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AN OVERVIEW OF PEAT RELATED CHEMISTRY

Thesis

CENTRIA UNIVERSITY OF APPLIED SCIENCES

Degree Programme in Chemistry and Technology

April 2015

Abstract

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Degree program Chemistry and Technology		
Name of thesis AN OVERVIEW OF PEAT RELATED CHEMISTRY		
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Supervisor Jana Holm		

From 1970 to 1990, many peat research studies were published. Nowadays, with the development of new technology and the decreasing price of other resources, peat studies have not been conducted in chemical research. The major applications of peat are in energy production. Peat as a valuable source has not been comprehensively used.

This bachelor's thesis will include a summary of the studies within chemistry that have been published mainly in Finland and the products made related to peat. The main two types of peat will be introduced, which include Carex peat and Sphagnum peat. All peat studies depend on its chemical, physical and biological properties. Furthermore, the peat studies that conducted in China, Canada and The United States are also mentioned in this thesis in general.

The aim of this study is to provide information foundations of peat for research that will be conducted in the future, for example, experimental equipment and extracting methods. When people read this thesis, they can search more studies of peat by looking through the references. This study will explain in detail what studies have been done, which can avoid repeating studies. This study also shows a clear structural idea in peat utilization such as peat collecting, analyzing, researching, restoring, rehabilitating, and managing.

Key words
Alkane and alkene, Humic acid, Organic carbon, Peat, Peat research, Peat production, Purification, Sterol

Content

1 INTRODUCTION

Peat is a type of renewable resource that has usually been ignored. Nowadays, people mainly apply peat as the heating energy resource instead of other purposes. This thesis elaborates many studies such as peat used in chemistry, which were utilized by researchers, and the product has been made according to special characteristics of peat. Finally, there will be the rehabilitation and the management of peat application. This thesis is cooperated with Geological Survey of Finland (GTK).

The aim of thesis is to give a summary of the achievement of research, which had been studied of peat that applied in chemistry. It would be valuable for today's studies, which provides the foundation of information on peat and basic knowledge of peat characteristics in chemical, physical and biological. The constituents in peat have been described in detail. Furthermore, in this thesis, the studies conducted in Canada, China and The United States are mentioned in general. This thesis also summarizes the applications and production of peat from 1970 to 2000.

Eight studies of peat- related chemistry will be discussed and they main focus of peat studies in Finland, which Kalevi Pihlaja took part in. They include the chemical mapping of peat, the peat lipids on the growth rate of E. COLI K12, the biologically active substances in peat, the effects of peat on onion root growth, the inorganic constituents in Finnish peatland, the extractable and waxy materials of peat, alkane and alkenes from reclaimed peat, and the sterol contents in the bog. Moreover, this thesis describes four kinds of peat production, for example, peat sorbent, peat in horticulture, peat in balneology, biological purification of ethylene contamination, and humic substance use for peat lipstick.

2 PEAT

Peat as a resource accumulates partially decayed vegetation or organic matter. When plant material is inhibited from decaying in acidic and anaerobic conditions, peat will be formed. Peatlands are land areas with an accumulated layer of peat. The ecosystem of peatland is the most efficient carbon sink on the planet. Peatlands are found in at least 180 countries and cover around 3% of the world's land area. Graph 1 shows the appearance of peat and peatland. In the following chapter, the peat resource existing in the world will be described in detail. (Ataur, Rafia, & Azmi 2012, 3-4.)

GRAPH 1. Peat and Peatland (Burgess 2009)

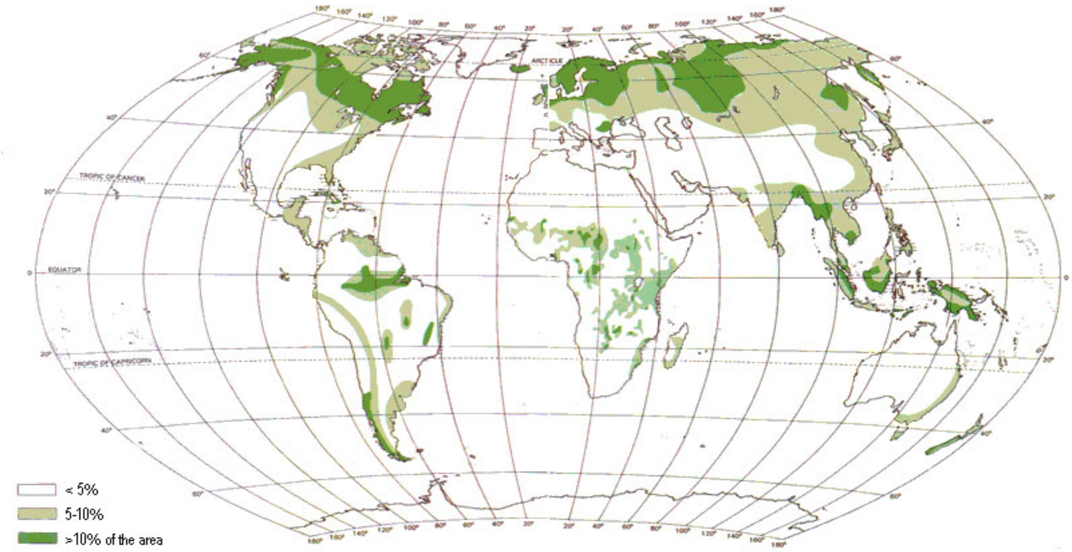
2.1 Brief introduction

Peat as a type of soil always appears as dark-brown to murky black colour. It can be found from peat swamps and it always grows in quantity with the dead leaves and plant materials. It can be as 20 metres thick from surface in maximum. Peat has greatest quantities of organic matter up to 65% and it contains animals and insects. Peat is formed at the condition that the accumulating rate of organic matter exceeds the decomposing rate. Peat usually grows in the wet area. Peat performs as a natural sponge, which has the unique ecosystem property of water logging. However, water regimes with acidic environment, low nutrients and dissolved oxygen levels also appear. As one of the important component in the world's wetlands, peat plays an important role in the dynamic link between land and water, the transition zone between water flows, the supplement of hydrological ecosystem and the recycling of atmospheric gases. Peatlands are also the potential and raw material for many chemical extractions such as the production of waxes, resins, sterols, humus and carbohydrates. (Ataur, Rafia & Azmi 2012, 3-4.)

When containing more than 40% mass of organic matter, soil can be classified as peat soil. Peat consists mainly of organic matter, which can be divided into four various advantageous groups such as bitumen (waxes and resins), carbohydrates (hemicelluloses, cellulose and pectins), lignin and humus substances. When containing about 20~39.9% mass of organic matter, soil will be classified as mull soils and with lower level will be defined as the mineral soils. (Myllys 1996, 65.)

2.2 World-wide resources

There are 400 million hectares of peat land in totally 180 countries, which cover 3% of Earth's surface area. The distributions of peatland are various with the different environmental conditions. Graph 2 shows the distribution of peatlands in global. Canada and Russia have the largest area of peatland that covers 170 and 150 million hectares respectively. Due to the condition of peat growth, in the Nordic countries with the high latitude and long winter time, the soil in land has high water content because it is covered by snow in winter and with medium temperature in summer. Therefore, high quantities of peatland are covered in Nordic countries, for instance, 66,680 km^2 in Sweden, 94,000 km^2 in Finland and 23,700 km^2 in Norway, which occupy about 30% of worldwide peat resource. (Nordic joint commitee for agricultural research 2012; Clarke & Rieley 2010, 11.)



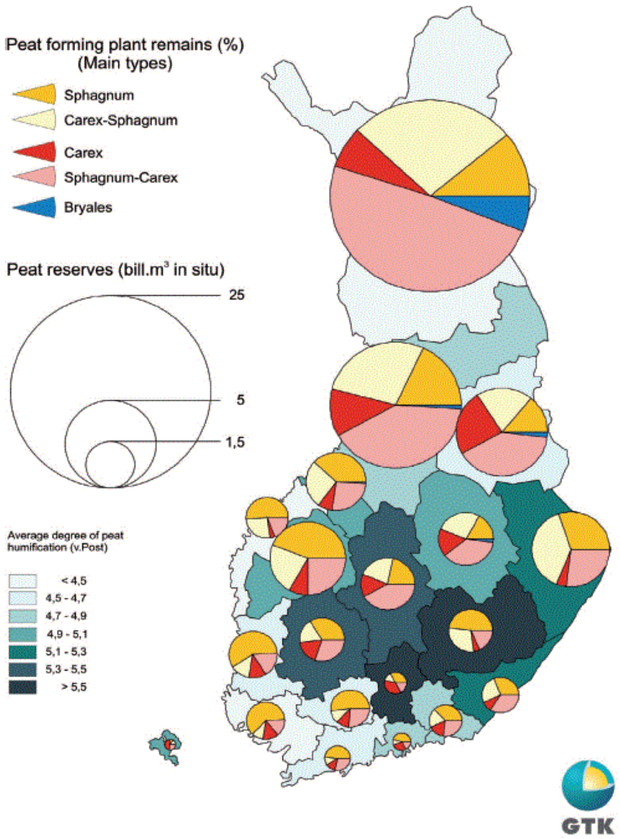
GRAPH 2. The distribution of peatland (Clarke & Rieley 2010, 11)

TABLE 1. The usable peat resource in Finland (Virtamen, Hänninen, Kallinen, Vartiainen, Herranen & Jokisaari 2003)

Province	**Area (ha)**	**Mean depth (m)**	**Total reserves (mill.m^3)**
South Finland	137,459	2.42	3328
West Finland	873,642	1.61	14052
East Finland	505,107	1.55	7851
Oulu area	1,530,715	1.17	17975
Lapland area	2,069286	1.27	26280
Åland Islands	705	1,10	8
Total area	5,116,914	1,35	69287

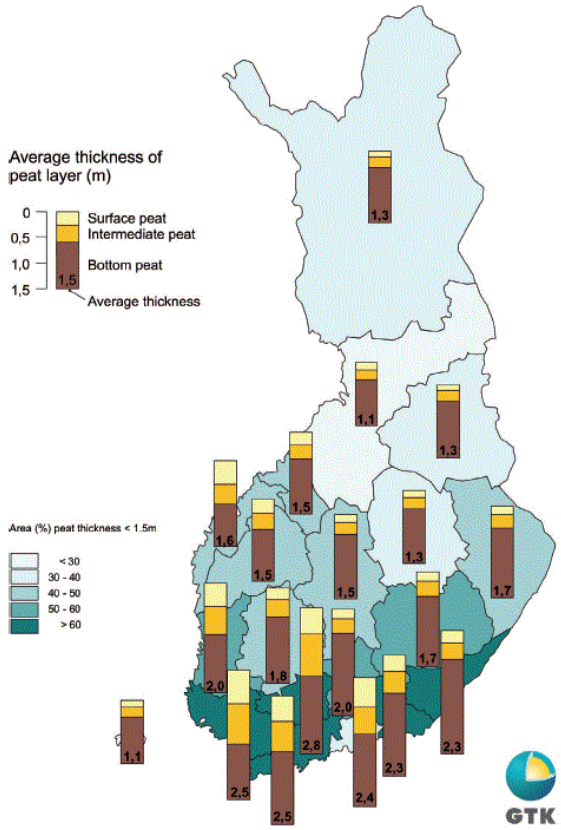
In Table 1, the peat resource in Finland is represented clearly by the area of peat, the deepness of peat and the reserves of peat. The largest peat covering regions are in Lapland, which is about 2,069,286 ha area. The reason of this is not complicated as described because that the soil is in wet condition for long time and it is covered by snow. The depth and thickness of peat depends on the nature condition such as the quantity of soil and the growth of plant. (Pihlaja, Ketola & Luomala 1983, 446; Virtamen, Hänninen, Kallinen, Vartiainen, Herranen & Jokisaari 2003)

The new data of peat resource in Finland can be found in the book named as Finland-Fenland worte by Korhonen, Korpela and Sarkkola. Approximately 30% of area in Finland is covered by peat, which are 9.03 billion hectares. In Finland, there are 100,000 peatland unites (single basins) and one third units exceed 20 hectares, which provide convenience for researching and producing. The geographic distribution maps are also showed in this book, which included the main peat types, the average degree of humification in different area of Finland shows in Graph 3, and the thickness of the peat layers in different area of Finland shows in Graph 4. (Virtanen 2008, 29-31; Myllys, Lilja & Regina 2012)



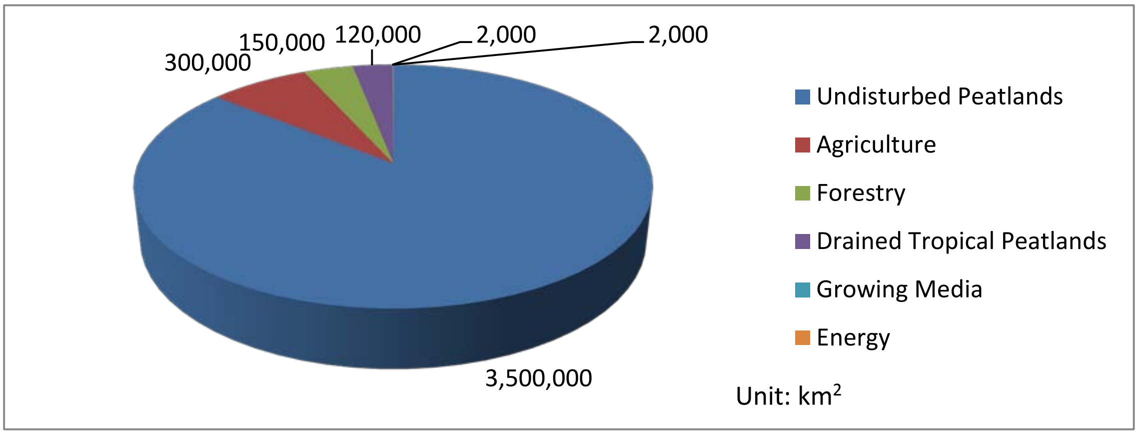
GRAPH 3. The main peat types and average degree of humification in Finland (Virtanen 2008, 29)

In Graph 3, the main types of peat in Finland are included Sphagnum peat, Carex-Sphagnum peat, Carex peat, and Sphagnum-Carex peat. In the north of Finland, peat reservation is approximately 25,000,000,00m^3, which is exactly higher than other areas in Finland. The average degree of humification is showed by blue color in the picture, for example, humic degree in north of Finland is less than 4.5. And the average thickness of peat layer shows in Graph4. For example, in the north of Finland, the average thickness of peat layer is 1.3m. (Virtanen 2008, 29)



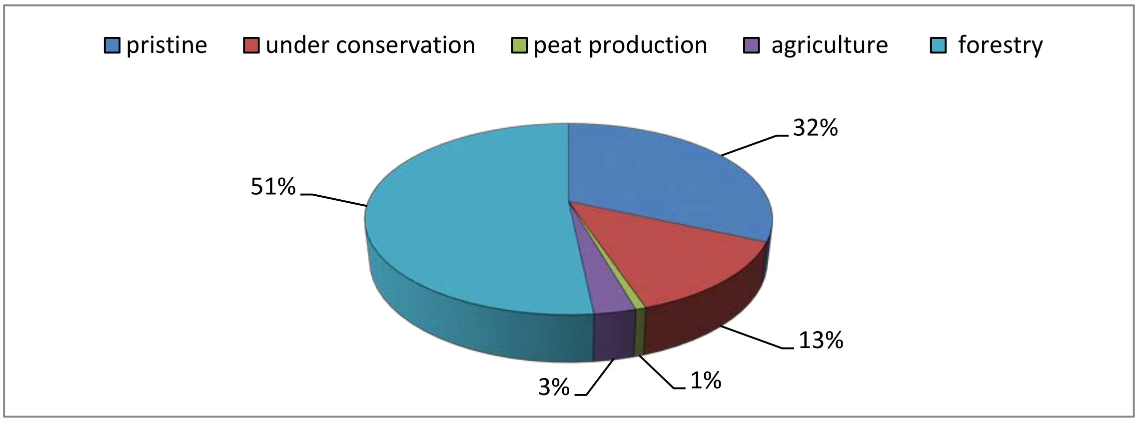
GRAPH 4. Tickness of the peat layers in Finland presented according to province (Virtanen 2008, 30)

Peatlands can be divided into two parts by different applying objective: undrained and drained peatlands. Undrained peatlands have many valuable habitats, which represent biodiversity and ecosystem services. They are also managed as nature reserves. Drained peatlands are used for forestry and agriculture. The extracts are collected from drained peatlands can be used for energy and growing soil. (Clarke & Rieley 2010.)



GRAPH 5. Application type of Peatlands in the world (Clarke & Rieley 2010)

Graph 5 shows the uses of peatlands in the world. It can be clearly seen that the biggest area consists of undisturbed peatland with 3,500,000 km^2. The peatland used within agriculture is about 300,000 km^2. The peatland that is applied in forestry is 150,000 km^2. The drained tropical peatlands hold 120,000km^2. (Clarke & Rieley 2010.)



GRAPH 6. Application types of peatlands in Finland (Myllys, Lilja & Regina 2012)

Graph 6 shows the peatlands application in Finland. In Finland, there are about 9.03 billion hectares peatlands and peatlands account for 30% land of the whole country. 13% peatlands are under conservation. 32% peatlands are undisturbed. 51% peatlands are in forestry. Only 1% peatlands are applied to peat production. Furthermore, 3% peatlands are used as agriculture. (Myllys, Lilja & Regina 2012)

TABLE 2. The amount of peat used for environmental purposes in Finland in 1994 (Mutka 1996, 96)

Environmental purposes	**Amounts** (m^3)
Litter material in cowsheds and agriculture sludge handling	414,450
Sludge handling and composting	145,950
Biofilter peat (including export)	2,000
Total	568,400

Table 2 shows that over 0.5 million cubic meter of peat were applied in environmental protection in Finland in 1994. Peat being applied in environmental protection is based on the properties of peat, such as the excellent cation exchange capacity, high porosity, excellent liquid holding capacity, good growth media for microbes, high organic matter content, long lasting structure an light mass. It is worth mentioning that peat is applied in the cleaning of waste water and biological air purification. (Mutka 1996, 97-98.)

In Finland, peat filter systems constructed in the ground are used for cleaning waste water. There is a sand layer with drainage pipes under the system. The peat lies on top of the sand and waste water runs through the peat layer. After cleaning, the reduction constituents obtain biochemical oxygen demand (BOD) 94 %, N 85 %, P 99 % and suspended solids 99 %. In Europe, annually 10000 $m^3$of peatlands are applied for biological air purification. In this process, gases are led through a filter material, in which specialized bacteria use the gases as their source of energy and break them down. Different bacteria have different requirements. Peat is used to adjust the pH value and nutrients to a suitable level for the different bacteria. (Mutka 1996, 97-98.) Examples of peat biological purification have been mentioned in Chapter 6.4.

3 CLASSIFICATION OF PEATLAND

In this chapter, a particular peatland classification will be described. It is separated into two parts: the history of peatland classification and the grouping of site types. Forty types of peatland group will be represented and they will take in use as the information foundation of peat application and research of peat. Due to the research being focused on Finland, the peat group types are divided by the Finnish peat land site.

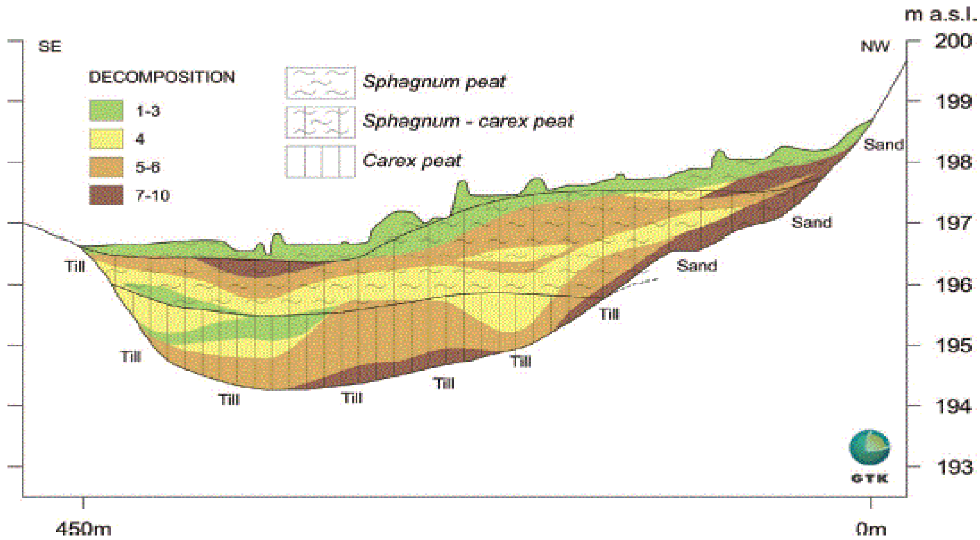
3.1 The history of peatland classification

In Finland, the first classification was published hundred years ago. It takes time to adjust the classification of peat going to impeccable. The description of peat classification have been mentioned in the work “Study in Moore Finland” such as spruce mires, pine mires, treeless bogs, poor fens, and rich fens. An important early observation can be found in studies. The system is consisted of about 50 vegetation type. It has formed the botanical basis and the applied site classification type until the present time. Researchers introduce the correlation analysis that included the description of vegetational variation in peatland and defining ecological species groups. The eutrophic pine mires of North Finland is described and classified with the methods of a continuum series. Havas made the applied correlation method. He also classified the species groups and vegetation types in sloping mires. The clustering analysing and multivariate the ordination of Finnish peatland vegetation multivariate are performed by Pakarinen & Ruuhijärvi and Mannerkoski (1979). (Heikurainen & Pakarinen 1982, 14-15.)

3.2 Grouping of site types: Carex peat and Sphagnum peat

In the book of peatlands published in 1981, peatlands have been distinguished in 25 to 35 site types in Finland, which is aimed to the practical use. In botanical systems, a more particular partition was divided into about 60 to 70 site types. However, in this thesis, a total of 40 types are grouped and they include three major categories. After the Third Forest Inventory in Finland from 1951 to 1957, the percentage of those three kinds of site types was given. The hardwood –spruce mires were 17.5% of the North Finnish peatlands and 26.3% of the South Finnish peatlands. The pine mires were 41.6% of the North Finnish peatlands and 42.1% of the South Finnish peatlands, and for treeless mires were 36.9% and 13.9%. (Heikurainen & Pakarinen 1982, 15.)

There are two common kinds of peat soil, Carex peat and Sphagnum peat. The Carex peat soil with the moderately decomposed hypnaceous is classified as the best peat soil. The Sphagnum peat has weak quality compared with other types of peat. A comparison of chemical contents for those two types will be represented in detail in Chapter 4. However, Graph 7 will show the different peat forming layer species and their degree of decomposition. (Virtanen 2008, 30.)



GRAPH 7. Mire profile shows peat forming species of a layer and their degree decomposition. (Virtanen, Hänninen, Liisa Kallinen, Vartiainen, Herranen & Jokisaari 2000, 12)

4 CHARACTERISTICS OF PEAT

In this chapter, properties in peat will be discribed, which will include the chemical characteristics, the physical characteristics and the biological characteristics. The chemical characteristics will be particularly represented because the whole thesis is related to peat used in chemistry. Furthermore, chapter 4 and 5 will show the different peat chemical properties applied in various technology areas such as cleaning technology, food production, plant cultivation and balneology.

4.1 Chemical characteristics

Due to the varied composition of the plants forming the peat, differences between varied types of peat will be noticed. The type of peat can also be affected by nature of mineral soil and bedrock both underlying and adjoining the peatland. The substances are transported by wind and water, the degree of temperature is also influenced chemical characteristics. The reason that made the various chemical content inside peat is in a natural state, which will be depend on the around circumstance. To find out the optimized sampling strategy for peatland characterization, Juhani Peuravuori and Kalevi Pihlaja made a more accurate study. (Kurki 1982, 37.)

To solve the problem of various effects, Peuravuori and Pihlaja written that the most important influence to control the chemical content is the variations of natural vertical and horizontal environment. Therefore, first they collected samples and then analysed errors by different types of peat, various methods, vertical segregation (diverse level of layer), and horizontal segregation (semivariogram technique). The explanation of semivariogram technique is a technique that is used to analyse a limiting distance. This limiting distance makes sample points having the reliably enough average concentrations of different contents. Finally the sampling optimization methods were summarized. (Peuravuori & Pihlaja 1989, 134-149.)

TABLE 3. Constituent value of peat (Peuravuori & Pihlaja 1989, 136)

Constituent	**Unit**	**Mean value**
Volume weight	kg/m3	87.7
Water constent	%	90.4
Ash	%	3.6
pH-value		4.8
Lipids	%	5.4
Waxes	%	3.0
Humins	%	75.1
Humic acids	%	8.8
Fulvic acids	%	3.1
Water soluble organics	%	2.7

TABLE 4. Element content value of peat (Peuravuori & Pihlaja 1989, 136)

Elements	**Unit**	**Mean value**
Al	%	0.21
As	ppm	2.9
Ba	ppm	36.6
Ca	%	0.41
Cd	ppm	0.4
Co	ppm	1.3
Cr	ppm	5.6
Cu	ppm	8.5
Fe	%	0.67
Mg	%	0.09
Mn	ppm	80.0
Mo	ppm	1.2
Ni	ppm	3.5
P	ppm	483.6
Pb	ppm	4.6
Si	%	0.02
Sr	ppm	26.9
Th	ppm	0.6
Ti	ppm	57.1
U	ppm	9.4
V	ppm	11.3
Zn	ppm	16.7
N	%	1.4
S	%	0.17

Peuravuoti and Pihlaja collected samples from 17 peatlands and amounts are total in 117 points in Finland in 1989. 15 samplings of them were collected from average deep 1m in a peatland, and 102 samples collected from average deep 2.9 m in 16 peatlands. Table 3 and table 4 were estimated the mean value of 10 constituent parameters and 24 inorganic elements. When using peat into application, each proportion of constituent will play an important role to consider. (Peuravuori & Pihalaja 1989. 137-138)

TABLE 5. The constituent value comparing between Sphagnum and Carex (Peuravuori & Pihlaja 1989. 137-138)

Constituent	**Units**	**Sphagnum**	**Carex**
Ash	%	0.72	5.26
Al	%	0.02	0.29
As	ppm	0.17	0.96
Ba	ppm	8.52	68.2
Ca	ppm	0.14	0.4
Cd	ppm	0.18	0.23
Co	ppm	0.34	2.17
Cr	ppm	1.01	7.19
Cu	ppm	3.83	10.46
Fe	%	0.06	1.64
Mg	%	0.08	0.08
Mn	ppm	14.19	201.03
Mo	ppm	0.31	1.02
Ni	ppm	0.87	5.08
P	ppm	120.38	681.2
Pb	ppm	7.87	15.01
Si	%	0.01	0.03
Sr	ppm	10.07	33.33
Th	ppm	0.22	0.38
Ti	ppm	5.25	62.61
U	ppm	3.45	2.94
V	ppm	0.36	11.51
Zn	ppm	12.64	8.08

For the clear consideration of peat application, Table 5 is descripted the comparetion of two special types of peat, Sphagnum peat and Carex peat. Table 5 was applied the same sample with the sample of Table 3. It was also chosen 23 mean value of constituents for analysing and comparing. (Peuravuori & Pihlaja 1989, 135.)

One thing need to be mentioned, which plays an important role in the constituent of peat. That is peat humus. The humus substance of peat soluble in alkalis can be divided into humus acids, fulvic acids and humines. Recently the humus substance has been studied by researchers from the University of Joensuu and University of Turku. In this phenolic constituent, the highest potential of peat fractions decomposed rate of peat can be up to 80%. The humus and fulvic acids have been found to strengthen the root system of plants and to improve the crops of plants cultivated in peat. (Fagernäs 1996, 115.) This will be described in detail in Chapter 5.4.

4.2 Physical characteristics

With the same reason as chemical characteristics, the physical properties of peat are also always changed with various such like the types of peat and the condition of environment. Therefore, only a range of each property can be discussed. According to one research named as the physical properties of organic soil in Stolowe Mountains National park, the physical characteristics of peat in Poland are summarized. After the analysing the horizons, the specific gravity is about 1.48 -2.25 g/cm^3. The bulk density is 0.07 -0.62 g/cm^3 and the total porosity is 74.2 -95.3%. The ash content is 2.2 -72.6% dry matter of soil. The values of vertical water permeability in saturated zone were expressed by coefficient K, and ranged from $1.09*10^{-4}$ cm/s in muck horizons to $6.64*10^{-8}$ cm/s in strongly humified muddy peat horizons. The macropore content is 10.9 -33.9%. (Bogacz 1998, 105-111.)

4.3 Biological characteristics

The biological characteristic of peat is mainly mentioned with the biologically active substances. Biologically active components not only possess the therapeutic importance, they are also useful for agriculture and horticulture. Biological characteristics can be divided into two parts, biostimulators and bioinhibitors. Some components inhibit the growth of bacteria and viruses and stimulate the growth of bacteria and plants such as steroids, triterpenoids, humic and fulvic acid. After finding the biologically active components are sensitive to pH value, Ca^{2+}, and the type of preparation, oversimplifying the complexity of peat will exist. (Pihlaja, Karunen and Wiklund 1983, 495-496.)

Non- humic and humic substances are removed by alkaline extractions, and the use of alkali to extract peat and the extraction technique can modify the nature of the humic substances. It is complicated to tell the effects of humic substance to the plant growth, which depends on various parts such as the plant culture condition, the type of humic substance, and the species of plant test. But confirmed thing is that the humic substances can indirectly influence the growth of plant by modifying the physical and chemical properties. (Rengo, Spigarelli & Pihlaja 1989, 480-481.) An exact experiment describe the biologically active substance affecting the growth rate and seedlings of lettuce and winter wheat made by Kalevi Pihlaja, Pirjo Karunen and Tom Wiklund. It will be show in Chapter 4.

5 STUDIES OF PEAT IN CHEMISTRY

Numerous of different studies were made by professional researchers. In this chapter, studies and products related to chemistry will be described in detail and most of studies that the professor Kalevi Pihlaja have took part in. Studies consist of the organic and inorganic constituent in peat and the primary part is about the peat study in Finland and one study investigating about Poland. Furthermore, studies conducted in three different countries China, Canada and The United States will be introduced in general.

5.1 Chemical mapping of peat

The research focuses on the peat situation in Finland. Finland has one of the richest peat resources in the world. The applying of peat in Finland can be traced back to the 17th century. Even so, peat has been widely used into agriculture, horticulture and energy production. There are not paid a great attention to the systematic mapping of peatland for its chemical refining and geochemical purposes. With the diminishing of the energy studies of peat, the chemical prospecting has been widespread respected. The research by Pihlaja, Ketola and Luomala was published in 1983. It cooperates with the Geological Survey of Finland and department of Chemistry in University of Turku. To develop new peat production, it is necessary to systematize, diversify long-term research and coordinate with the chemical mapping of peat. (Pihlaja, Ketola & Luomala 1983, 453.)

Six main elements were included in the chemical mapping of peat such as peat classification, organic extractives, carbonhydrates lignins, humic substances, instrumental analysis, organic constituent, ion exchange capacity prospecting and complex formation. This research introduced the instrumental analysis and the inorganic analyses. In instrumental analysis, three methods had been mentioned which were included Electron Paramagnetic Resonance spectroscopy (EPR), Infrared spectroscopy (IR), and Fourier Transform spectroscopy (nuclear magnetic resonance) (FT-NMR). EPR has been applied into the determination of the degree of the humification of peat and the studying of paramagnetic species such as Fe^{3+} and Mn^{2+}. IR is used to characterize the functional group's type and amount, and predict the selfheating trendency of milled peat. FT-NMR can gain the scope of soil samples and organic matter extracts. In inorganic analyses, it mainly analyse the elements in peat such as Zn, Cu, Ni, and U. Focusing on the development of a binding model for peat and metallic cations, for instance, flooding, peatland draining, and fallout influence the results given by ash analyses. (Pihlaja, Ketola & Luomala 1983, 445-452.)

5.2 The effects of peat lipids on the growth rate of E. COLI K12

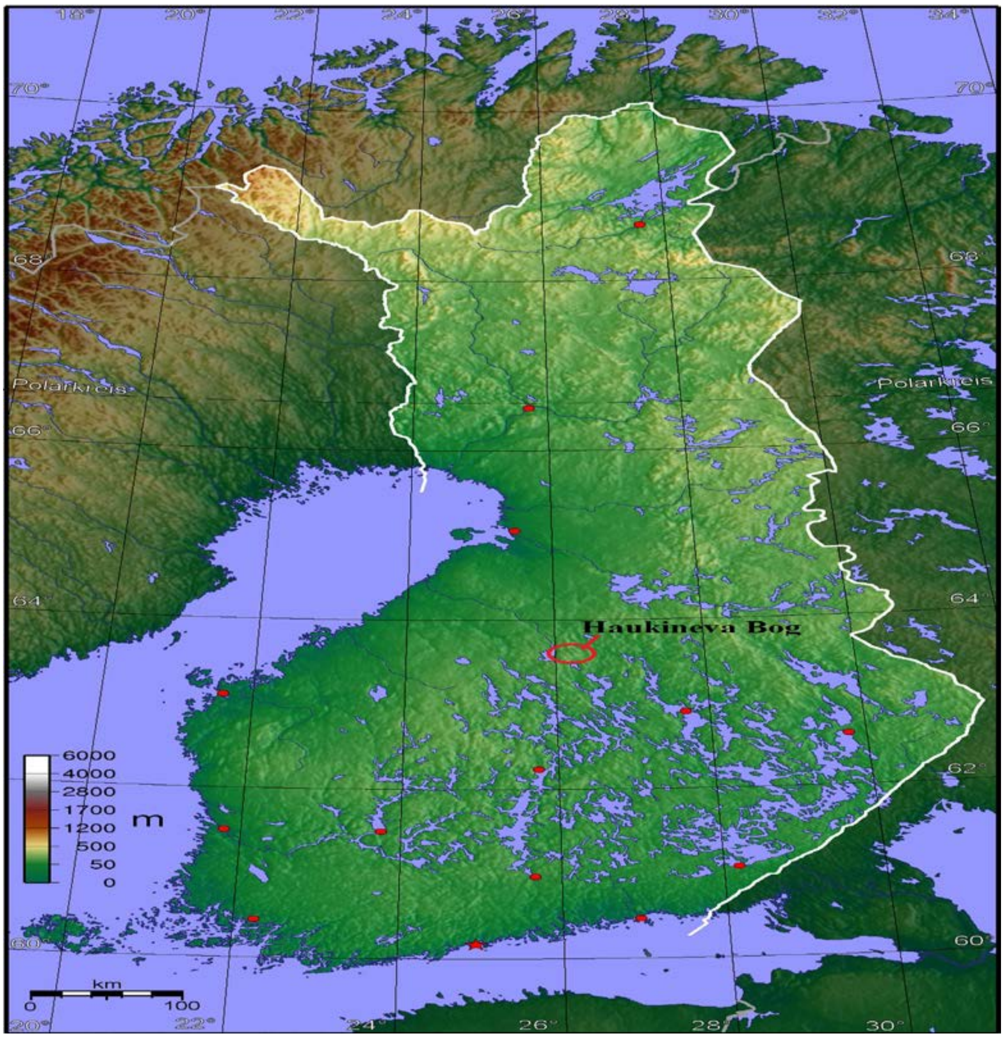
The research having the discussion of the humic acids is published and it effects on crop growth which cause the crop more resistant to pests and bring the increase of the sugar and carbohydrate contents of crop. However, peat lipids become toxic when higher concentration of humic acids exists. With this background, in this research, an analysing of the effects of peat lipids on the growth rate of E. COLI12 will be described. The E.COLI (Escherichia Coli) is defined as one of the most diverse bacterial species, which is a gammaproteobacterium and it can be found from the lower intestine of warm-blooded organisms. (Pihlaja, Kukko & Luomala 1981, 349; Centers for Disease Control and Prevention, 2014.)

During the experiment, the samples were collected from the Laitila bogs. Researchers Pihlaka, Kukko, and Luomala made comparation of two extract methods. One of methods is the bituminous peat with CH_2Cl_2 was divided into 6 fractions and 2 subfractions by Thin Layer Chromatography (TLC) by using different eluent such as Et2O and petroleum ether. The other method is bituminous peat in toluene and divided into 8 fractions by TLC using various eluent for instance HOAc, Et2O, and petroleum ether. TLC is a fast and cheap procedure which will quickly solve problems for example components in mixture. (Pihlaja, Kukko & Luomala 1981, 347.)

After finished the experiment, the total lipids from peat samples extracted with CH_2Cl_2 have retarded the bacterial grow but no same result from the toluene extract. No exact explanation can be confirmed but there can be three possible reasons. Firstly, the environmental chemistry Trihalomethanes (THMs) compounds such as $CHCl_3$ retard the growth of fibroblasts altogether. Secondly, when the total lipids extracted with CH_2Cl_2, there included humic acids, which inhibited the bacterial growth. However, when at higher concentrations, there is a counterbalanced retarding effect. Finally, there is an effect of antibiotics from activity of ancient bacteria of the actinomycetales group. The final result is gained at the highest bitumen concentration. The highest bacterial growth is with increasing rate. Furthermore, the existence of lipid components will stimulate the growth of E. COLI K12, but this phenomenon will be decreased when the peat grows older. (Pihlaja, Kukko & Luomala 1981, 347-354.)

5.3 Biologically active substance in peat

The importance of biological characteristics was described in Chapter 3. According to the research before, conducting tests detect the presence of biologically active substances. In the research made by Pihlaja, Karunen and Wiklund (1983), more information is regarded to various bioassays. The samples of peat in this research were collected from the Haukineva Bog and the situation will show in Graph 8. Both water and organic extracted from the peat were bioassayed for growth-promoting activities. There are mainly four parts of bioassays: Auxin bioassays, root growth tests, Gibberellic acid bioassay and Cytokinin bioassay. In each part, they included that the influence of water and organic extract of peat to the root growth by analysing different types of plants. (Pihlaja, Karunen & Wiklund 1983, 496.)



GRAPH 8. The map of Haukineva Bog (Pihlaja, Karunen & Wiklund 1983, 496)

5.3.1 Auxin bioassays

The Avena coleoptile was used in the test of auxin-like growth hormone activities of peat extractive. The result is the segment of Avena coleoptile that are proportional to the logarithm of the exogenously applied IAA (indol- 3- acetic acid) concentrations. Furthermore, the length of the coleoptile segment was increased depending on the pH value of phosphate buffer. The results of water and organic extractives from this research were described. Firstly, the water extractives from peat stimulating or inhibiting the extension growth of coleoptile are depended on the pH value of the buffered system and the concentration of the extractive. When no IAA but with the highest concentration (151 mg/dm^3) and pH equalling to 3.0, the grow promotion was clearly stimulated. The rate of the water extractives behaviour was dependent on the pH value of bioassay medium, which was included hydrolysable compounds and the components whose protonating or deprotonating equilibria depends on pH value and other solution's characteristics. Secondly, after the experiment and analysing, auxin-type substances in the organic extractives not contain. (Pihlaja, Karunen & Wiklund 1983, 501-502.)

5.3.2 Root growth tests

The root growth tests were carried out by cress and cucumber seedlings. The root growth tests are more complex than the Auxin bioassay. Firstly, the result of this research made by Pihlaja, Karunen and Wiklund (1983) was that water soluble substance from peat stimulating the root growth of cucumber. It was found that the water extractive from peat dissolved in distilled water decreasing the cucumber root growth at pH 4.0. The highest concentration with 273 mg/dm^3 was the most inhibiting condition. When water soluble substances are dissolved in phosphate buffer, the promotion of root growth is at the concentration of 2.73 mg/dm^3. It was the same phenomenon with cress experiment. (Pihlaja, Karunen & Wiklund 1983, 503-505.)

Secondly, at the beginning of experiments, the organic extractives inhibited the growth of cucumber root but only when the organic extractives were up to the highest concentration, the cucumber root growth can be restrained with the extent of strongest. There were more dilute solutions stimulating the cucumber root. At later experiments, the organic extractives from peat contained growth-promoting lipophilic substances in the cress root testing. Therefore, the activity of organic extractive was only found in the testing of cress root but not cucumber root, which indicated the specificity of active compounds in species, hypothetical synergistic and antagonistic agents of peat.

These possible active substances in the organic extract of peat are sterols and their derivatives. (Pihlaja, Karunen & Wiklund 1983, 503-505.)

5.3.3 Gibberelic acid and Cytokinin bioassay

In the Gibberellic acid bioassay, the dwarf pea seedlings were affected by the gibberellic acid with the concentration in the range of 0.01-10.24 μg/plant. In this experiment, the gibberellic acid stimulated pea seedlings growth at 0.03 μg/plant. However, no peat extractive showed Georgia-mediated growth responses. Therefore, in the peat samples that were collected from Haukineva bog, no active GA-like agents exist. In the Cytokinin bioassay, radish cotyledons were used for test. In the preliminary test, the water extractive was collected from the peat that preserve at 20°C for one month. This water extractive clearly promotes the radish cotyledon growth. However, in the later experiment, this phenomenon became weaker and finally stopped. So the conclusion is that it will be destroyed the agents for cytokinin-like activities when water extractive being protected in +5°C in refrigerator or peat samples in long storage at -20°C. (Pihlaja, Karunen & Wiklund 1983, 503-505.)

5.4 The effects of peat extracts on onion root growth

In this research, the onion bulb roots were used for the assessing that about the growth stimulating potential of substances solution extracted from peat. There were three different kinds of extractions: the natural extraction of a harvested peatland by leaching and drainage of nature waters, a conventional alkaline extraction of humic substances with 1 % NaOH, and mild extractions with dilute acid, distilled water, or dilute alkali. It achieves the goals such as that gathering preliminary information about the potential for using peat as a source to cause the humic enhancers of plant growth, developing suitable techniques for humic substances extraction and measuring plant growth stimulation. (Rengo, Spigarelli & Pihlaja 1989, 470-471.)

5.4.1 Natural water samples

The first experiment results that the humic matter in the river water was less stimulatory or can be definite that the ability of the humic matter apportion to stimulate onion bulb root is less in river water. However, the humic matter may be masked by inhibitory substance for instance aluminium. There is no visible change of the nutrient solution dilution caused the root growth for reasonable explanation. Firstly, the nutrient solution had stimulated root growth by fertilization but the critical fertilization level was less than that present in the weakest nutrient solution tested. Secondly, the presence of dissolved matted benefited onion root growth by buffering but nutrients were not responsible for growth stimulation. Furthermore, the macronutrient concentrations were higher in the nutrient solution but lower than in natural water samples. (Rengo, Spigarelli and Pihlaja 1989, 472-474.)

5.4.2 Mild peat extracts

The second experiment results that the mild acid extract figured to be the most stimulating to root growth and the mild alkali extract figured to be the least stimulating. The optimum concentration of growth stimulation is about 100 mg/L for the dilute acid extract and water extract. The extract’s growth stimulating potential is related to the pH value of extraction slurries. It can be suggested that a great number of stimulating matter is released from peat when it is under lower pH conditions. (Rengo, Spigarelli & Pihlaja 1989, 474-476.)

5.4.3 Conventional alkaline peat extracts

This test was related to decide that whether the unpurified solution of humic and fulvic acids conventionally are extracted form peat with strong alkali stimulating root growth or not. After the experiment, the conventionally extracted humic and fulvic acid solutions were less stimulatory than the mild solution. The purification is needed with strongly attention, which will decide that fulvic acids and humic acids are suitable for use as enhancers of plant growth. (Rengo, Spigarelli & Pihlaja 1989, 476-480.)

5.5 Inorganic constituents in Finnish peatlands

In this research, 313 samples were analysed to find out the content of 22 elements, the ash contents, pH value, degree of humification, and the fractions of different peat types by using Principal Components Analysis (PCA) and Partial Least Squares (PLS). Samples were gathered from 6 different mires in various sites in Finland, and each peatland were drilled. PCA and PLS are two kinds of mathematical tools in SIMCA program package. PCA is more useful in the classification problem, while PLS is focused on the relationships of cause and affects between two group's variables and this relationship can be modelled and investigated. (Peuravuori, Pihlaja, Heikka & Minkkinen 1989, 189-201.)

According to the research conducted by Peuravuori and Pihlaja, results of peat inorganic constituents were found. Firstly, due to the sampling sites, PLS introduce the subgroups which formed peat, and PLS also explain 63%-84% variance of both dependent and independent variables. Ash content validates the directions of the first principal component. The weakest modelling power was found with Si, Cd, Th, and the degree of humification. Secondly, Sphagnum peat is the most humified type of peat and Sphagnum peat has the less organic contents than others at average. Sphagnum peat sometime is favoured by the elements Mo, Pb, Th, and U. Furthermore, the elements show the positive correlation to the degree of humification for example Mg, Ca, Sr and Ba. Finally, Carex and Bryales peat connect to the pH value. And sometimes samples that conclude the Carex peat will show a positive relation to the degree of humification. (Peuravuori, Pihlaja, Heikka & Minkkinen 1989, 189-201.)

5.6 Extractable and waxy materials of peat distributed in western Finland

In this research made by Ketola, Luomala and Pihlaja, 54 samples were collected from 8 sites from a drained peatland area. The samples were extracted from peat samples by a Soxhlet extraction using dichloromethane CH_2Cl_2 as a solvent. They were also analysed by thin layer chromatography and high-resolution capillary gas chromatography combined with mass spectrometry. The higher decomposed peats were found to give more quantities of extractive yields. The aim of this research was to examine the distribution features of peat extract, wax and their chemical composition. (Ketola, Luomala & Pihlaja 1983,276-286.)

All of the extracts were saponified and studied further for monomeric constituents. There were identified matters, which included acidic and neutral compounds. The acidic fractions were constituted by fatty and waxy acids (C12-C30), long-chain -hydroxyl acids (C12-C28), and aliphatic dicarboxylic acids (C16-C24). In this acid fraction, the fatty and waxy acids were the main content. Neutral monomers were constituted by normal alkanes (C15-C33), normal aliphatic alcohols (C16-C28), sterols and triterpenoids. In the neutral matter, alcohols and sterols were accounted for a significant proportion. (Ketola, Luomala & Pihlaja 1983, 276-286.)

5.7 Alkane and alkenes from a reclaimed peatland in north-eastern Poland

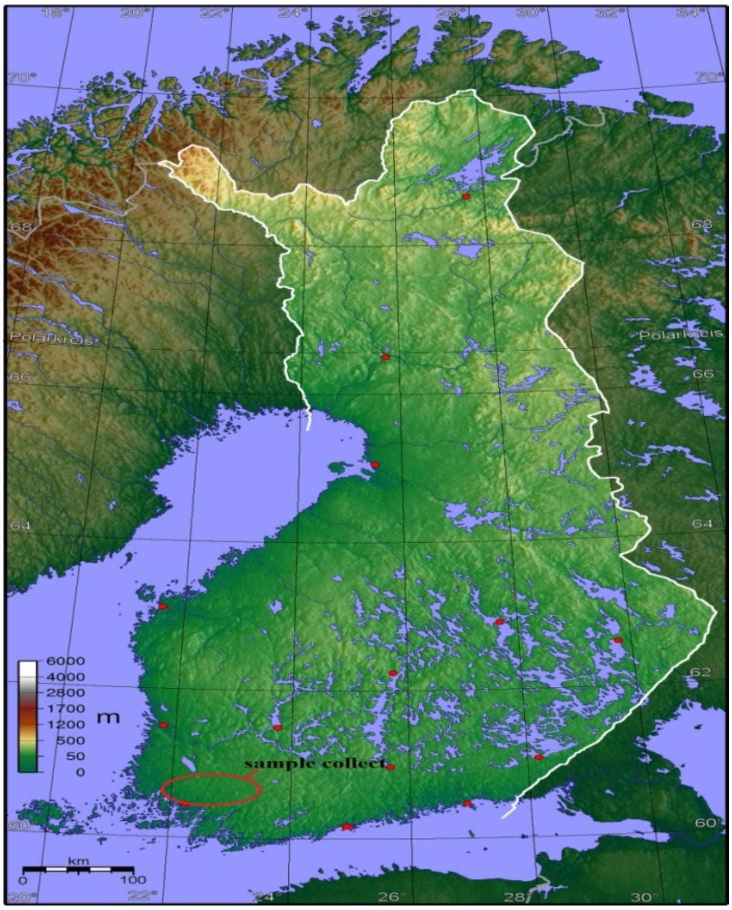
In the research made by Ketola, Pihlaja and Malinski, samples were extracted at the average thickness of 1.5 m and varied from 0.5 to 2 m in an unindustrialized and unpolluted part of Poland. The extractions were collected from air-dried samples by using a 9:1 dichloromethane-acetone mixture. The hydrocarbon fractions were separated from the extracts by liquid-solid column chromatography, fractionated further by urea adducts, and then analysed by GC/MS-techniques. After analysing the deep, the results of the organic extract amounts were lower than those of sphagnum peat in Finland. In the GC techniques, the presence of long-chain n-alkanes was revealed. The hydrocarbon fractions contain minor components in addition to n-alkanes and 1-alkanes. To make the structural analysis easier, hydrocarbon fraction can be divided into straight-chain and branched/cyclic hydrocarbons by urea-adduction or molecular sieve absorption. The non-urea-adduct forming subfractions from peat in gas chromatographic traces were identified as fichtelite and diploptene. Furthermore, the minor components were pristane, pristene and phytane. (Pihlaja, Ketola, Malinski, Kusmierz & Szafranek 1989, 218-222.)

This research is the first time that indicated the presence of biologically originated C23-C31 1-alkenes and polycyclic partially aromatizing hydrocarbons in fresh-water peat deposits. Resulting from diagenetic changes, polycyclic aromatic hydrocarbons are formed by tracnsformation of tetracyclic or pentacyclic triterpenoids with six members. In the deepest peat layer, the high diploptene content indicates a substantial activity of bacteria in the early stage of its formation. It also means diploptene do not undergo subsequence conversions within the period of peat formation. The presence of demethylated hopanes and of hopane homologues predict that triterpenorid alcohol transformation into hydrocarbons with the same carbon skeleton in peat occurs parallel to the aromatization processes. (Pihlaja, Ketola, Malinski, Kusmierz & Szafranek 1989, 222-233.)

5.8 The extracts and sterol contents in bogs of south-western Finland

In the research conducted by Aaltonen and Pihlaja, about 6 to 35 samples were collected from two bogs and six sampling sites in south-western Finland where the sample thickness was 20 cm. After analysing of extracts and sterol contents, a comparation between the bogs of south-western and peatland of Lappland had been discussed. The area of sampling resource will be shown in Graph 9. There are various extractive methods to get the extracts and sterols. The extraction was carried out with the mixture of acetone and dichloromethane and dried by a rotary evaporator. Waxes were separated by dissolving the extract in boiling 94 % ethanol. Sterols were separated from the extract on TLC plates precoated with silica gel, and elution was finished with a mixture of diethyl ether and petroleum ether. (Aaltonen, Pihlaja & Tuittila 1989, 272-288.)

In the results, there were from 1.8% to 12.1% weigh amounts from dry peat being extracted. No confirmed relationship was found between the total extract amount and sample depth. It was not found to depend on degree of humification either. The average wax content of the extracts was 45 %-65 % weight of the dry peat. The sterols contents were from 0.21 to 4.23 mg in 1mg of dry peat. The main sterol component were β- sitosterol and β- sitostanol approximately 53 % and 26 % of total sterol. Furthermore, the total amount of sterols were relatively greater in the bogs of southwestern Finland than in the peatlands of Lappland. (Aaltonen, Pihlaja & Tuittila 1989, 272-288.)



GRAPH 9. The area of sampling (Aaltonen, Pihlaja & Tuittila 1989, 272-288)

5.9 Peat studies in Canada, The United States, and China

In this part, large amounts of peat research that have been published in Canada, China and The United States will be described in general. It is convenient for people to search more information about peat and peatland studies that conducted by different countries. In Canada and The United Sates, many studies can be found in Canadian Journal, for example, Canadian Journal of Microbiology and Canadian Journal of soil science. In China, the studies of peat can be searched in the website named as Weipu. (www.cqvip.com). A large amount of research can be found in those areas. When search by the same word in website, for example peat application and peat research in chemistry, these three countries have different results. In China, peat studies mostly focus on three parts, which include peat purification of wastewater, analysis of peat performances, and peat sorbent used in adsorbing metals such as nickel. In Canada, peat studies more paid attention to the purification of wastewater by using peat and the analysis of peat elements and properties. In The United States, to improve the environment and to repair ecosystem seems more important in applying of peat. (Xun, Zhirong, Peng, Kai & Jungang 2006; Brown, Gill & Allen 2000; Stanek & Silc 1977.)

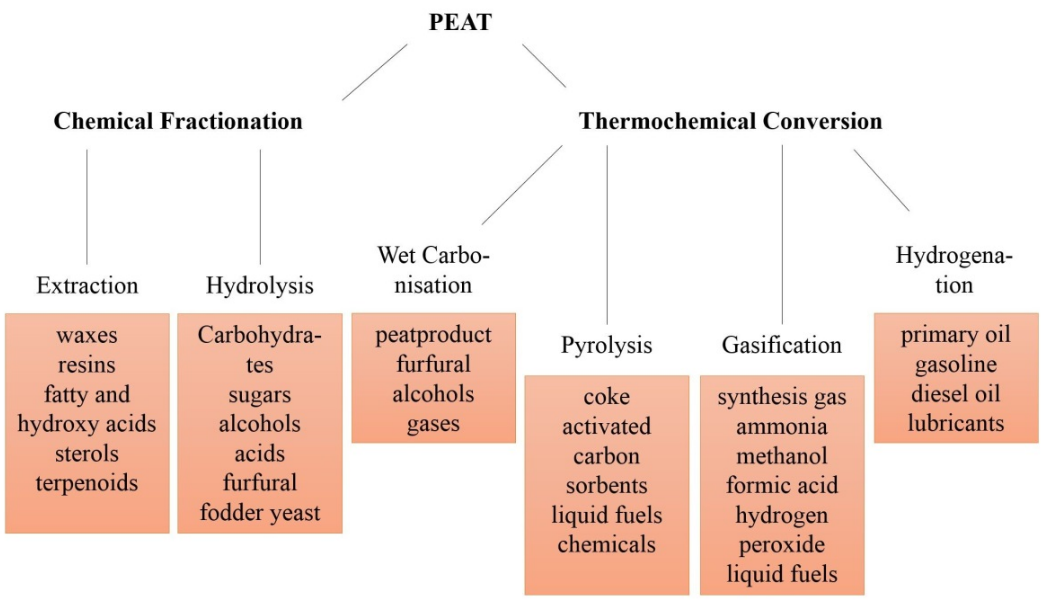
In China, for example, study about dissolution performances of peat was conducted by researchers Xun, Zhirong, Peng, Kai, and Jungang in 2006. The summary about heavy metal wastewater filtered by peat was conducted by researchers Ling, Zhirong, and Chuanmao in 2005. Furthermore, the adsorption and desorption characteristics of nickel to peat was conducted by researcher Peng, Zhirong, and Kai in 2006. (Xun, Zhirong, Peng, Kai & Jungang 2006; Ling, Zhirong, Chuanmao 2005; Peng, Zhirong & Kai 2006.)

In Canada, for example, studies about metal removal form wastewater by using peat were conducted by researchers Brown, Grill and Allen in 2000. The comparisons of four methods for determination of degree of peat humification were conducted by researchers Stanek and Silc in 1977. Furthermore, the relationships of vegetation to surface water chemistry and peat in chemistry in fens of Alberta were conducted by researchers Vitt and Chee in 1990. (Brown, Grill & Allen 2000; Stanek & Silc 1977; Vitt & Chee 1990.)

In The United States, for example, studies about the ecological study of the peat bogs of Eastern North America were conducted by Pierre and Fernando in 1952. The study about bulk density of surface soils and peat in the north central United States was conducted by Grigal, Brovold, Nord, and Ohmann in 1989. Furthermore, the article about biological control of plant pathogens research, commercialization and application in the USA was conducted by Gardener and Fravel in 2002. (Pierre & Fernando 1952; Grigal, Brovold, Nord & Ohmann 1989; Gardener & Fravel 2002.)

6 OTHER PEAT PRODUCTS

Peat is not only used in chemical research, but also in other applications. In this chapter, five main parts of peat products will be described for example peat sorbent, peat in horticulture and balneology, peat used as a biological purification, and peat lipstick. Those five parts will relate to the physical characteristics and biological characteristics of peat. However, according to the more attention have been paid on the peat that used in energy and agriculture, no related content will be revolved. (Fagernäs 1996, 114-117.)



GRAPH 10.The alternatives of chemical conversion of peat (Fagernäs 1996,115)

When making peat chemical conversion, there are two parts that can be separated, chemical fractionation and thermochemical conversion. From the Graph 10, the methods are obviously discovered. Based on the separation of chemically similar components, two methods are used in chemical fractionation. By using the methods of extraction, the components can be easily collected for example waxes, resins, fatty, sterols, and hydroxyl acids. The components such as carbohydrates, sugars, alcohols, and acids can be obtained by hydrolysis method. Thermochemical method is applied into decomposing the organic structure of peat for instance wet carbonization, pyrolysis, gasification, and hydrogenation. (Fagernäs 1996, 114-117.)

6.1 Peat sorbent

Basic ideas of peat used as sorbent can be searched and this kind of application has been used in many countries for example Russia, China. Three main parts of peat sorbents have been discussed: peat sorbents for arsenic removal, peat sorbents for removal of phosphate ions from aqueous solution, and technological processes of sorbents production on the peat base. Sorbent used by peat as a material has numerous advantages such as high sorption capacity, low cost, simplicity of manufacturing and application, as well as environmental safely utilization. Without these three ideas, a research has been described for the adsorbing of radionuclides by raised bog peat, which is about the sorption of radionuclides 137Cs and 60Co in the flux regime. (Timofeev & Pukhova 2012, 144.)

In peat sorbent for, peat, modified peat with iron compounds and iron humate were researched to remove arsenic. The adsorption process of arsenic compounds was investigated both as function of pH and temperature. The results show that the modified peat and humic acids can purify the drinking water which contains arsenic compounds. (Ansone, Klavins & Eglite 2012, 87.)

In peat sorbents that remove phosphate ions from aqueous solution, modified peat was used as a sorbent for the removal of phosphate ion from wastewater. The results show that the sorption efficiency was high. When the concentration ranges are from 0.1 to 25 mg/L, there are more than 99 % phosphate ions forming sorbet. The sorption capacity was pH dependent and the maximum uptake occurred at pH 2. Therefore, the modified peat could be used as an effective sorbent to remove phosphate ions from aqueous solutions. (Robalds, Liga & Marisi 2012, 146.)

In sorbent producing of technological processes on the peat base, the most suitable production of sorbent is to pelletize with the plate granulator, which keeps the materials at low density and high porosity condition. The peat mineral composite basis can be added mineral components for three purposes, which include reducing the initial humidity of pellets, increasing the speed of pelletizing and modifying physic mechanical characteristics. One of the sorbents properties changing direction is thermochemical modifying. (Timofeev & Pukhova 2012, 108.)

6.2 Peat in horticulture

Peat in horticulture usually works as a growth media or peat-based substrates. However, there is a defect that horticulture plants grown in peat-based or other soilless substrates adsorb low amounts of P, which means that the risk of phosphorus losses are high. Therefore, there is a need for increasing P applying efficiency in the horticulture for example crops productions. For this purpose, the research about added Bara clay and mycorrhizal inoculation was finished, which analysed the possibility of combing mycorrhizal inoculation with the addition of P enriched clay to control P availability in peat-based substrates. Finally, the P enriched clay can be used to control the content of soluble phosphorus in the substrate. (Kron & Caspersen 2012, 97.)

The other study that made by Carlile, Nichualain and Cattivello is about the behaviour of young trees cultivated on peats with different degrees of decomposition. The experiment analyse two kinds of tree species: Fraxinus ornus and Ulmus pumila on two different peats: a less decomposed peat of Northern European origin and a more decomposed peat originating from the Republic of Ireland. Species and substrates were irrigated with tap water and tap water with NaCl. The trial period is six months. The results showed on the plant quality and leaf colour. (Carlile, Nichualain & Cattivello 2012, 91.)

6.3 Peat in balneology

Since the early 19th century, German-speaking central Europe started applying the peat in balneology and the mainly used in the organizing of bath and spa. This science of baths has a great influence in human health. The fast speed decomposing of peat, the concentrations of biologically active substances, humic acids and humins cause peat becoming as a useful medicine for some diseases such as rheumatic and degenerative arthritis. The application of peat in balneology has a surely good future in terms of health and financial. (Korhonen 1996, 119 & 121.)

6.3.1 History and application

From the time of the Roman Empire, Europe people began to consider of peat used in balneology. In Finland, the investigation of balneological peat was started at 1989, which is the cooperation between Geological Survey of Finland and the University of Turku. As a kind of soil that applied for treating rheumatic and other diseases such as locomotory organs, gynaecological and urological ailment, peat has a good heat retention capacity which is double water heat retention capacity. Furthermore, there are more biological active substances, which will penetrate people’s skin and adsorb rheumatic factors, normalize hormone activities and invigorate the metabolism. However, there is no classification of balneological peat, and one German specialist Dr. W. Naucke had a research, which is classified as the degree of composition, between H6 and H8 for Sphagnum peat and between H8 and H10 for miner trophic Carex peat. No matter what type of peat, the concentration of humic acids has a clear connection with the degree of composition. (Korhonen 1996, 119 & 121.)

6.3.2 Method of use

People usually use peat bath with the mixture of water and peat, which will be warmed to 39° C ~ 42° C. With the high heat retention capacity of peat, the bather can not stay in it more than 20 minutes. After bathing, people require to use a blanket wrapped themselves for 30 minutes, which will cause the persistent sweating. It is definitely necessary for people drink more spring water at the same time. (Korhonen 1996, 120.)

6.4 Biological purification of ethylene contaminating air

A research made by Elsgaard represented that a peat-soil biofilter can remove ethylene C_2H_4 from 100-ppm-range to concentrations near the threshold level for plant hormonal activity. This research was based on the ethylene-oxidizing bacteria. And it tested that the efficiency of indigenous microorganisms in horticultural peat soil applying to purify C_2H_4 contamination air under biofilter conditions. The plant physical process such as ripening and senescence is affected by the gaseous plant hormone and ethylene air pollutant. (Elsgaard 1999, 181.)

Peat soil was arranged in a biofilter with 687 cm^3 volume. Then it was subjected to an air flow with about 117 ppm ethylene and the rate of air flow was 73 mL/min. After operating for 12 days at 26° C, the ethylene content was decreased to 0.034 ppm, which shows the efficiency of the purification was more than 99%. However, during the day of 16th to 21st, the efficiency of removing ethylene was decreased to 51%. Finally, the results was that using horticultural peat soil to make the prolonged and efficient purification of highly ethylene contaminated air under biofilter conditions apparently depends on the bacterial inoculation. (Elsgaard 1999, 182-184.)

6.5 Humic substances use for peat lipstick

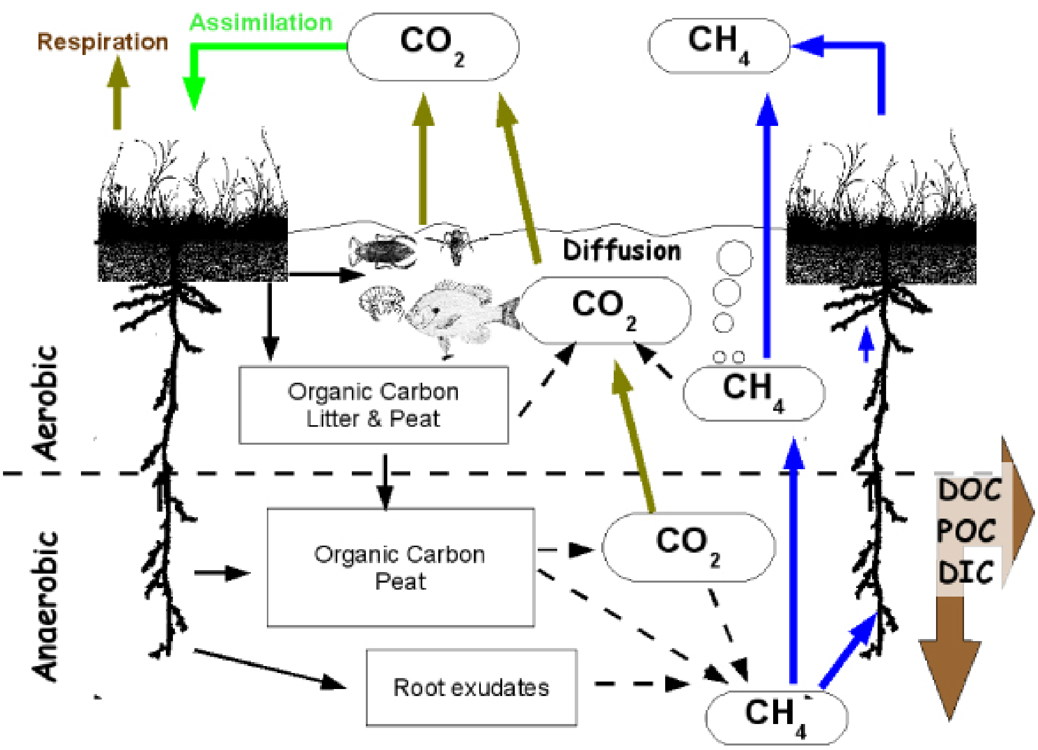
Herpes labialis is a worldwide spread recurring viral infection, which is caused by herpes simplex virus type1. UV-B radiation can be the major provocation factor for viral reactivation. Considering the humic acid and the UV-B protecting effects are antiviral, humic substance were tested to be the promising candidates for developing a photo-protective peat lipstick. This kind of lipstick will minimize or even prevent the UV-induced recurrences risk. In this study made by Seel, Guhr and Schubert, the comprehensive Humic Acid-like substance, the natural humic acid UV/VIS spectra and the different basic lipstick components were tested to collect the most appropriate UV absorbing ingredients for the product under development. The selected humic substances were then analysed in various concentrations for their UV-B protective effect in human U937 cells. (Seel, Guhr, Klöcking & Schubert 2012, 191.)

In the testing, researchers used a special arrangement. The two UV-transparent cell culture plates were put to the top, especially one on the top of the other. The cells were in the lower. The test substances which will be acted as the UV filters will put in the upper plate. By using microprocessor-controlled UV irradiation system called Bio-Sun, the UV-B irradiation was carried out. (Seel, Guhr, Klöcking & Schubert 2012, 191.)

The results showed the expected high absorption degree of all Humic Acid (HA) in the UV-B range, but revealed substantial differences in the UV-A range. After UV exposition, cell counting at 24, 48 and 72 hours gave the evidence of the important dose-dependent UV-B protective. Effects of the tested HA are similar to p-aminobenzoic acid (PABA). This PABA was used as the positive reference substance. (Seel, Guhr, Renate Klöcking & Schubert 2012, 191.)

7 REHABILITATION AND MANAGING OF PEAT

People can use peat not only as a resource in doing research and making production, it could also accumulate carbon. There are two parts that include the decreasing tendency of carbon accumulation such as the natural development of mires and the changes in the vegetation conditions, which has more contribution than the climatic factors. The high net carbon accumulation rates can be attributed to low decomposition rates, which is related to the humid periods. Furthermore, a marked decline in the carbon accumulation rate also may indicate a period of relatively dry and warm climate. The accumulation process of carbon in peat shows in Graph 11. (Clarke & Rieley 2010.)



GRAPH 11. Carbon cycling in mire ecosystem (Lloyd, Rebelo & Finlayson 2013)

Accoding the describtion of the peat application and research, there are numerous different methods to use. However, if people only pay attention to the consuming but not concern with the rehabilitation and management, there will be one day that resource be exhausted. For many economic purposes such as agriculture, forestry, the energy, many of peat land are needed in the world. Therefore, environment requires rehabilitation and management after utilizing. The rehabilitation measures are needed to restore peat into the condition which can continue peat biodiversity and reduce CO_2 emissions. Those measures must be suitable for peat, depending on the type of peat, the environmental conditions around peat land and the former management of the applied peat. Also focusing on the application period, the long-term and short-term application can be solved with different methods. For example, after long-term agriculture use, meadows on peat could be re-wetted. The method and action will be took the responsibility mostly by the relevant planning authority. (Clarke & Rieley 2010, 21.)

8 CONCLUSIONS

Peat as a valuable resource should be applied to technical aspect not only pays attention to energy production. It is a waste in some content that the properties of peat have more economic value and should be exploited. Focusing on the different characteristics of peat in chemical, physical and biological aspect, the various ideas could be carried out. The studies introduced in this thesis made by Kalevi Pihlaja provide more useful knowledge for people doing further research for example the methods of extracting, and the experimental equipment.

There are many organic and inorganic elements in peat. The chemical mapping of peat gives the instrumental analysis in constituents and elements of peat by using EPR, IR, and FT-NMR. The peat lipids have the effect on the growth of E.COLI K12 and this effect will be decreased when the peat grows older. Biologically active substance in peat has been analysed by four types of bioassays, which included Auxin bioassays, Root growth tests, Gibberellic acid bioassay and Cytokinin bioassay.

Through the comparing of the natural water samples, the mild peat extracts and the conventional alkaline peat extracts, the onion root growth stimulate the potential of substances solution that extracted from peat by different condition. By using PCA and PLS, researchers analysed the classification, effects and causes of inorganic constituents in peat. After analysis of inorganic constituents, the properties of inorganic elements were showed in Table 4. When examining the distribution features of peat extract, wax and their chemical composition, the extracts were analysed by thin layer chromatography and high-resolution capillary gas chromatography combined with mass spectrometry. Alkane and alkenes in reclaimed peatland were analysed with GC MS techniques. After comparing the sterol content in the peat, the conclusion is that the amount of sterols is greater in the bogs of south-western Finland than the lapland.

In peat products, peat can be used in horticulture and balneology or peat can be a sorbent and purifying product. Furthermore, the humic acid in peat can be used in peat lipstick. For the future, numerous studies about the elements existing in peat resources have been conducted. Peat researchers should pay more attention on the application of elements such as carbon, humic acid, organic and inorganic matters. A suggestion can be summarized that combining the biological and physical characteristic of peat to produce a kind of make-up production such as cleaner mask, pharmic content soap.

One important thing need to be taken in serious. When people utilize peat as a resource, the rehabilitation and management of peat after using should receive more attention. No matter what the resource is, each procedure such as collecting, analysing, researching, managing, restoring, and rehabilitating is part of peat application as a sustainable resource in the future.

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