic solids generated from urban refuse amounts to 129 million tons per year, based on analyses presented in the references previously cited.

Logging and Wood Manufacturing Residues

Approximately one-third of the volume of wood harvested in the United States is unused. This amounted to 4.4 billion cubic feet of wood in 1968, of which 2 billion cubic feet were logging residues (13). Some of these wastes are concentrated at sawmills and veneer mills, and they could be a source of raw material for conversion to oil or gas for fuel. Much of the logging waste left in forests is not concentrated, but, due to its potential fire hazard and its possibility for spreading tree diseases, it might be collected and become available (14). At present the logging and wood processing residues amount to 55 million tons per year.

Sewage Solids

Municipal sewage contains organic solids which must be filtered, treated, or removed if the water is to be recycled. Increasing pressures to bring this

about are becoming more evident. Sewage, however, is principally water, about 99.8 percent (22), with the remaining materials in suspension or solution. Organic materials in sewage include human wastes, paper, and food scraps. Gates has further classified the organic materials in domestic sewage (exclusive of ground garbage) as 50 percent carbohydrates, 40 percent nitrogenous matter, and 10 percent fats (8). In 1971 approximately 12 million tons of organic solids were generated as suspended and dissolved solids (sewage sludge) based on 0.33 pound of organic solids per capita per day (8).

Industrial Wastes

Industrial wastes are any materials discarded from industrial operations. These include processing, packaging, shipping, office, and other wastes. Since industries vary so much in the type and quantity of materials handled and processed, the composition of the wastes from one industry may be entirely different from that of another. Sludges, waste plastic, rags, paper and cardboard, scrap metals, slag, rubber, ceramics, etc., may be in the waste from a single industrial operation. The waste generated by industry has been estimated to be 110 million tons annually (5). Since the quantity and composition of this waste varies from one operation to another, the contained organic material will be available only at particular locations. There is also some difficulty in calculating a reasonable value for the quantity of organic materials present in industrial wastes. However, from data accumulated from several sources, 40 percent seems reasonable (4). On this basis some 44 million tons of organic waste solids are generated by industry annually. It should be emphasized that these wastes do not include mineral wastes, which are estimated to amount to 1.1 billion tons annually and are expected to increase to at least 2 billion tons by 1980 (6).

Miscellaneous Organic Wastes

In addition to wastes shown in the previous categories, there are many others which, when added together, constitute a significant quantity. These include antibiotic fermentation residues, wastes and carcasses from cats, dogs, horses, and marine animals, organic wastes from Federal installations, and many other wastes not previously accounted for. A conservative estimate for the quantity of this material is 50 million tons per year.

ENERGY POTENTIAL FROM ORGANIC WASTES, 1971 AND 1980

The total quantity of organic wastes generated in the United States in 1971 is summarized in table 2. Estimates of the quantities that will be generated in 1980 are also given. The values are somewhat conservative since some specific sources of organic wastes are omitted because data were not available. The quantities given for 1980 are based on a population of 236 million (21). Some increases, which are not caused by population increases, are expected. These include an annual increase in the per capita consumption of beef from 112 pounds in 1970 to 130 pounds in 1980 (1). The amount of urban refuse per capita is also expected to increase to at least 8 pounds per day, a figure which represents only collected wastes. Although larger quantities of agricultural crops will be produced in 1980, agricultural

crop wastes figures for that year were not increased because there is no conclusive proof that crop waste quantity is directly related to crop yield.

TABLE 2. - Estimates of organic wastes generated, 1971 and 1980

	1971	1980
Source:		
Manure.....million tons/year..	200	266
Urban refuse.....do.....	129	222
Logging and wood manufacturing residues.....do.....	55	59
Agriculture crops and food wastes[1].....do.....	390	390
Industrial wastes[2].....do.....	44	50
Municipal sewage solids.....do.....	12	14
Miscellaneous organic wastes.....do.....	50	60
Total.....do.....	880	1,061
Net oil potential[3].....million barrels..	1,098	1,330
Net gas for fuel potential[4].....trillion cubic feet..	8.8	10.6

[1]Assuming 70 percent dry organic solids in major agricultural crop waste solids (6).

[2]Based on 110 million tons of industrial wastes per year in 1971 (5-6).

[3]Quantities of oil are based on conversion of wastes to oil by reacting carbon monoxide and water. Net oil produced based on 1.25 barrels per ton of dry organic waste.

[4]Gas estimate is based on 5.0 cubic feet of methane produced from each pound of organic material (7).

The significant amount of oil that could be produced from organic wastes is also given in table 2. For 1971 the oil demand in the United States was estimated to be 5.8 billion barrels of which 1.4 billion barrels were imported (11). The potential from organic wastes (1.098 billion barrels per year) is approximately 15 percent of the 1971 oil demand and over 77 percent of the oil imported in 1971. As previously stated, a likely use of this oil would be as fuel oil for the generating of electric power, which would supplement the usual supplies from petroleum. The domestic residual fuel oil demand in 1971 was approximately 860 million barrels.

Table 2 also gives the quantity of gas that could have been produced from the quantities of wastes shown. In 1971 the 8.8 trillion cubic feet would have amounted to over 38 percent of the 22.8 trillion cubic feet used in the United States.

The possible impact of using the potential oil estimated on electric power generation is shown in figure 1. The total residual fuel oil demand has been increasing each year and the use of this fuel by electric utilities has also increased rapidly (as shown by the right-hand bar for each year). Figure 1 also shows that a major portion of this residual fuel oil has been supplied from imports. The bar on the extreme right shows the amount of oil that could have been produced from the organic wastes tabulated in table 2. This potential is significant and if developed could provide a much needed source of low-sulfur oil. Nearly all of the United States east coast supplies of residual fuel oil are imported and that area, being heavily populated, also generates large quantities of organic wastes.

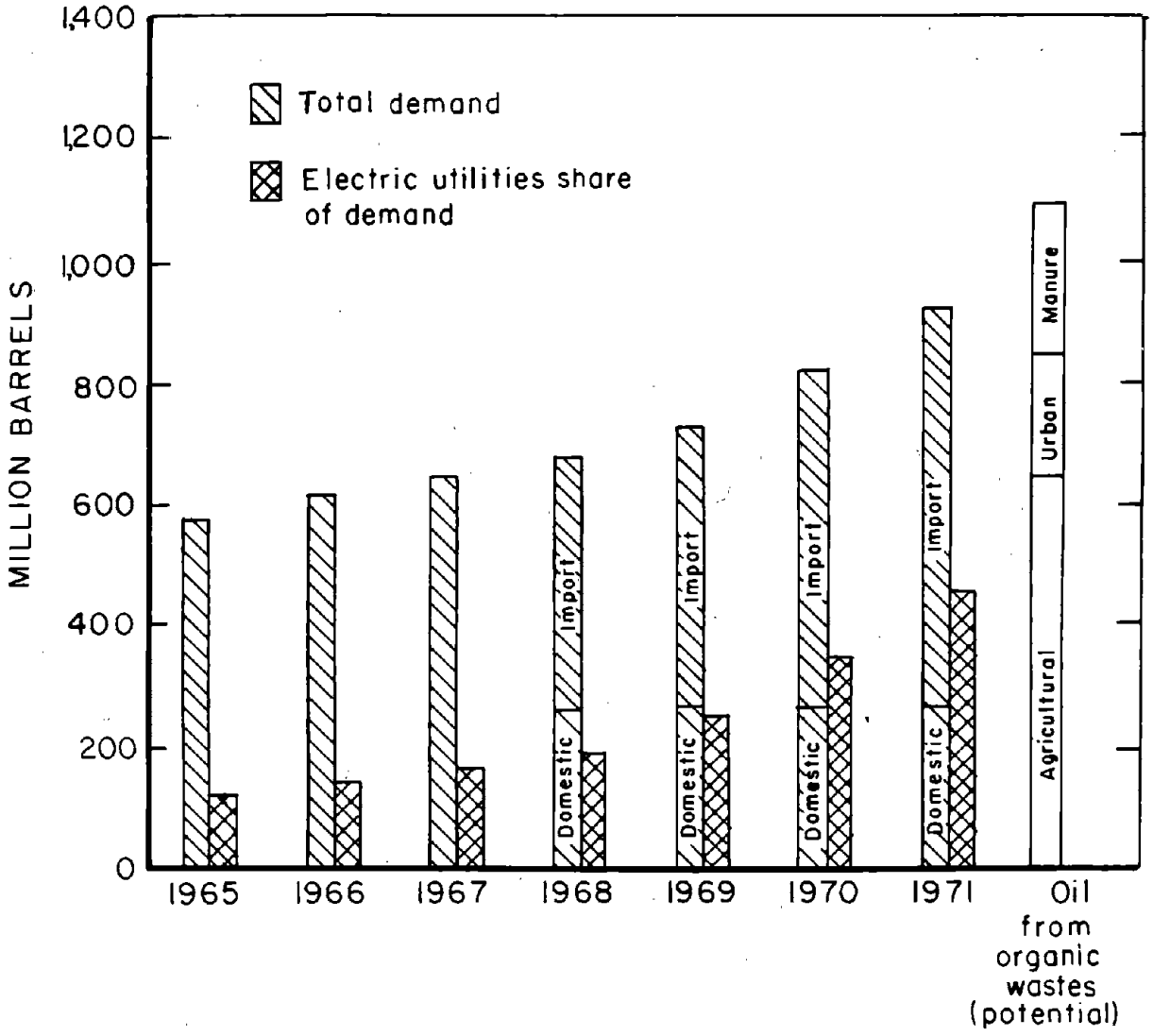

FIGURE 1. - Residual Fuel Oil Demand.

The organic waste generated could be processed by pyrolysis to make char, tar, light oil ammonium sulfate, and gas. The Bureau of Mines has also studied and carried out development work on pyrolysis of wastes (4). Both pyrolysis and gasification of wastes appear to be possible methods of conversion to usable energy forms using existing technology.

AVAILABILITY OF ORGANIC WASTES FOR CONVERSION TO FUEL

The quantities of organic wastes given in table 2 are potential but include much material that is not collected and is not likely to be collected in the foreseeable future. If a commercial process for the conversion of these organic wastes to oil or gas is developed, the feed material for the process will be quantities of waste that constitute a serious disposal problem. Successful processing of these wastes would stimulate the collection of other wastes and increase the amount of wastes available for processing.

An estimate of the quantity of organic waste which has accumulated and which would be available for conversion to oil is described in the paragraphs that follow. This estimate will be a minimum value and will include only quantities that are now concentrated by municipal collection, feedlot operation, etc.

Manure from Cattle, Chickens, and Hogs

Of the 200 million tons of dry organic solids from farm animals generated annually, estimates indicate that 50 to 80 percent comes from animals raised in confined conditions, that is, feedlots, dairies, egg laying, or broiler operations. The trend in the United States is to fewer but larger operations of this type. The waste accumulation from beef cattle makes up most of that generated by farm animals in confinement. The trends in confined feeding of beef cattle are graphically shown in figures 2 and 3. These figures show that not only are more animals being confined to feedlots with thousand or more head per lot but that the fastest growing feedlots are the largest ones (those with 32,000 or more head per lot). Similar trends are evident on poultry farms where 100,000 to 1,000,000 birds per operation are increasing; on dairy farms where several hundred to more than 1,000 cows per farm

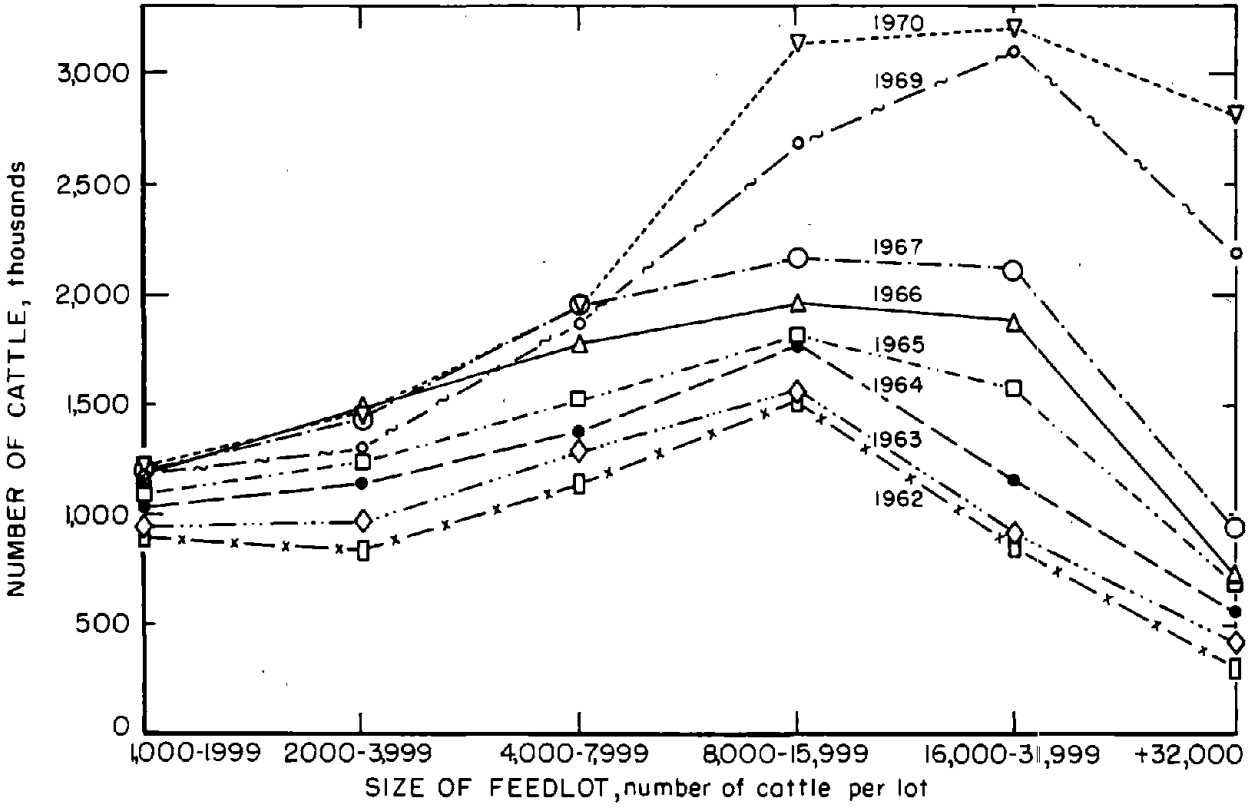

FIGURE 2. - Number of Beef Cattle on Feedlots With Thousand or More Head per Lot. (Based on information from the Crop Reporting Board, Statistical Reporting Service, U.S. Department of Agriculture.)

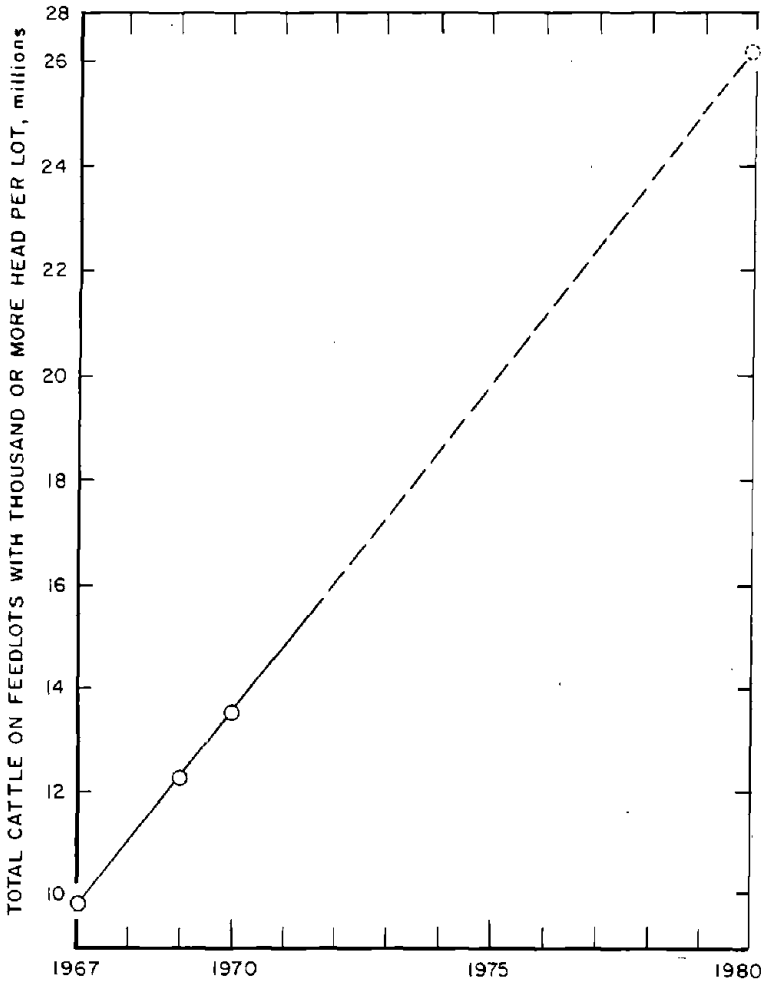

FIGURE 3. - Increase of Cattle Confined on Feedlots With Thousand or More Head per Lot. (Based on information from the Crop Reporting Board, Statistical Reporting Service, U.S. Department of Agriculture.)

are common; and in hog-feeding operations where several thousand hogs may be confined at a single location.

In some areas such as Texas, Kansas, Nebraska, and Iowa, several large feedlots may be located close enough for accumulation of manure in a single location for processing. The distance the manure can reasonably be transported is not great, however. Removal and disposal of most manure from feedlots involves some expense. Some manure may be processed for refeeding or for crop fertilizer, but this does not appear to be an adequate solution (14, 26).

Assuming that only animal wastes from feedlots having thousand or more cattle and those from the largest poultry and hog operations can be processed to make oil or gas, it is estimated that approximately 26 million tons of dry organic solids would be available. If successful processing were established, the size of feed lots and their proximity to one another would be affected and this would make more manure available for processing.

Agricultural Crop Wastes

Although the tonnage of crop waste and crop spoilage is significant much of this material is widely dispersed and is usually disposed of on the farm. The practice of burning harvest residues may be limited in the future, transforming more of this material into a waste disposal problem. At the present time the organic material available from this source for conversion to oil or gas for fuel is limited but significant in size at specific processing plants such as canneries, mills, slaughter houses, and dairies. Assuming that only corn milling and canning, slaughtering of animals, sugar refining, and

dairying have quantities of waste available for conversion to oil, the amount of this source is estimated at 113.1 million tons (8). Allowing for 80 percent water, the organic waste still amounts to 22.6 million tons.

Urban Refuse

Landfilling is the most predominant method for disposal of urban refuse. In estimated 90 percent of the United States, this waste that is collected is disposed of in this manner at some 12,000 individual sites. Incineration accounts for most of the remaining solid waste disposal (5). However, many problems exist in incineration technology and there is some question whether incineration plants can meet the air quality standards now being imposed in many cities. The amount of refuse generated in the 100 largest population centers in the United States in 1971 amounts to 144 million tons, which includes 71 million tons of dry organic solids. This estimate is based on the population of urban areas (21) and assumes the same composition of urban refuse as previously cited (17). The organic material from these most populous areas can be easily collected and could constitute a significant energy source when converted to oil or gas for fuel.

Logging and Wood Manufacturing Wastes

Logging and manufacturing residues from timber products in the United States were estimated at 4.4 billion cubic feet (55×10^6 tons) in 1968 (13). Forty-five percent of this material (2.0 billion cubic feet) was left in the forests as logging debris. Although this material is a reservoir for plant diseases and a serious fire hazard, it will probably not be collected or concentrated unless a profit can be realized by its transportation to a processing location. Because of the projected demands for increased timber products, most of the wood wastes will probably be used for wood products. The amount of wood wastes should, in fact, decrease because of improved forest management practices and more efficient utilization of the wood actually processed at mills. Undoubtedly, some bark, sawdust, and other materials will continue to accumulate at specific locations and will require disposal. The amount of this material now available is estimated at 5.0 million tons, most of which is now disposed of by burning.

Sewage Solids

Because of increased concern of the public over the pollution of rivers, streams, lakes, and even the oceans, the usual methods for disposing of municipal sewage used in the past have become obsolete, and in some cases, illegal. The principal pollutant in this sewage is organic matter (22). The availability of this organic material for conversion to oil will depend somewhat on the legal requirements imposed on municipalities to treat sewage water before disposal or recycle. A conservative estimate for 1971 is that 1.5 million tons of organic solids are available from this source.

Industrial Wastes

The amount of industrial wastes collected has been estimated at 23 percent of the total amount generated (10). Considering the amount of organic material in industrial wastes, 5.2 million tons of organic solids are collected and disposed of from industry and can be considered as available.

Available Organic Wastes

Table 3 summarizes estimates of organic wastes presently available and which present a disposal problem since they are concentrated at locations where disposal requires some special expense, processing step, or transportation. These estimates are somewhat conservative since they neglect to include many specific organic wastes such as manure from dairies, several major crop wastes, food and other scraps disposed of in sewers, paunch manure, dead animals and their parts not collected at major slaughtering plants, fermentation wastes, and many other sources of organic materials. Miscellaneous organic wastes are assumed at 10 percent of the total amount generated.

TABLE 3. - Estimates of available organic wastes, 1971

	Total organic wastes generated	Organic solids available
Source:		
Manure.....million tons/year..	200	26.0
Urban refuse.....do.....	129	71.0
Logging and wood manufacturing residues.....do.....	55	5.0
Agriculture crops and food wastes.....do.....	390	22.6
Industrial wastes.....do.....	44	5.2
Municipal sewage solids.....do.....	12	1.5
Miscellaneous organic wastes.....do.....	50	5.0
Total.....do.....	880	136.3
Net oil potential.....million barrels..	1,098	170
Net gas for fuel potential.....trillion cubic feet..	8.8	1.36

Large quantities of these available wastes are now concentrated at specific locations. For example, a single cattle feedlot with 100,000 head would produce about 410 tons of dry organic solids per day or 150,000 tons per year. A city and its nearby suburbs with a population of 1 million would generate 1,750 tons of dry organic solids per day or 640,000 tons per year. Of course at a feedlot or city of the above sizes, the amount of waste material to be handled would be considerably more than the amounts given since the organic material is only part of the waste. There are several areas where a large city or several cities could collect their wastes in a common location. There are also locations in the high plains of West Texas and in California where several large feedlots or dairies are in close proximity.

In actual practice, a city and its suburbs could combine its urban refuse, sewage sludge, industrial wastes, manure, and agricultural wastes. Alternatively, these wastes could be added to conventional fuels used for generating electric power. Their effect would be to lower the sulfur content of the conventional fuel.

The inorganic material in waste is not converted to oil or gas. It would still have to be disposed of by landfilling or other methods. The quantity, however, would be only a fraction of the original waste material and it would be a sterile solid without the pollution potential of the original waste.

The oil potential from available organic wastes as shown in table 3 is 170 million barrels. This is a significant quantity, roughly equivalent to 47 million tons of low-sulfur coal. This quantity of oil would have amounted to only 3.0 percent of the 1971 crude oil demand but could have decreased the importing of foreign crude by 12 percent. Perhaps more important, the use of oil from available wastes could have decreased residual fuel oil imports by over 25 percent in 1971. The waste, if gasified, could have substituted for 6 percent of our natural gas demand in 1971.

CONCLUSION

The quantity of organic waste generated in the United States annually is enormous and will continue to increase. The organic matter alone is estimated at 880 million tons and will amount to over 1.06 billion tons in 1980. The distribution of this material is changing due to changing practices in cattle (feedlot) management, food processing, urban waste collection, and many industrial operations. The solid waste problem associated with the concentration of wastes can be somewhat relieved by the conversion of the organic part of the wastes to oil or gas for fuel. The oil or gas produced will be a valuable commodity having a low sulfur content and a high heating value. The possible production of oil from wastes accumulated is estimated to be 170 million barrels per year. This could provide half of the residual fuel oil currently obtained from domestic sources and would reduce imports of this fuel accordingly. If converted to pipeline-quality gas, this available waste could produce 1.36 trillion cubic feet of pipeline-quality gas per year.

The economic feasibility of converting organic wastes to oil or gas has not as yet been proven. Further research is required and successful continuous processing in pilot plants will have to take place before the processes can be considered practical. This work needs to be done. The wastes are nuisances, which are polluting our environment. However, at least of equal importance is the fact that organic wastes represent an energy source and unlike conventional fuels, the quantity of this energy source is actually increasing each year. Should the conversion of organic wastes to oil or gas prove successful, it will have a tremendous impact on waste disposal practices and energy conversion in future years.

ACKNOWLEDGMENTS

The author gratefully acknowledges the assistance received in obtaining the data used in this report. Particularly helpful were Dr. T. C. Byerly and others in the U.S. Department of Agriculture, Washington, D.C., and Dr. Irving Wender, Paul M. Yavorsky, and other Bureau of Mines scientists at the Pittsburgh Energy Research Center, Pittsburgh, Pa. The author also wishes to express appreciation to John S. Tosh and Dr. G. Alex Mills of the Bureau of Mines for valuable assistance and encouragement.

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