NONFUEL USES OF PEAT

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Peat can roughly be defined as the product resulting from a special arrested decay of dead vegetation. The more typical pattern followed by dead plants is to undergo complete decay, with conversion of the organic matter into gases that are released into the atmosphere, while the inorganic matter remains in the soil. This complex process can take place only when the characteristic needs of the microorganisms that bring it about are met; these include, among others, air, water, and suitable nutrients. When dead plants accumulate under water, however, air is excluded and only a partial decay takes place, together with physical disintegration. After some hundreds of millions of years the successive products are lignite, then bituminous coal, and ultimately anthracite coal. But at a relatively very early stage, after some 10,000 to 20,000 years, the product of this arrested decay is peat. Peat, then, represents the bare beginning of the coalification process.

Considerable data have been published on the areas of peat bogs in various parts of the world, and on the amounts of peat in these bogs. It is probably safe to accept these data so far as they indicate orders of magnitude. Beyond this, they must be treated with considerable reserve, for the very good reason that virtually nowhere has the utilization of peat been great enough to justify the tremendous expense of an exhaustive accurate survey. (Two exceptions to this statement may be noted: first, in the Soviet Union and in Ireland, where there are large fuel peat industries; second, in any other area where there might be an exhaustive local survey for a specialty high-value peat, such as horticultural-grade sphagnum.) With these disclaimers, the following estimates are probably as good as any:

Table 1

World Peat Deposits[1]

Country	Square Miles	Country	Square Miles
U.S.S.R.	65,000	Great Britain	9,400
Canada	37,000	Ireland	4,700
Finland	30,000	Newfoundland	3,000
Sweden	19,000	Norway	2,900
U.S.A.	11,200	Austria	1,500
Germany	9,900	Denmark	400

In addition, peat deposits are known to exist in the other continents, but there we cannot make even uneducated guesses.

Data on the amount of peat in the bogs are even less reliable than the bog areas, since the depths of peat deposits will vary over wide ranges; typically, from 4 to 20 feet within a given bog, and depths as shallow as

a foot or two, and as deep as 50 feet or more, are not unknown. The following estimate, that of Kazakov,[2] again is presented only as an order of magnitude:

Table 2

World Peat Reserves[2]

		Billions of Tons[a]
U.S.S.R.		153
Rest of world		
Europe (except U.S.S.R.)	24.8	
North America	18.1	
All others	27.1	70
World total		223

(a) On an air-dried (30% moisture) basis

And for the United States, we have the data of Soper and Osborn:[3]

Table 3

United States Peat Reserves[3]

State	Peat Area, millions of acres	Peat, millions of tons, air-dried basis
Minnesota	5.2	6,835
Wisconsin	1.0	2,500
Florida	—	2,000
Michigan	—	1,000
Virginia - North Carolina	—	700
New York	0.8	480
Maine	—	100
California	0.06	72
Ohio	0.05	50
All others	—	90
Total		13,827

Data on current production are presented in Table 4. The discrepancies between the sums of the values for individual countries and the totals at the bottom are due to the fact that the values in the table are based on data from two different sources,[4,5] and some of the values are estimates by this author in an attempt to reconcile these sources. Only the larger producers are listed.

Table 4

World Peat Production in 1960

Country	Thousands of Tons		
	Fuel	Nonfuel	Sum
U.S.S.R.	59,100	86,000 (est.)	145,000 (est.)
Ireland	4,510	14	4,530
West Germany	871	895	1,780
East Germany	——	——	550
Netherlands	——	——	500
U.S.A.	none	471	471
Sweden	275	70	345
Norway	198	42	240
Denmark	——	——	187
Canada	negligible	185	185
Finland	132	6	138
Poland	——	——	125
Total (estimates)[5]	60,000	100,000	160,000

A few conclusions are immediately evident from these data. First, with some 90 per cent of world production, Russia is by an overwhelming margin the largest factor in the world peat industry. Second, only in Russia and in Ireland does power from peat make up a substantial fraction of the national energy supply. Third, since nearly all the "nonfuel" use is in agriculture, world consumption of peat in agriculture is apparently greater than the amount burned for fuel. ("Apparently" because Russian data on nonfuel utilization are much less complete and up-to-date than their fuel data, and were here estimated by extrapolation.) Finally, in this country peat utilization is synonymous with agricultural utilization. Before going into this, it might be useful to describe the various types of peat.

While peats are classified by soils scientists into some half-dozen or more well-defined groups, commercial statistics[6] are generally based on the following three classes:

Moss peat, or sphagnum peat moss, is peat derived largely from sphagnum and hypnum mosses. This is a light-colored material, springy, with a well-defined layered structure in its natural state. It is the least decomposed of the peats, with the lowest bulk density (7-15 lb./cu. ft.), the lowest ash content (usually under 4 per cent), the lowest pH (typically 3.5 to 5.0), and the highest moisture-holding capacity—up to 20 times and more its own weight of water. Virtually all peat imported into the United

States consists of sphagnum, which commands a much higher price than the other varieties.

Reed-sedge peats are peats derived from reeds, sedges, grasses, cattails, and various shrubs. They are much more decomposed and disintegrated than sphagnum peats, have a higher bulk density (20-35 lb./cu. ft.), are usually dark in color, and tend to have a fibrous structure that is due to their content of relatively undecomposed stems and roots. The pH range is 4.5 to 7.0; the ash content will typically vary from about 4 to 15 per cent but may be a good deal higher; and the moisture-holding capacity is about one-half that of sphagnum. About one-half to two-thirds of the peat produced in this country is reed-sedge.

Humus is a catch-all name for peats so completely decomposed and/or disintegrated as to have lost their biological identity. Humus may be native peat, or it may derive from peat land on which crops have been grown. The terms humus, muck, and peat soil tend to over-lap, but the ash content usually serves as a convenient if arbitrary dividing line between "true" peat—ash under 40 per cent--and peat soil--over 40 per cent. About one-third of United States domestic production can be classified as humus.

Although the nitrogen content of peat, some 1 to 3 per cent, is not negligible, this nitrogen is released so slowly that peat is not considered to have any particular value as a direct fertilizer. Its value in horticultural applications lies, rather, in its soil-improvement characteristics.[7,8] The addition of peat to a heavy clay soil, for example, brings about a tremendous improvement in the structure of that soil. And the water-holding capacity of peat is beneficial to any soil, since peat tends to supply a buffer-type action: it will absorb excess moisture during periods of too-heavy rainfall, and release this water during drought periods, thus providing the growing plant with a more uniform supply of water. This is notably advantageous in sandy soils. These properties are particularly beneficial in the building of new lawns, for which large quantities of peat are mixed into the soil prior to the application of seed or sod. For similar reasons, peat is widely used as a mulching agent for ornamental plants and shrubs.

In addition to the major use just described for soil improvement, peat is used in a variety of other ways relating to agriculture. Potting soils, widely marketed in small plastic bags, are generally mixtures of peat and soil. Mushroom growers have been using peat for mushroom beds, and this practice appears to be growing.[9] A relatively new outlet for peat is found in the small molded peat pots now sold in most garden supply stores. These were first developed in Norway, and substantial amounts of Norwegian pots are marketed in this country. More recently, several American producers have begun to manufacture these pots from domestic peats. And similar pots are now being made in Ireland on a different principle. Unlike

the Norwegian and American pots, which involve a high pressure molding operation, the Irish pot is made by cutting a suitable cavity in a block of air-dried peat. This preserves the original structure and porosity of the peat, and it is claimed that the greater cost of production is justified by the superiority of the product.

Another quite recent development shows particular promise. As the culmination of work extending over more than a decade, Baker[10] and his colleagues developed the "U.C." formulas for nursery soil mixes, consisting essentially of mixtures of peat moss and fine sand to which suitable nutrients are added. This has attracted widespread and favorable interest. For example, the Irish national peat establishment, Bord na Mona,[11] has developed a modification of the U.C. formula adapted to European conditions, and is now marketing this material as the U.C.E.E. seed and potting compost.

Several older agricultural applications still account for substantial quantities of peat consumption. One of these is the use of peat for animal bedding and poultry litter. Its high moisture capacity makes the peat particularly suitable for this purpose, and the exhausted product consists of fine manure whose value is greatly enhanced by the soil-conditioning property of the peat with which it is combined. Another well-established utilization consists of the addition of 5 to 10 per cent peat to manufactured fertilizers. This is based on the fact that some of the components of commercial fertilizers are hygroscopic, so would become sticky in humid weather and hard-caked under dry conditions. By absorbing or releasing moisture as needed, the peat tends to keep the fertilizer free-flowing. Still another application of the moisture-holding property of peat is found in its use in the packaging of cut flowers and certain vegetables. Asparagus crates, for example, are sometimes lined with a layer of peat which is then wetted. By slowly releasing its moisture, the peat maintains the asparagus in good condition during shipment.

The one agricultural use which may ultimately have the greatest potential of all would be to incorporate into peat, by chemical or microbiological means, suitable plant nutrients in the right proportions and with the necessary characteristics of availability and rate of release, such as to add fertilizer properties to the soil-conditioning activity which peat already possesses. Needless to say, this problem has been and is being given energetic study in almost every laboratory where peat is looked at from a chemical or engineering point of view. Equally needless to say, the fact that a major industry of this nature does not exist indicates that the problem is still quite far from a solution. Nevertheless, two operations are in existence today in which such a peat-fertilizer-soil-conditioner is being produced. One is in Austria,[12,13] where the Österreichische Stickstoffwerke A. G. produces two peat derivatives of this nature--Humon and Voll-Humon. Humon is made by the reaction of air-dried peat (40% moisture) with anhydrous

ammonia in the presence of air, at atmospheric pressure. The ammonia is completely absorbed in one pass with virtually no loss. This process raises the nitrogen content from about 1 to 3 per cent. The important consideration is the rate of release of nitrogen—about one-half becoming available the first year and the remainder within two years. The nitrogen content of the product is deliberately kept down to 3 per cent in order that as much humic material per unit of nitrogen as possible be supplied to the plant. The essential difference between Humon and Voll-Humon ("Complete Humon") is that the latter contains, in addition to nitrogen, the nutrients potassium and phosphorus, together with certain trace elements. A major problem with Humon and Voll-Humon appears to be that the cost of production still makes these products too expensive for ordinary agricultural use and thus limits their market to horticultural applications. Nevertheless, about 10,000 tons per year were being produced in 1957.

A related process is the one developed by the French company, Societe de Produits Chimiques et Engrais d'Auby.[12,13] The process involves a fermentation of peat following a treatment with ammonia and other chemicals. Here, too, the cost of the product appears to present the major obstacle to widespread utilization of the process. Annual production was said to have been about 100,000 tons before the Algerian war destroyed a major part of the market.

Before we turn to nonfuel uses other than agriculture, which are found only outside the United States, a few statistics on United States production and consumption may be in order.

Table 5

United States Peat Consumption[14]

		Domestic Production			Imports	
	Total Consumption, Thousands of Tons	Thousands of tons	Value, Thousands of Dollars	Domestic Producers	Thousands of tons	Value, Thousands of Dollars
1939	134	55	362	39	79	1,204
1946	225	141	1,006	59	84	2,704
1950	255	131	1,143	48	124	3,867
1955	503	274	2,283	82	229	9,262
1958	597	328	3,446	81	269	12,034
1959	706	419	4,372	105	287	13,580
1960	735	471	5,138	115	264	13,509
1961	777	525	4,991	123	252	13,178

A few trends become apparent from these statistics. First, the use

of peat has shown a steady increase in this country with no sign yet of levelling off. This is understandable—we have become a nation of home-owners, and every lawn and every garden represents a new market for peat. Second, while domestic production shows a steady increase paralleling consumption, imports seem to have reached a maximum and leveled off. What is really surprising is the dollar value of the domestic product compared with that of the imported. In 1961, for example, we find 525,000 tons of domestic valued at about 5 million dollars, for an average of slightly less than $10 per ton, as compared with an average value of the imports of over $50 per ton—5 times as great. Two factors are involved. In the first place, the domestic prices reflect the proceeds received by the original producer f.o.b. plant, and frequently are for a product shipped in bulk. The imported prices are those paid by the importer p.o.e., and invariably include the cost of a rather expensive package. Nevertheless, there remains a considerable spread, and this is due to the fact that nearly all the imported material is peat moss, which commands a much higher market price than reed-sedge and humus, of which most domestic production consists. In fact, the major reason that imports are so high is that only a very small proportion of American peat deposits are sphagnum moss of suitable size and quality for commercial operation.

The next table shows, for the year 1960, the major sources of the peat consumed in the United States and the major outlets. The discrepancy between supply and utilization is due to the fact that only the material sold in commercial channels is listed in the consumption, with no account taken of peat utilized in captive operations.

Table 6

Peat in the United States—1960[14]

Major Domestic Sources	Thousands of Tons
Michigan	214
Florida	39
California	33
Pennsylvania	31
Washington	28
Indiana	27
New Jersey	25
39 Other states	less than 10 each
Major Foreign Sources	
Canada	157
West Germany	84
Poland	8
Netherlands	8
Denmark	6

Table 6 (continued)

Major Uses	Thousands of Tons
Soil Improvement	405
Potting Soils and Flower Packings	17
Miscellaneous	9

The nonfuel uses of peat outside of agriculture account for only a minor fraction of total peat consumption. On the other hand, one of them constitutes an important basic industry, and several show considerable interest and promise.

Perhaps the most important of these nonfuel nonagriculture applications of peat is its use as the raw material for the manufacture of activated carbon. The importance of activated carbon in sugar refining, gas purification, chemical processing, and other industries is well known. At least one of the major producers (Norit Co., Amsterdam)[12] makes most of its activated carbon from peat, and there are indications that others may follow suit. A serious limitation lies in the rather stringent specifications of the starting material. The nature of the (secret) process is such that the peat must be quite decomposed, to the extent that it sticks together like a damp mud when pressed by hand. At the same time, its ash content must not exceed about 3 per cent. So far as the writer knows, only one particular peat--a bog at the Holland-Germany border--has this combination of properties. The only low-ash American and Canadian peats are sphagnums, very little decomposed, and the ash content of the well-decomposed peats is rarely as low as even 6 per cent.

Since cellulosic substances constitute one of the major organic constituents of peat (15 to 50 per cent), the fermentation of peat to produce ethanol is a well-known process. However, it is not competitive with ethanol by other processes. On the other hand, the Russians[12,15] have developed a thermo-chemical processing of peat that at least in the Soviet economy is competitive. In this process the peat, only partially dried, is autoclaved with steam to destroy its colloidal structure. This makes it possible to dewater the peat by filtration, a process which the colloidal nature of untreated peat renders impossible. The process is therefore called "artificial dehydration." Some chemical products are produced during the autoclaving, and others during a subsequent fermentation, with the following overall yields from 1000 kg. of peat (37 per cent moisture basis): 6-8 liters of ethanol, 3.5-4 kg. of furfural and substituted furfurals, 700-750 kg. of peat fuel. Modifications under development would add 22-24 kg. of oxalic acid and 5-6 kg. of acetic acid to the above products. In 1957, a plant near Leningrad was operating at an annual peat consumption rate of 50,000 tons.

Processes for using peat for the manufacture of products such as wallboard, heat insulating plates, sound-proofing materials, and even papers and fabrics, are well known, and many patents have been issued. With suitable additives, these products can be made fire resistant. Before World War II the Soviets were known[15] to produce heat insulating plates from peat on a large scale, but no current information is available. A related product from peat is a flooring material of rather high quality, which has been manufactured at various times in Sweden, Germany, and Russia, and probably elsewhere. And in the same category we find peat used as a filler in linoleum.

Wax constitutes another of the major organic constituents of peat (5 to 15 per cent), and the extraction of waxes from peat has been widely studied (Reilly, Ireland; Dragunov, Russia; Sundgren, Finland; Risi, Quebec). These waxes are comparable to the montan waxes from brown coal, and can be refined to a product comparable to Brazilian carnauba wax. But whether peat wax is competitive with these products remains to be seen.

A recent (1961) peat development that shows great promise is based on some work by the British Cast Iron Research Association,[16] who found that the substitution of a particular type of peat for the coal dust or wood flour ordinarily used in iron foundry casting sands affords an improved product requiring less finishing. Current annual production of "Berkoal," the trade name for peat meeting specifications for this purpose, is of the order of 12,000 tons.

Two minor uses of peat may deserve mention. During World War I, sphagnum moss was used on a large scale as a filler for surgical dressings and mattresses, an application based on its absorptive and antiseptic properties. And today in Germany, there are a large number of health spas whose major attraction consists of taking baths in a hot peat-water slurry. These are elaborate establishments, usually with one or even several physicians in full-time residence. The writer has no information as to how effective these peat baths are medically, but since the spa is usually located in beautiful mountain country far from the cares of everyday life, the overall effect is undoubtedly all to the good.

A final topic that should at least be mentioned is the use of peat lands for growing crops--either on native bogs, or on reclaimed peat land after removal of the peat. As an example of the first, suitably developed muck soils are highly regarded for crops such as celery and potatoes, while reclaimed bog lands are ideal for blueberries and cranberries. It should be emphasized, however, that the effective use of peat lands constitutes one of the major problems of soils scientists, particularly in the countries of Western Europe where arable land is scarce and precious, and that full realization of the potentialities of these lands still lies far in the future.

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