PHYSICAL AND CHEMICAL PROPERTIES OF PEAT

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Summary

Peat properties reflect the peat-forming environment, development processes of peat and the types of peat-forming plant. These also provide the major basis for peat classification and quality evaluation.

The physical properties of peat include decomposition degree, water content, specific density, bulk density, etc. The decomposition degree of peat has a large range of variation. Usually, peat can be classified into low decomposition, moderate decomposition and high decomposition according to the degrees of decomposition. Through the 'fist closing' method, J. Visscher et.al divided the decomposition degree into ten grades. The decomposition degree of peat is closely related to the depositional environment of peat and the types of peat-forming plant, as well as other peat properties. The absorption capacity and water retention capacity of peat can be measured. The humidity and the saturated soil water content in *Sphagnum* peat are the highest, and they are least in herbaceous-woody peat. The specific density of peat, which has a close relationship with the components of the plant residues found in peat, is relatively low, usually ranging from 1.0 to 1.6 Kg m^{-3}. The bulk density of peat, depending upon the ash content, decomposition degree and components of plant residues, is also low, usually ranging from 0.1 to 0.5 Mg m^{-3}.

The chemical properties of peat include elemental composition, organic components, and ash. The five basic elements of peat are C, H, O, N and S. The elemental properties of peat are generally between that of wood and coal. The elemental proportion of lowly decomposed peat approximates to that of wood, while highly decomposed peat resembles that of the lignite.

The organic components of peat can be divided into four groups. The first group is bitumen (a natural compound found in peat) which can be extracted by organic solvents. The second group includes water-soluble matter, easily hydrolyzed matter and cellulose. The contents of water-soluble matter and easily hydrolyzed matter have a large range of variation, which decrease with the increment of decomposition degree of peat. The third group is humus which includes humic acid and fulvic acid. The fourth group is a kind of mixture including lignin, lignin-like matter, cutin, suberin, etc. The components of the fourth group do not hydrolyze in water.

Among the elemental compositions of peat ash, the major elements—Si, Al, Fe, Ca, Mg, Na, and P—account for about 90% of the total elements. The content of another 40 microelements does not exceed 1%. In addition, some rare elements can be found.

Among all the properties of peat, the physiochemical properties of peat are the most special. CEC is mainly dependent upon the type and quantity of colloids in peat. Acidity and alkalinity of peat are useful indicators in investigations of the origins of peat and its utilization. The particle-size dispersion degree is an important indicator for evaluating the structure of peat. The water-absorption capacity and accumulative density of peat are useful in evaluating the properties of raw peat material and its products.

The variability of the natural environment has led to diversity within peat-forming environments, peat-forming processes, and the properties of the peat-forming vegetation, resulting in the large differences in properties of peat around the world.

1. Introduction

Research on the physical properties of peat lags behind the literature on utilization of peat. Early publications on peat properties includes J.H. Pegener's book: *Teutschlands Neuentdeckte Gold-Grube, Torf* (1731*),* which deals with peat utilization and properties. M.V. Lomonosov of Russia discussed peat properties and values in *Earth's Surface.* In the 1950s and later, I.I. Lishtvan and his colleagues wrote: *Basic Properties of Peat and Measuring Methods, Physical and Chemical Principles of Peat Production Technology,* and *Physical and Chemical Properties of Peat.* These books deal especially with peat properties, measuring methods and physical and chemical principles of production technology of peat. Other books that discussed peat properties include: P.D. Moore and D.J. Bellamy's *Peatland,* S.N.Tiulemnov's *Peat Deposit,* Sakakuchi's *Geography of Peatland,* etc. At present, research on peat properties mainly discusses physical and chemical assessment of peat utilization.

Peat properties are the main indicators when classifying and evaluating the quality of peat. Peat properties reflect the peat-forming environment, development process and the types of peat-forming plants.

Peat consists of organic matter, mineral matter and water. Under natural conditions, the content of water in peat exceeds 80% and content of gases content is about 6%. In dry peat, the organic matter content can reach 50%. There are many differences between peats from different areas.

2. Physical properties of peat

Physical properties of peat mainly include decomposition degree, water retention properties, specific gravity and bulk density.

2.1. Decomposition degree of peat

The decomposition degree of peat is the proportion of the matter which has lost its cellular structure due to the decomposition of plant residues. Decomposition degree is usually expressed as a percentage. Under the natural conditions it ranges from 1% to 70%. Generally, the decomposition degree of peat is divided into three levels. Lowly decomposed peat is less than 20%, and highly decomposed peat is higher than 40%. When the decomposition degree is between 20% and 40%, the peat is regarded as moderately decomposed.

V. Post and J. Visscher, et.al measured the decomposition degree of peat using the fist-closing method and divided the decomposition degree of peat into ten levels depending upon the water content. The following summarizes their method:

H1: almost all the plant residues are still present; water in the peat is transparent.
H2: the plant residues are barely decomposed; water is transparent but with a light brown color.
H3: small amounts of plant residues are decomposed; water is turbid and brown.

H4: small amounts of plant residues are decomposed; water is very turbid, but the peat cannot flow between the fingers.
H5: the plant residues are somewhat decomposed, but the organisms can still be discerned; water is brown and very turbid; small parts of the peat can flow between the fingers.
H6: Large quantities of the plant residues are decomposed; about 1/3 of the peat can flow between the fingers, and the remains of plants left in the hand can still be discerned.
H7: The plant residues are highly decomposed and about 1/2 peat can flow between the fingers; the water is clear in color.
H8: the plant residues are highly decomposed and 2/3 of the peat can flow through the fingers; plant remains in the hand are hydrolyzed rootstocks and the woody material.
H9: fully decomposed; all parts are fluid and the organisms cannot be discerned.
H10: fully decomposed; the peat is all washed away with water.

The decomposition degree of peat is primarily dependent upon the peat-forming environment. Peat formed in a cold and humid environment decomposes slowly, resulting in a low decomposition degree. Peat developed in a dry and hot climate, is more likely to be highly decomposed. Under anaerobic environments with perennially accumulated water, peat has a low decomposition degree; while under conditions of seasonally or temporarily accumulated water the peat will be highly decomposed.

In addition, the decomposition degree of peat has relationships with peat types and the residue components of peat-forming plants. According to the statistics in *Basic Characteristics and Measuring Methods of Peat*, the decomposition degree of oligotrophic peat (15 to 25%) is usually lower than that of eutrophic peat (25 to 35%). Woody peat and woody-herbaceous peat have the highest decomposition degree (35-65% and 25-60% respectively). *Sphagnum* peat has the lowest decomposition degree (3 to 45%), and herbaceous peat occupies the middle range (10 to 60%). According to the statistics issued in *"China's Mire"* (1991), the average decomposition degree of eutrophic peat in China is 30.97% (sample number: 603), and the main range with a frequency of 46.8% is from 25 to 35%.

When the frequencies of decomposition degree are plotted, that of eutrophic peat approximates to a normal distribution, with no significant differences among the different eutrophic peats in the world, while that of oligotrophic peat does not have a normal distribution.

There is a close relationships between the decomposition degree and the other properties of peat (see Table 1). For eutrophic peat, the relationship is less obvious than that of oligotrophic peat. Table 1 shows that decomposition degree of eutrophic peat and oligotrophic peat is positively related to the caloric value of peat, carbon content, bitumen content, humus content and the particle-size fraction (<250 μm), while it is negatively related to water content, content of water-soluble matter and easily-hydrolyzed matter, content of reductive matter and cellulose content. Sakakuchi further summarized many scholars' research results on these relationship. He pointed out regular correlation between the decomposition degree and other properties, including

the specific surface, water permeability, water holding capacity, contractibility, compressibility, base-exchange capacity, calorific value, and the content of total nitrogen, etc.

Related properties with decomposition degree	Correlation coefficient	
	Oligotrophic peat	Eutrophic peat
Calorific Value	0.83	<0.50
Water	-0.50	-0.65
Carbon content	0.80	<0.50
Oxygen content	-0.80	<0.50
Asphalt content	0.80	<0.50
Content of water-soluble matter and easily-hydrolyzed matter	-0.75	-0.53
Reductive matter content	-0.62	-0.64
Humus acid content	0.81	<0.50
Cellulose content	-0.62	<0.50
Particle size <250 um	0.79	0.61

Source: I.I. Lishtvan & N.T. Kololy (Dai Guoliang & Ma Xuehui translate into Chinese) (1989)

Table 1. Relationships between the degree of decomposition and other properties of peat

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Biographical Sketches

Hu Jinming was born in 1973. He obtained his Bachelor in Geography in 1995 at Anhui Normal University, Wuhu City, China and his Master in Physical Geography in 1998 at Changchun Insitute of Geography. He is now studying in the Department of Urban and Environmental Science in the doctorate program, Peking University. His main research fields are about the environmental change under human impact. He has published several scientific papers in Chinese professional journals.

Professor Ma Xuehui was born in 1938. In 1960, she obtained a Bachelor Degree in geography at Northeast Normal University. In 1960s, she undertook research on mires and peat. During this period, she took part in investigation, experimentation and research on mires (peatlands) in the Sanjiang Plain, the Zoige Plateau, the Xin'anlin Mountains, the Changbaishan Mountains, Xinjiang Province and some other south provinces in China. In the 1970s, she took part in wilderness resource investigations in the Sanjiang Plain of China. In the 1980s, under the support of the national scientific fund, she undertook several key projects on the investigation and comprehensive exploiting and experimental research of the natural resources in the Sanjiang Plain, China. In recent years, she has undertaken research on carbon cycling, microgas emission and the influencing factors in the peatlands of the Sanjiang Plain.

In 1992, she was appointed as associate professor, then professor by Changchun Institute of Geography, Chinese Academy of Sciences. She is also a member of the Chinese Coal Society and the Jilin Peat Society, and managing director of the Editorial Research Society of the Natural Scientific Journal, for the Chinese Academy of Sciences.

She has published about 60 scientific papers on peat and wetlands in Chinese as well as international professional journals. She co-edited several books in Chinese, such as *Mires in China*, *Mires in the Zoige Plateau*, etc.